Transactions of ISATE

The 12th International Symposium on Advances in Technology Education

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Nurturing Professionals for Smart Cities: Way Forward for Technology Education

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18 – 21 September 2018

Hong Kong

ISATE 2018 Technical Programme Committee

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About ISATE

The 12th International Symposium on Advances in Technology Education (ISATE 2018) provides a platform for educators from higher education institutions to share their knowledge and experiences in practice-based engineering and technology education. Through the Symposium, stakeholders can benefit from sharing innovative teaching methodologies and practices used in schools.

Organisers

National Institute of Technology, Japan
Nanyang Polytechnic, Singapore
Ngee Ann Polytechnic, Singapore
Republic Polytechnic, Singapore
Singapore Polytechnic, Singapore
Temasek Polytechnic, Singapore
IVE Engineering Discipline, Vocational Training Council, Hong Kong

Co-organisers

Nagaoka University of Technology, Japan
Toyohashi University of Technology, Japan

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Name	*Institution*
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Welcome Message



On behalf of the Vocational Training Council (VTC), it is my great pleasure to welcome all delegates to the 12th International Symposium on Advances in Technology Education (ISATE). We are much honoured to host this important event for the first time in Hong Kong.

Skilling the workforce is high on the agenda in many world cities, while the development and adoption of technology is the greatest and fundamental driving force. Hong Kong strives to be a world class smart city where people are empowered by disruptive technologies to boost connectivity and productivity, support better living and create opportunities for all. The conference theme "Nurturing Professionals for Smart Cities: Way Forward for Technology Education" underscores the need for us, as educators, to embrace technologies in education and learning for grooming skilled professionals for the digitised world.

The four-day event will bring together hundreds of delegates around the world to share knowledge and experiences in "hands on" engineering, as well as innovative and technology-based teaching methodologies for the advancement of vocational and professional education and training. Apart from academic exchange, I am also proud of the rich cultural exchange elements in the ISATE 2018. The Symposium will not only foster innovative ideas sharing, but also cross-cultural exchange and future collaboration. I hope all of you will enjoy the ISATE 2018 and establish new networks for future collaboration.

Last but not least, let me express my appreciation on behalf of VTC to the ISATE 2018 Organising Committee and Technical Programme Committee for their hard work in making this event possible.

Dr Roy CHUNG Chi-ping

Chairman
Vocational Training Council
Hong Kong

Welcome Message



As the President of National Institute of Technology, Japan (NIT), it is my great pleasure and honor to welcome you to ISATE 2018 held in Hong Kong, on September 18-21, 2018, hosted by Hong Kong Institute of Vocational Education (IVE).

ISATE provides a unique platform for educators and experts from institutions of higher education in engineering and technology around the world to share their knowledge and experiences in practical-based engineering and technology, and to foster young people with relevant knowledge and skills required for a better future of society. The symposium started in 2007 as an academic exchange program between 10 colleges under NIT in Kyushu and Okinawa areas of Japan and 3 polytechnics in Singapore. At present, ISATE is a regular annual event organized by 5 polytechnics (Nanyang Polytechnic, Ngee Ann Polytechnic, Republic Polytechnic, Singapore Polytechnic, Temasek Polytechnic) in Singapore, IVE in Hong Kong, TUAS in Finland, KMITL in Thailand and NIT (with its 51 Colleges, KOSEN, in Japan) together with Nagaoka University of Technology and Toyohashi University of Technology in Japan. This year, I am pleased to have about 140 fruitful presentations, including those from Australia, China, France, Mexico, UK, Thailand etc., and I would like to welcome a lot of members from overseas countries in addition to Japan, Hong Kong, and Singapore. These participants will provide new insights into engineering and technology education on the symposium theme of this year, "Nurturing Professionals for Smart Cities: Way Forward for Technology Education" as the Main Theme with 4 Sub Themes, which are Innovative Learning and Teaching, Technology Enhanced Learning, Multidisciplinary Collaborations, and International Connectivity. I hope through discussion in this symposium we can obtain more information to foster young people to be world-class engineers, as I recommend to call, "Social Doctors", who work hard to keep the society healthy in hard and soft aspects, and as "Creators" of new concepts and new values for the future wealthy and affluent society.

I would like to sincerely thank the members of Organizing and Technical Program Committees for their great efforts to prepare this symposium and Dr Eric Liu, Deputy Executive Director, Vocational Training Council, Hong Kong for hosting this symposium. Also, I would like to thank all the speakers who give the papers in this symposium.

I believe that ISATE 2018 is interesting, stimulating and rewarding for all participants. I hope you all enjoy this fruitful symposium and you will see many new friends and colleagues for further academic exchange and collaborations with a lot of new ideas. Once again, please enjoy the symposium and your stay in Hong Kong, very exciting, beautiful, lovely, and energetic place.

Dr Isao TANIGUCHI

President
National Institute of Technology
Japan

Welcome Message



It is my pleasure and privilege to welcome all delegates to the 12th International Symposium on Advances in Technology Education (ISATE) 2018.

ISATE 2017 symposium last year was held in Ngee Ann Polytechnic, Singapore. This year, we are happy to be in Hong Kong. We thank the Hong Kong Institute of Vocational Education for hosting the symposium in this vibrant and beautiful city.

As well as participants from Japan, Singapore and Hong Kong, this symposium has also attracted diverse participants from institutions of higher learning of Australia, China, France, Mexico and UK. All have travelled here for a great time of learning, and to exchange ideas and explore collaboration.

The theme of ISATE 2018 is "Nurturing Professionals for Smart Cities: Way Forward for Technology Education", with sub-themes on "Innovative Learning and Teaching", "Technology Enhanced Learning", "Multidisciplinary Collaborations" and "International Connectivity".

This theme is very apt. We are living in an exciting time of significant technology changes, and perhaps disruptions. New technologies and learning models, such as Artificial Intelligence (AI), Personalizing Learning Models, Adaptive Learning Software, Cloud-based Technology and Micro-learning, are not just changing the field for students, they are shaking up the role of educators, creating shifts in approaches to teaching, and remodelling the classroom.

Just look at what Prof Ashok Goel did at Georgia Tech in the US in 2016. Prof Ashok teaches computer science, and in his online course called Knowledge-Based Artificial Intelligence, he decided to use AI to answer questions from students who attend the course. So he introduced Jill Watson, as one of his teaching assistants for the course who will answer questions from students in a online discussion forum. The students were unaware that Jill was not an actual person and interacted with her like what they would do with a normal TA. Jill did wonderfully well, and helpfully answered questions with 97% accuracy.

Let me share another example. At Temasek Polytechnic in Singapore, the use of AR and VR allow my aerospace engineering students to have a more immersive, true-to-life learning experience. These interactive technologies not only optimise resources that would otherwise be spent on expensive aircraft engines and specialised equipment, they also greatly enhance student learning. Using AR and VR, students are able to experience the un-experienceable (e.g., walking into an aircraft engine combustion chamber) and work on difficult tasks such as the assembly and disassembly of aircraft systems, before they do the hands-on practice on actual systems.

So the time has come for educators like us to leverage the potential offered by technology to make our teaching more effective and engaging so that our students can learn better.

I am sure there are more examples from all of you here, on how you have leveraged technology to enhance teaching and learning. I hope that over the next few days, through the various platforms in this symposium, you can share your experiences in leveraging technology and other innovative practices in education, and the lessons that you have learnt. This way, all of us can benefit from your valuable experiences.

On behalf of the Polytechnics in Singapore, I thank the Organising Committee for the great effort in planning the event. I wish all the participants a fruitful symposium and rewarding networking session.

Thank you.

Mr Peter LAM

Principal & CEO
Temasek Polytechnic
Singapore

For and on behalf of:

Nanyang Polytechnic
Ngee Ann Polytechnic
Republic Polytechnic
Singapore Polytechnic
Temasek Polytechnic

Welcome Message



On behalf of the Organising Committee, I would like to extend a heartfelt welcome to you all to the 12th International Symposium on Advances in Technology Education (ISATE) in Hong Kong. I am particularly pleased that this annual event, with strong support from all the organisers and co-organisers, is held in Hong Kong for the first time.

According to a study in the United Nations Population Fund, the world is undergoing the largest wave of urban growth in history. More than half of the world's population now lives in towns and cities, and by 2030 this number will swell to about 5 billion, roughly 66% of people will live in Urban areas. These figures not only represent the massive challenge in how we build and manage our cities but opportunities to improve the lives of billions of people.

Rising to this challenge, governments around the world pursue to the development of smart cities, with the objectives of ensuring sustainable growth and competitiveness of a city and enhancing the quality of life of its people. With this in mind, government authorities are striving to build smart cities through the use of innovation and technology to address urban challenges, enhance city management and improve the quality of living, sustainability, efficiency and safety to their cities. In Hong Kong, our government formulated the Smart City Blueprint for Hong Kong in December 2017, which outlined the vision of Hong Kong that is liveable, competitive and sustainable "Asia's World City".

The development of smart city requires a supply of professional talents from different sectors. "Nurturing Professionals for Smart Cities" is thus the priority task of our societies. In this connection, we are truly grateful to have been able to organise the ISATE 2018 for educators to exchange their thoughts on issues of common interest. In particular, how we nurture professionals for smart cities under the four symposium sub-themes, namely Innovative Learning and Teaching, Technology Enhanced Learning, Multidisciplinary Collaboration and International Connectivity.

Last but not the least, I wish to express my sincere appreciation to all members of the Organising and Technical Programme Committees for their hard work to prepare for the symposium. Without their unfailing efforts during the past months, ISATE 2018 would not have been such a fruitful event. It has been my pleasure to work with all of you. Besides, I would also like to extend my thanks to all speakers who will share their valuable insights and experience through their presentations at the symposium.

I wish all participants a rewarding symposium and our overseas visitors a pleasant and memorable stay in Hong Kong.

Dr Eric LIU

Honorary Chairman, ISATE 2018 Organising Committee
Deputy Executive Director, Vocational Training Council
Hong Kong

Welcome Message



It is my great honour as the organiser to welcome all of you to the 12th International Symposium on Advances in Technology Education (ISATE) 2018, to be held in Hong Kong from 18 to 21 September 2018.

Since 2007, ISATE provides a unique platform for educators from higher education institutions to share their knowledge and experience in practice-based engineering and technology education. Through the Symposium, you can benefit from sharing innovative teaching methodologies and practices for Vocational and Professional Education and Training (VPET).

In response to the global trend in smart cities development, the main theme of the symposium this year is "Nurturing Professionals for Smart Cities: Way Forward for Technology Education". Under which, participants will have great opportunities for discussion and exchange of experience in the four sub-themes on Innovative Learning and Teaching, Technology Enhanced Learning, Multidisciplinary Collaboration, and International Connectivity.

ISATE 2018 consists of 4 Keynote Presentations, 8 Institutional Presentations, about 140 Parallel Presentations and 8 Workshops. Technical Visits are also available for the symposium participants. I am sure you will have fruitful and rewarding exchanges through the symposium.

Before I close this address, I would like to thank the organising and technical programme committees for their tremendous efforts in organising the symposium.

Thank you, and hope you will have a pleasant stay in Hong Kong.

Mr SHIU Chi-Yung

General Chairman, ISATE 2018 Organising Committee
Academic Director (Engineering), Vocational Training Council
Hong Kong

Welcome Message



This 12th International Symposium on Advances in Technology Education (ISATE) is focused on "Nurturing Professionals for Smart Cities: Way Forward for Technology Education". This event is hosted by Hong Kong Institute of Vocational Education, and is organized by National Institute of Technology, five polytechnics (Nanyang Polytechnic, Ngee Ann Polytechnic, Republic Polytechnic, Singapore Polytechnic and Temasek Polytechnic) in Singapore, along with Nagaoka University of Technology and Toyohashi University of Technology.

As educators, we do our best to support our students. We are expected to foresee the future, to look ahead to the next 10 to 30 years and anticipate future trends. We are also expected to enhance the teaching environment so that our students can overcome challenges to realize their dreams. These are no borders in our efforts to improve the quality of education to cultivate creative and practical engineers. ISATE 2018 is a good platform towards these aims.

ISATE 2018 consists of 4 keynote presentations, 8 institutional presentations, and near 140 research presentations from participants of various countries. These professionals are dedicated to engineering education and I look forward to the sharing of practical techniques to cultivate good engineering education for positive impact.

Dr Nobuhiko AZUMA

President
Nagaoka University of Technology
Japan

Welcome Message



It is my great honor as a co-organizer to welcome all of you to the International Symposium on Advances in Technology Education 2018 (ISATE2018). The ISATE series commenced through the comprehensive agreement between three polytechnics in Singapore and KOSENs in the Kyushu and Okinawa regions of Japan, and has been developing to the organization of five polytechnics in Singapore, National Institute of Technology, Japan, Nagaoka University of Technology, and Toyohashi University of Technology.

Globalized engineers have to have a comprehensive and integrated perspective of the world, and the ability to bring together knowledge and technology at every level, because globalization is accelerating due to the spread of research networks and the increasing pace of technological innovation. In order to foster global engineers, it is important not only to provide opportunities for acquiring fundamental knowledge and experience, but also to train necessary skills for collaborating with other researchers beyond specialized fields, and also the philosophy of "Sustainable Development Goals".

The main theme of ISATE2018, "Nurturing Professionals for Smart Cities: Way Forward for Technology Education" is timely and very important subjects for sustainable growth of cities with satisfying high-level quality-of-life. All of participants will share their experiences and knowledge by attending parallel sessions and will find a solution for education of practical engineers. We will have about 140 presentations from 10 countries, i.e., Australia, China, Finland, France, Hong Kong, Mexico, Singapore, Thailand, UK and Japan. I hope that the symposium will contribute to furthering education for practical engineers in acquiring a comprehensive and multilateral perspective.

Dr Takashi ONISHI

President
Toyohashi University of Technology
Japan

Keynote Presentation (1) 19 September 2018 CKK Auditorium

Nurturing Smart People for Smart Cities



Dr Winnie TANG
Honorary President
Smart City Consortium
Hong Kong

Abstract

Countries around the world have been striving to develop smart cities by using information and communications technology (ICT) to enhance quality of life and city management. Smart city is all about people and people play the most important role in smart city development. Most of the Smart City applications and initiatives are driven by some key technologies including IoT, Big Data, AI and GIS, etc. Nurturing people and equipping our future workforce with relevant knowledge and skills become a critical success factor of the development of a Smart City. Hong Kong's tertiary education has been well-known for its quality. As one of the leading smart cities in Asia and part of the Greater Bay Area, Hong Kong has privilege of attracting excellent talents to form an innotech hub. What we need right now is to create the required ecosystem for our talents and help them to develop their innovation. This presentation will review the current situation of the smart people initiatives in Hong Kong and explore the way forward for Hong Kong to be talents hub of Asia Pacific.

Keynote Presentation (1)

Profile

Dr Winnie Tang, is an Honorary Professor in the Department of Computer Science at the University of Hong Kong. She is one of the locally-bred IT entrepreneurs of Hong Kong. In the 1990s, Dr Tang founded Esri China (Hong Kong) Limited to develop and promote Geographic Information System (GIS) software and solutions. Over the years, Dr Tang has been actively advocating the use of technology through her services in government and non-government organizations in Hong Kong. In recognition of Dr Tang's outstanding contributions to society, she was recognised as one the Distinguished Alumni by the Faculty of Science of HKU in 2009 and as one of the Ten Outstanding Young Persons of the year by the Junior Chamber International Hong Kong (JCIHK) in 2006. Dr Tang also received the Young Achiever of the Year in the Women of Influence Award presented by the American Chamber of Commerce in 2004.

Keynote Presentation (2) 19 September 2018 CKK Auditorium

International Contribution of KOSEN, Japan



Dr Kenji Higashida
Executive Director
National Institute of Technology
Japan

Abstract

The National Institute of Technology, Japan (KOSEN) is an original and successful organization of higher education in Japan to foster young students aiming at becoming creative, practical and world's highest level engineers and scientists by the early and novel education system of five years from fifteen years old. It was established in 1962, and it is now organized by fifty-one colleges in all over Japan (more than 50,000 students, 4,000 faculty members). Recently, the education system of KOSEN born in Japan attracts much attention from overseas countries. In this talk, the present policy and future direction of international contribution of KOSEN will be presented.

Keynote Presentation (2)

Profile

Dr Kenji Higashida is currently the executive director of National Institute of Technology (NIT), Japan, the director of the Center for International Exchange, NIT, and the president of Sasebo College, NIT. He received his Ph.D. in Metal Science and Technology at Kyoto University, Japan, in 1984. He joined the faculty of Materials Science and Engineering at Kyushu University in 1992. He stayed at University of Illinois, Urbana-Champaign as a visiting researcher in 1996. He was promoted to a full professor at Kyushu University in 2007. In 2016, he was appointed to the president of Sasebo College, NIT (Sasebo KOSEN), and concurrently serves as the executive director of NIT, Japan from 2018. His major field of study is Materials Science and Engineering, and his research has been focused on the mechanical properties of materials such as the basic mechanism controlling plasticity and fracture of crystalline materials. He is now a Professor Emeritus, Kyushu University, and a member of Editorial Board of Materials Science and Engineering.

Keynote Presentation (3) 20 September 2018 CKK Auditorium

Nurturing Power Expertise and Youth Engagement for Hong Kong as a Smart City - a CLP Case Study



Mr Paul POON
Vice Chancellor
CLP Power Academy
Hong Kong

Abstract

In October 2017, CLP Power Academy was established, offering accredited professional programmes for school leavers who are working in or aspire to a career in the power industry, hence providing them with a new upwardly mobile career path.

This new educational initiative comes at a time when Hong Kong has embarked upon major infrastructure projects while developing as a smart city, and demand for power engineering professionals is expected to grow because of increasing need for competent professionals for the infrastructure projects and other developments as well as their subsequent operation and maintenance. Such demand in professional resources could only be met by placing a stronger emphasis on Vocational and Professional Education and Training, and the critical success factor of this new educational initiative is close collaboration between the Universities/Education Institutes and the Power Industry, together with support from the HKSAR government.

In his presentation, Mr Poon will share the unique features of the Degree, Professional Diploma and Diploma programmes in Power Engineering that have been launched since late last year, which provide a new pathway for youths to advance their career in a professional industry in Hong Kong.

Keynote Presentation (3)

Profile

Mr Poon is the Vice Chancellor of CLP Power Academy. He sets up the Academy that aims to better meeting the engineering requirements of CLP Power and the demand for professional engineers, technicians and tradesmen for the power sector, while at that same time providing secondary school leavers who do not possess a formal degree qualification an upward mobility path in the engineering industry.

Mr Poon has over 38 years' experience in the power industry. He joined CLP Power Hong Kong in 1981. Since then, he had held various management positions in CLP. He was the Managing Director of CLP Power Hong Kong for about four years before assuming his current position in June 2017.

Mr Poon has been registered on National Engineer Register of Engineers Australia and serves as a Member of the HKQAA Governing Council. He has been appointed as a Co-opted Member of Council for The Hong Kong Management Association, a Director of the HKU School of Professional and Continuing Education, a Council Member of the Hong Kong Baptist University and a Council Member of the Hong Kong Productivity Council. He also serves on the Advisory Committees of various local tertiary education institutes, and is the Chairman of the Corporate Tech Academy Network.

Keynote Presentation (4) 20 September 2018 CKK Auditorium

Smarter City, Better Living: New Era of Work, Live, Play and Learn Empowered by Innovation & Technology



Ms Emily KONG

Managing Director
Business Innovation Group
Cisco Systems Inc.
Singapore

Abstract

In today's highly interconnected world, Technology Education is of vital importance in nurturing professionals for the digital economy. Innovation and Technology are the essence in building a more sustainable, resilient, and liveable community.

New Infrastructure underpinned by information and communication technologies (ICT) and Internet-of-Things (IOT) enables Smart Cities to achieve sustainability goals, boost local economies, transform public services, and improve citizen experiences.

Digital devices, adaptive software, and connected platforms offer a once-unimaginable array of opportunities for tailoring services to each individual's academic strengthens, interests and motivations, personal preferences, and optimal model of collaboration.

Innovative technologies harnessing big-data analytic, artificial intelligence and machine learning, are profoundly changing the way people work, live, play and learn.

Keynote Presentation (4)

Profile

Ms Kong has over 26 years of experience in business management, professional services delivery, information technology strategic planning, architecture design and software application development, programme and project management of large-scale systems integration solutions in multi-vendor and end-user environments, with diversified industrial experiences.

Leading Digital Transformation & Advanced Services organizations at Cisco Systems Inc., Ms Kong is managing a strategic professional services practice specializing in Digitalization and Internet-of-Everything Solution comprises of a vast portfolio of products ranging from hardware, software, services, and third-party offerings.

Ms Kong has championed many iconic Smart City and Internet-of-Things engagements in the region, including Cisco's flagship Smart & Connected Communities projects in South China, Europe, Australia and New Zealand. She also possesses in-depth expertise and experience of China marketplace with strong understanding and relationship with local government driving innovation projects at provincial and city level in the mainland.

Prior to Cisco, Ms Kong held various directorship and senior management positions at renowned global companies. She holds membership at several industry forums and chapters, and serves as the technology advisor to government boards and committees. She is also a frequent speaker at public events.

Institutional Presentation (1) 19 September 2018 CKK Auditorium

Transforming the Higher Education in Finland in order to Create 21st Century Skills



Dr Vesa TAATILA
Rector and President
Turku University of Applied Sciences
Finland

Abstract

The Finnish education system has been the key in transforming a developing and agricultural nation into a highly industrialized country that holds high positions in several international rankings. The education system has been based on decentralized and free schooling with very competitive teachers and high level of trust.

In the moment the learning needs are changing rapidly with the megatrends of globalization, digitalizationa and aging. Thus, the successful educational system needs to re-invent itself to suit the future requirements.

In higher education, the goal is to increasingly educate the young cohorts based on the needs to constantly develope the work markets. For that goal, Turku University of Applied Sciences has developed a pragmatistics approach to higher education, innovation pedagogy. It integrates learning with R&D and regional development, giving the organizations a faster access to new skills and the students learning opportunities that are based on the immediate requirements of their chosen field.

Institutional Presentation (1)

Profile

Dr Vesa Taatila works as the rector and president of Turku University of Applied Sciences in Turku, Finland. He is also an adjunct professor of innovation pedagogy in the University of Turku. Previously he has worked both in industry and academia, latest positions being the vice-rector of Metropolia University of Applied Sciences and the principal lecturer of innovation management in Laurea University of Applied Sciences. In industry he has held executive positions in project management, HR and competence management in multinational corporations Metso Oyj and Sonera Oyj. In addition he has worked as a member of the board, investor and a mentor in several start-up companies. His main area of interest is creation of world-class practical excellence and putting new innovations into action, either through changes in existing organizations or by establishing start-up companies.

Institutional Presentation (2) 19 September 2018 CKK Auditorium

Integrated Multidisciplinary Projects – A Nanyang Polytechnic Case Study



Dr Vinayak PRABHU
Assistant Director (Digital Engineering)
School of Engineering
Nanyang Polytechic
Singapore

Abstract

Nanyang Polytechnic (NYP) adopts an outcomes-based and practice-driven approach to pre-employment education and training for its 15,000 full time students, to better prepare them for work and life, equipping them to be life-long learners and to contribute to the technological, economic and social development of Singapore.

Project Based Learning (PBL) is one such approach that instils critical life skills into students, making them ready to grab the opportunities and face the challenges of the 21st century. Integrating multidisciplinary and team-based instruction into the PBL makes the approach even better because students can acquire teamwork, communication, and life-long learning skills and develop an appreciation for other disciplines.

This talk will present a case study conducted at Nanyang Polytechnic in which Integrated Multidisciplinary Projects (IMP) were undertaken with students and lecturers from engineering, chemical and life sciences, health sciences, business management and interactive and digital media. Twelve multidisciplinary teams worked on real-life projects over a period of six months using an underlying methodology of Design Thinking, encouraging the students to practice empathy towards the needs of the end users. All teams successfully delivered working prototypes, presented their projects in public settings, demonstrated growing levels of diverse technical and life skills through the project and reflected on their learning journey in the end to identify their strengths and areas of improvement.

Students involved the IMP acknowledged the benefits and learning outcomes of the programme. Supervisors observed the positive transformation of the students with respect to collaboration, communication and presentation skills, professional skills, and an increased intrinsic motivation for learning.

Institutional Presentation (2)

Profile

Dr Prabhu is the Assistant Director of Digital Engineering at the School of Engineering, Nanyang Polytechnic, Singapore and is the chair of the Integrated Multidisciplinary Project Programme – the topic of his talk today. At the School of Engineering, Dr Prabhu spearheads digitalisation of engineering education and leads inter-disciplinary innovation centres in advanced manufacturing and digital engineering to support the digital transformation journeys of Singapore's engineering industry. Dr Prabhu holds a PhD in manufacturing informatics from the UK, a dual Masters of Science in Micro-Electro-Mechanical Systems from Singapore and France and a Bachelor of Engineering in Computer Engineering from India.

Institutional Presentation (3) 19 September 2018 CKK Auditorium

Engineering Education and Research for Sustainable Development and Smart Society



Dr Masahiro INOUE
Vice President and Professor
Shibaura Institute of Technology
Japan

Abstract

In 2015 the United Nations adopted the 2030 Agenda for Sustainable Development. To achieve the sustainable development goals (SDGs) by innovation, countries and industries are working for smart cities and smart societies. To realize them, it is necessary to enhance interdisciplinary educations and researches of science and technology including systems engineering and project management. Internet of Things (IoT) and Artificial Intelligence (AI) will be introduced to all fields in mobility, energy management, environment, manufacturing, agriculture, infrastructure, and healthcare. International and interdisciplinary collaboration in various fields of IoT and AI becomes essential. Shibaura Institute of Technology is advancing education and research with international collaboration to realize sustainable society and founded the Global Technology Initiative (GTI) Consortium as an international collaboration platform for universities, industries and government organizations to cooperate in education, research and innovation. Global university-industry collaborative project-based learning courses (gPBL) are conducted worldwide in which students from different fields of expertise organize international teams to discover and solve problems to realize a sustainable society.

Institutional Presentation (3)

Profile

Dr Masahiro Inoue is Vice President and Professor, Shibaura Institute of Technology, Japan. He currently serves as an Executive Director and the Chair of International Committee at Japanese Society for Engineering Education.

He received B.S. and M.S. degree in Pure and Applied Physics from Waseda University and Ph.D. degree in Computer Science from Shizuoka University. During 1990-1991, he was a visiting research scientist at the University of Michigan. He joined Mitsubishi Electric Corporation in 1980. He was appointed as General Manager, Systems Engineering Division, Living Environment Systems R&D Center in 2002. Since 2005, he has been a professor of College of Systems Engineering and Science, Shibaura Institute of Technology. His field of research includes Internet of Things (IoT), embedded system, communication network, systems engineering, engineering education and project management. He received the Engineering Education Award, Japan (for the book), the Japanese Society for Engineering Education Award (for the achievement), and the Japanese Society for Engineering Education Award (for the thesis). He is a Professional Engineer in Japan and a Project Management Professional (PMP).

Institutional Presentation (4) 19 September 2018 CKK Auditorium

Nurturing Talents for Smart City Development in Hong Kong



Dr Jackson LAU
Deputy Academic Director (Engineering)
Vocational Training Council
Hong Kong

Abstract

Vocational Training Council (VTC), in support of the HKSAR government's commitment to develop Hong Kong as a smart city, will bring together the current work of developing specialized laboratories in Building Information Modelling (BIM), Robotics and Artificial Intelligence (AI), Internet-of-Things (IoT) technology, Big Data Analytics, and Cybersecurity, into a new initiative on "Nurturing Talents for Smart City Development". The main objectives of the initiative are to nurture future talents through training content enhancement of related curricula of VTC learning programmes; facilitation of students to undertake industry-related and multi-disciplinary projects of "smart" applications; and the development of an Innovation Centre to facilitate the execution of smart city projects and showcase to general public and local schools. The development of the specialized facilities to enhance learning and teaching will focus on smart mobility, smart living, smart environment and smart people.

Institutional Presentation (4)

Profile

Dr Jackson LAU is the Deputy Academic Director of the Engineering Discipline. He is primarily responsible for the operations of Campus and assists the Academic Director in the strategic planning and programme quality assurance of the Engineering Discipline. He also oversees the operation of the in-service training team and the academic development of Construction programme area.

Dr Lau is a seasoned engineer in the industry and has over twenty years' experience in vocational professional education and training. Before joining the VTC, he worked in consultants and contractors in England and Hong Kong where he gained substantive experience in engineering design and management. He is a registered professional engineer of Hong Kong and United Kingdom. He obtained his Master and Doctorate degrees from the University of Manchester, UK. Dr Lau has also served in a number of professional and industry bodies, including the Hong Kong Institution of Engineers and the Occupational Safety and Health Council.

Institutional Presentation (5) 20 September 2018 CKK Auditorium

Shenzhen Polytechnic's Philosophy in Promoting World-class Vocational Education



Prof LI Yue
Vice President
Shenzhen Polytechnic
China

Abstract

Shenzhen Polytechnic, established in 1993, has just celebrated its 25th anniversary. Over the past 25 years, the school has walked the walk according to the philosophy of innovation, to serve the Shenzhen Special Economic Zone, where it learned and grew. Today, it has become one of the distinguished tertiary level vocational institutions of the nation.

This presentation covers five aspects, where Shenzhen Polytechnic will share their experience how they provide education to support the development of Shenzhen, namely:

(1) To promote innovation and reform;

(2) To enhance teaching quality for the benefits of industries;

(3) To nurture startup and entrepreneurship;

(4) To highlight vocational education in people's livelihood;

(5) To explore diversified collaborations.

Shenzhen Polytechnic will strive to explore the future direction to become a top-notch vocational education institution with Chinese characteristics and pose the 'Shenzhen Polytechnic Model' for the world.

Institutional Presentation (5)

Profile

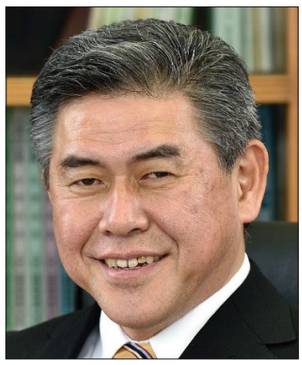
Professor Li Yue, PhD, was born in Changchun, Jilin Province in 1965. She is a Member of the Standing Committee of Shenzhen Committee of the Jiusan (Sept 3) Society, Co-Chairman of Grass-roots Committee in Nanshan District, Member of the Chinese People's Political Consultative Conference (CPPCC) of Shenzhen, and Member of the CPPCC Standing Committee of Nanshan District. At present, she is appointed the Vice-President of Shenzhen Polytechnic.

Professor Li received her PhD at Norman Bethune Health Science Center of Jilin University (formerly known as Norman Bethune Medical University) and Japan's Asahi University in 1983. She has widespread experience in oral medical education, clinical and scientific researches. She has led 17 scientific research projects and obtained three patents for the researches. She has also published over 20 publications, and served as the Chief Editor of three textbooks, which are widely used in the nation.

Professor Li is a recipient of the "National Award for Education and Teaching Achievements" (Second Class) and the "Award for Higher Education and Teaching Achievements in Guangdong Province" (First Class) in the project of "Curriculum Reform on Vocational Practice in Oral Medical Technology". She was also one of the awardees of the top ten "My Favorite Teacher" in Shenzhen in 2012.

Institutional Presentation (6) 20 September 2018 CKK Auditorium

Challenge of New Education Aimed at Global Engineers: Quarter System and Self-Directed Research Program



Dr Shigenao MARUYAMA
President
National Institute of Technology
Hachinohe College
Japan

Abstract

National Institute of Technology (NIT), Hachinohe College adopted the quarter system in 2015, and was the first NIT College to do so. At the same time, NIT, Hachinohe College introduced the self-directed research program, which is held for the entire autumn semester. This program enables students to conduct research projects unrelated to their major field. The only criteria for these research projects is that students must research an area that is both science-related and original without standard answers. Students discuss their projects with their peers in "Student Peer Discussion" sessions during which they exchange information and advices with each other. Professors provide guidance and suggestion for each student's unique research project, however, they do not directly teach the projects. We have found this self-directed research program to be very effective in developing various competencies, logical thinking ability and the presentation skills of our students. These abilities are essential for global engineers. We have recently extended our self-directed research program to our international program during which students are required to select a theme relating to an overseas local problem and attempt to find a solution working alongside the overseas students.

Institutional Presentation (6)

Profile

Dr Shigenao Maruyama is currently the President of National Institute of Technology (NIT) Hachinohe College, Japan. He received his Bachelor of Engineering in 1977, Doctor of Engineering in 1983 from Tohoku University, Japan, and Master of Science in 1979 from Imperial College, London University. He served as a full professor of Tohoku University (1997-2017), and was appointed Distinguished Professor (2008-2017), Councilor (2002-2014), Special Advisor to President (2006-2017), and Vice Commissioner (2012-2017) of Tohoku University. His research area is thermal and fluid sciences. He has published more than 200 journal papers, 14 books, and has 55 patent applications. He has also served as chairman of many international conferences on thermal science, and has received numerous awards, including Medal with Purple Ribbon (2012) from the Japanese Government.

Institutional Presentation (7) 20 September 2018 CKK Auditorium

Education Reinvented: KMITL Next Chapter in Learning Reform



Dr Rutchanee GULLAYANON
Assistant Dean for Research and Innovation
King Mongkut's Institute of Technology Ladkrabang
Thailand

Abstract

Rapid changes in technology trends and the urgent needs of over 15 million skilled workers within the next five years demand universities in Thailand to produce enough workforce for the industry. Currently, universities are not geared to the task. This talk presents KMITL's Next chapter in attempt to utilize modern technologies, such as the mobile Internet, the cloud, and automation of knowledge work, to empower teaching capability of the institution's education system. Other disruptive technologies, such as digital payments, verifiable digital identify, and advanced energy storage systems enabling digital transformation of the institution. Blended models of learning between theories and working on real-world projects help prepare students to be ready as close to what industry demands as possible. Looking forward, another transformational technology application will be immersive-learning software, capable of simulating the on-road experience as part of a driving lesson.

Institutional Presentation (7)

Profile

Dr Rutchanee Gullayanon received her B.S. in Electrical and Computer Systems Engineering from Rensselaer Polytechnic Institute, U.S.A., in 2001 and her M.S. and Ph.D. in Electrical and Computer Engineering from Georgia Institute of Technology, U.S.A., in 2005 and 2012 respectively. She has been working as a faculty member of King Mongkut's Institute of Technology Ladkrabang (KMITL) in Bangkok, Thailand. Currently, she serves as the director for the KMITL Research and Innovation Services (KRIS) for the institute. Prior to joining KMITL, she had worked for IBM as Computer Engineer. Her fields of research interests include autonomous robots, intelligent maintenance engineering and artificial intelligent.

Institutional Presentation (8) 20 September 2018 CKK Auditorium

Grooming Entrepreneurs



Mr Patrice CHOONG

Director
The Sand Box
Ngee Ann Polytechnic
Singapore

Abstract

Entrepreneurship is a key theme that was highlighted as part of the recommendations of the Committee for Future Economy in 2017. Since then, Singapore Government has put in place several initiatives to encourage entrepreneurship as a country and to attract foreign startups to set up in Singapore.

The Sandbox (TSB) was setup at Ngee Ann Polytechnic (NP) in 2015 to nurture and groom students into innovators and entrepreneurs. TSB has since mounted several programmes both at NP level and across the Polytechnics in Singapore.

This presentation will illustrate NP's approach to building a sustainable entrepreneurial ecosystem on campus and share NP's journey of entrepreneurship development and its response to a pertinent question as to whether entrepreneurship can be taught, and if so, how.

The presentation will discuss two models used in NP to groom entrepreneurs namely (i) the Value Chain Funnel model, and (ii) the Honey Pot model with each targeting students at a different stage of their entrepreneurship journey.

The Value Chain Funnel model exposes students to innovation and entrepreneurship throughout the three years in NP and nudges them along the value chain as they explore in greater depth their interest in innovation and entrepreneurship (I&E). This works well for students who have yet to be exposed to I&E but have nascent I&E abilities or mindset. For students who have demonstrated aptitude and interest in entrepreneurship, the Honey Pot model works best as it targets the needs of the students who have entrepreneurship experiences. This model offers just-in-time learning experiences targeted at different stages of a students' journey.

Institutional Presentation (8)

Profile

Patrice is the founding director of The Sandbox, the Innovation and Entrepreneurship office of Ngee Ann Polytechnic. At The Sandbox, Patrice kickstarted several initiatives to promote innovation and entrepreneurship.

Some of these initiatives include:

- Global Entrepreneurial Internship Programme which sends students to intern in startups located in 10 key entrepreneurial cities of the world. (www.geip.sg).
- Pollinate, a Joint Polytechnic Incubator, co-funded by National Research Foundation, with over 20 startup incubatees. (www.pollinate.space).
- Makers Academy which aim to raise the level of rapid prototyping skills in students from any discipline.
- Campus Ecosystem which aims to foster innovation on campus by partnering with startups to bring innovative solutions on campus. (www.campusecosystem.sg).
- A spectrum of innovation projects ranging from Chatbots to Blockchains.

Prior to The Sandbox, Patrice was helping the Polytechnic at the Planning and Projects office in areas such as Strategic Planning, Management Workplans and Institutional Knowledge. Patrice also taught in the School of InfoComm Technology as a Senior Lecturer in the field of Information Security for 9 years.

Patrice graduated with a B.Eng (Computer Engineering), a Masters in Computer Science from the National University of Singapore, and a Masters in Education from the University of Adelaide.

Workshop (1) 19 September 2018 Conference Halls 4 & 5

Sub-theme 1 Innovative Learning and Teaching

Workshop Summary

When students are learning concepts and tasks that are new and challenging, such as those that could be too complex and difficult for their present abilities, these concepts and tasks could become more accessible and manageable through a lecturer's effective scaffolding of the students' learning. When lecturers incorporate scaffolding in their classrooms, they become more of a mentor and facilitator of knowledge rather than the dominant content expert.

In this workshop, participants will get hands-on experience with a high-impact learner-centred learning activity aimed at scaffolding a concept. The post-activity debrief and reflection will help participants explore how scaffolding can be effectively employed during the facilitation of students' learning.

Workshop (1)

Sub-theme 1 Innovative Learning and Teaching

Facilitator



Dr LIEW Beng Keat

Deputy Director
School of Infocomm
Republic Polytechnic
Singapore

Co-facilitators



Ms Sharmila Kanna

Senior Lecturer
School of Infocomm
Republic Polytechnic
Singapore



Ms Janice Lim

Lecturer
School of Engineering
Republic Polytechnic
Singapore

Workshop (2) 19 September 2018 Conference Halls 6 & 7

Sub-theme 2 Technology Enhanced Learning

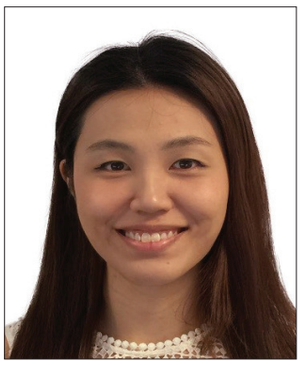
Workshop Summary

To inspire learning for millennial generation with vast and handy online resources, the wide and fast adoption of EduTech tools in higher education has greatly enhanced the flexible and lifelong learning all over the world. As the leading provider of Vocational and Professional Education and Training (VPET) in Hong Kong and the nearby region, the Vocational Training Council (VTC) has devoted in developing and delivering different means of EduTech tools for trade-specific subjects to nurture sub-degree students' learning. In this workshop, VTC's case in adopting the EduTech tools in trainings would be shared. The Virtual Reality-based Simulation Training and Digital Game/Story-based Learning and Teaching Packages were well-developed to stimulate student's learning motivation as well as enhance their learning efficiency. With the mindful planning of the Teaching and Learning activities and pedagogy, the EduTech tools bring liveliness to the traditional education by providing students with more opportunities for active creation, contribution, collaboration and communication.

Workshop (2)

Sub-theme 2 Technology Enhanced Learning

Facilitator



Ms LAU Sin Yee, Ciny

Education Development Officer
Centre for Learning and Teaching
Vocational Training Council
Hong Kong

Workshop (3) 19 September 2018 Conference Hall 3

Sub-theme 3 Multidisciplinary Collaborations

Workshop Summary

Problem-based Learning to Spark STEM Interest in Students

STEM (Science, Technology, Engineering and Math) education is of critical importance to students in entering the era of information and knowledge to produce tech-savvy workforce that leading the way into a sustainable and prosperous future. As the leading provider of Vocational and Professional Education and Training (VPET) in Hong Kong and the region, VTC STEM Education Centres (STEM Centre) were set up in 2017 with an aim of delivering an inspiring STEM education within the VTC and across the local community. In the workshop, STEM Centre will share the STEM activities we plan and deliver to raise the awareness of STEM education, to enhance the abilities of teachers in teaching STEM subjects and to stimulate interest in STEM studies and careers among students by offering opportunities to integrate their knowledge and skills to solve the real-life problems not only through practical activities, but also integrating IoT and programming knowledge in their learning journey. Moreover, the effectiveness of the technology to nurture STEM interest in youth will be examined at the end of the workshop.

Workshop (3)

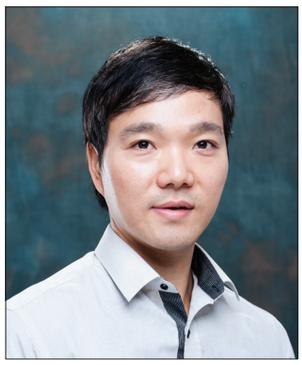
Sub-theme 3 Multidisciplinary Collaborations

Facilitators



Mr Jonathan LEE

Head
STEM Education Centre
Vocational Training Council
Hong Kong



Dr Johnny KWONG

Senior Project Officer
STEM Education Centre
Vocational Training Council
Hong Kong

Workshop (4) 19 September 2018 Conference Halls 1 & 2

Sub-theme 4 International Connectivity

Workshop Summary

In 2015, United Nations set The Sustainable Development Goals (SDGs) which are a collection set of 17 global goals to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These issues are no longer issues to be confined to one country,but global issues so that global interdependence is all the more increasing.

In our globalized world, real experience of different cultures in youth is very important for 21st century engineers and it helps broaden one's career options. This experience is also essential especially people be leaders of organisations. Therefore many schools and institutions are proactively promoting international experience among students. Most of these schools provide opportunities for exchange programmes, overseas internship and more for students. These schools aim to have their students see and learn from the various realities of this globalised world.

I hope participants of this session can find new associates with shari their successful cases at this world café style workshop, and because nothing is more important than cross-border networks of individual people in the age of globalisation.

Workshop (4)

Sub-theme 4 International Connectivity

Facilitator



Dr Yasuyuki SHIMADA

Director
Global Leadership Development Center
National Institute of Technology
Kumamoto College
Japan

Workshop (5) 20 September 2018 Conference Halls 4 & 5

Sub-theme 1 Innovative Learning and Teaching

Workshop Summary

This workshop will discuss "cooperative learning" as a tool to motivate students to learn. Before the discussion participants will share thoughts about "team flow," a process through which learners work a collaborative task or activity, not being aware that they are actually learning, potentially leading to increased long-term motivation.

Workshop (5)

Sub-theme 1 Innovative Learning and Teaching

Facilitator



Dr Yasuhiro KURAMASHI

Associate Professor
National Institute of Technology
Tokuyama College
Japan

Workshop (6) 20 September 2018 Conference Halls 1 & 2

Sub-theme 1 Innovative Learning and Teaching

Workshop Summary

Innovation pedagogy is a learning approach aiming at producing graduates who have the ability of participating in the innovation processes in their future working life possessions after graduation. To reach this aim Innovation pedagogy concentrates on making sure that both study field specific competences as well as innovation competences are set as an aim for the learning in universities. This becomes possible when the learning process is designed so that it includes several cornerstones defined in innovation pedagogy, supportive assessment being one them. Assessment is important as students tend to orientate their learning according to how they are being assessed.

In this workshop we describe the basic ideology behind Innovation pedagogy and concentrate on Innovation competences and especially their assessment. We first discuss assessment in general and present a tool developed for the assessment, the FINCODA innovation competence assessment barometer.

Working methods used in this workshop are very participatory and the audience has an active role in the delivery. Participants gain understanding about innovation competences and their assessment.

Workshop (6)

Sub-theme 1 Innovative Learning and Teaching

Facilitators



Dr Liisa KAIRISTO-MERTANEN
Executive Lecturer
Faculty of Engineering and Business
Turku University of Applied Sciences
Finland



Ms Meiju KEINÄNEN
Senior Lecturer
Faculty of Engineering and Business
Turku University of Applied Sciences
Finland

Workshop (7) 20 September 2018 Conference Halls 6 & 7

Sub-theme 2 Technology Enhanced Learning

Workshop Summary

In this workshop, participants will learn the principles of good flipped learning designs, try out simple EduTech tools, and apply their knowledge to design a flipped lesson.

Workshop (7)

Sub-theme 2 Technology Enhanced Learning

Facilitator



Mr Mark WAN

Academic Mentor
School of Electrical and Electronic Engineering
Singapore Polytechnic
Singapore

Workshop (8) 20 September 2018 Conference Hall 3

Sub-theme 4 International Connectivity

Workshop Summary

To nurture and fully prepare its students to become globlal citizens of the 21st century, the Vocational Training Council (VTC) of Hong Kong has put forward its internationalisation initiative under the Second 8-year Strategic Plan. In 2013, the International Development Committee was established to steer the direction of the Initiative while the International Development Office (IDO) was set up to spearhead the implementation of the Initiative.

Evidence shows that the international connectivity of VTC has been enhanced and fruitful experiences have been gained by students and staff culturally and professionally since 2013.

From a new initiative of the Council to become something embraced by teachers and students in the teaching and learning process, internationalisation strategies and its implementation have gone through different stages. This workshop will share with participants this 5-year journey of ours - our expereince gained over the years, the challenges encountered, what have been rolled out, the outcomes of the initiative, and the way forward.

Workshop (8)

Sub-theme 4 International Connectivity

Facilitators



Ms Heidi FUNG

Director
International Development Office
Vocational Training Council
Hong Kong



Mr Jonathan LEE

Deputy Academic Director (Engineering)
Vocational Training Council
Hong Kong

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Sub Theme 1

Innovative Learning and Teaching



SELF-MONITORING TRAINING PRACTICES FOR READING ENGLISH ALOUD AND THE EDUCATIOAL EFFECTS

Mariko Okuzaki[a] and Masaya Narumi [a]

[a] General Department, NIT Hakodate College, Hokkaido, Japan

*okuzaki@hakodate-ct.ac.jp

Abstract

This study investigates whether self-monitoring training activities for oral reading of English improved reading skills and learning aptitude in novice Japanese English as second language students. This study aims to establish a training system that promotes proactive after-school self-learning.

Two different self-monitoring training practices were conducted on 170 students in the second year of school using a 90-min English class held once a week, 30 times in the fiscal year of 2017. The first self-monitoring training was conducted three times as an individual activity with GlobalVoiceCall2 (GVC2), a pronunciation training software program developed by HOYA. The second self-monitoring training was conducted three times as a peer-review activity for groups of three. Both self-monitoring training practices were conducted after oral reading training activities such as chunk reading, chorus reading, overlapping with model reading, shadowing, and speed-reading. After the self-monitoring training activities, the students were required to take a practical reading-aloud test in front of the English teacher and class. Students did a total of four tests over the course of self-monitoring activities. We posed two hypotheses to investigate whether the two self-monitoring activities for oral reading of English improved students' reading skills or learning aptitude.

1. Do the two different self-monitoring training practices result in differences in reading error rate and reading speed?

2. Does students' learning aptitude change after participation in self-monitoring training practices?

We found that the group monitoring activity resulted in a greater decrease in reading errors than the self-monitoring activity, but had no influence on students' oral reading speed. Following the self-monitoring training activity, the number of highly self-controlled students increased, but high meta-cognition and self-efficacy rates decreased by the end of the year.

Keywords: *self-monitoring, oral reading, reading errors, reading speed, learning aptitude*

Introduction

This study investigates whether self-monitoring training activities for oral reading of English improved novice Japanese English as second language students7 reading skills and learning aptitude. This study aims to establish a training system that promotes proactive after-school self-learning.

Two different self-monitoring training activities were conducted with 170 students in the second year of school in a 90-min English class held once a week, 30 times in the fiscal year 2017. The first self-monitoring activity was conducted three times as an individual activity with GlobalVvoiceCall2 (GVC2), a pronunciation training software program developed by HOYA. The second self-monitoring activity was conducted three times as a peer-review activity done by groups of three. Each self-monitoring activity was conducted after oral reading training activities such as chunk reading, chorus reading, overlapping with model reading, shadowing, and speed-reading. After the self-monitoring training activities, students were required to take a practical reading-aloud test in front of the English teacher and class, four times in total over the course of self-monitoring training activities. Our study tested two hypotheses to determine whether the two self-monitoring training activities for oral reading of English improved students' reading skills and learning aptitude:

1. Do the two different self-monitoring training activities lead to differences in reading errors and reading speed?
2. Does students' learning aptitude change after participating in self-monitoring activities?

Nakayama and Suzuki (2012) examined the learning strategies for English shadowing performance in an individual-learning group and a pair-learning group and found that the individual-learning group was more productive in shadowing than the pair group. In this study, we investigated how the two different self-monitoring strategies influenced students' performance in oral reading tests and their learning aptitude, which is expected to be potentially beneficial for their learning.

Self-monitoring with GVC2

In the first semester of 2017, students used GVC2 to prepare for oral reading tests by self-monitoring their

English showing the GVC2 program. After listening to a model English example, a student records himself or herself reading through the microphone attached to the headset. The performance displayed as a speech waveform, and its similarities to the pronunciations, accents, intonations, timings, and overall performance of the model English examples are shown with graphs and scored out of 100. Each student can self-monitor his or her oral reading objectively and precisely using GVC2. We expected that students would be able to reduce their reading errors using GVC2.

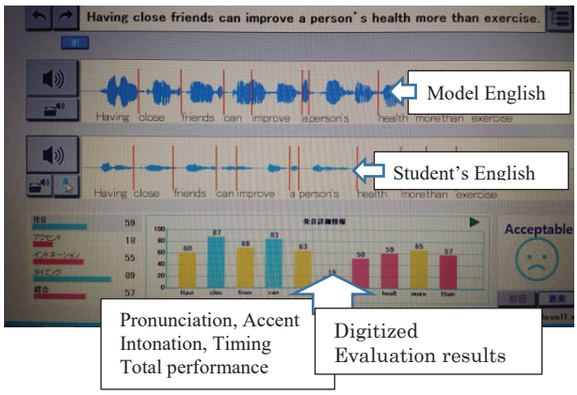

Figure 1: PC Monitor Image of GlobalVoiceCall 2

Group monitoring

Table1: Reading Aloud Rubric

Evaluating point	More than 80%		More than 50%		Less than 50%		Rarely recognized	
English pronunciation of each word in the text	Self-evaluation 1		Self-evaluation 1		Self-evaluation 1		Self-evaluation 1	
	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3
English stress and pitch on words in the text	Self-evaluation 1		Self-evaluation 1		Self-evaluation 1		Self-evaluation 1	
	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3
English intonation on sentences in the text	Self-evaluation 1		Self-evaluation 1		Self-evaluation 1		Self-evaluation 1	
	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3
English meaning chunks in the text	Self-evaluation 1		Self-evaluation 1		Self-evaluation 1		Self-evaluation 1	
	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3
Clear tones and volume for comprehension	Self-evaluation 1		Self-evaluation 1		Self-evaluation 1		Self-evaluation 1	
	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3
Good tempo and speed for comprehension	Self-evaluation 1		Self-evaluation 1		Self-evaluation 1		Self-evaluation 1	
	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3	Peer2	Peer3

In the second semester of 2017, students worked on peer monitoring in groups of three, each of who led a specific role: (1) reader, (2) evaluator, or (3) time keeper. After reading a text out loud in class, every student evaluated his or her own reading using the Reading Aloud Rubric. The first session started with the teacher's cue. The first reading read his or her text aloud twice, then the evaluator evaluated each reading and marked the scores on the Rubric. The time keeper monitored the ending times and recorded the reading speed (word per minute: WPM) on the Rubric. The participants took turns and each took a turn playing each role. Table 1 is the Reading Rubric we used in class. We expected that peer monitoring training would facilitate a competitive spirit among students to read faster and thus anticipated their WPM would improve by the final reading test.

Practical Oral Reading Test

The teacher conducted the oral reading tests to help students recognize that oral reading is an effective way to master the phoneme sounds, phonetic changes, stresses, rhythms, and intonations unique to English (Nakamori 2009). We expected that students would expand their learning aptitude, especially meta-cognition, self-control, and self-efficacy through self-monitoring training practices for better oral reading close to the English models.

For the test, students chose their own reading materials from the previously learned texts. During test time, whenever a student prepared for the test, he or she sat in front of the teacher and started reading English aloud on the teacher's cue. The teacher checked their reading errors while measuring the reading time. The reading performance was conducted in front of the classroom, and other students observed the test performances or practiced their reading with peers until their turns came. The following table shows the reading materials and the number of words in each text.

Table 2：Oral Reading Materials of Departure English Expression Ⅱ Part2

Test Conducting Time	Lesson	Contents	Text Words
The first mid-term May	1	Computerized Society	98
	2	Impression on Japanese	106
	3	Team Hoyt	108
The first final July	4	Kazuo Ishiguro	114
	5	Language Features on Japanese	118
The second mid-term November	6	Pictograms	104
	7	Heart diseases	124
	8	Japanese cultures	113
The second final January	9	Japanese Voting Rights	119
	10	"Silver seats" as Privileged Seats	127

Students learned from their English teacher about difficult pronunciations, important intonation patterns for conveying meanings, and meaningful chunks through Japanese translation handouts distributed and shown to the entire class before the self-monitoring training activity and oral reading tests.

According to Shozu (2015), the ideal oral reading speed in English for Japanese junior high students is 100~120 WPM. Thus, we set a minimum requirement of 60s as the time limit to pass the test for our second-year students, which provides about 30% fewer English lessons* than a typical public high school in japan. Therefore, students who did not feel confident about reading aloud would tended to choose a fewer-word-text to pass the oral reading tests. After the test, the teacher offered feedback on the students' use of prosody, chunks, reading volume, and other features by showing the marked text. The students calculated their reading speed after the test and recorded it in their learning portfolio.

Results and Discussions

Table 3 shows the error variations and the numbers of 170 students on four reading tests in 2017.

Table 3: Total Error numbers of 170 Students' Oral Reading Tests in 2017

Oral Reading Test / Error variations	The first mid-term	The first final	The second mid-term	The second final
phoneme errors ex. our[áuər]➜[óuər] , see[sí:]➜[ʃí:]	107	223	129	150
word's accent errors ex. influence[ínfluəns]➜[ìnflúəns]	23	76	33	38
Intonation errors ex. [A↗,B↗, or C↝]➜[A↝, B↝, or C↝]	42	1	6	2
Meaning chunk errors ex. there / are indirect expressions	12	2	18	2
Non –error-observed performances	48	39	69	54
Self-monitoring style	Individual monitoring with GVC2		Peer Monitoring of Three with Rubric	

The following graph shows the frequency distribution of 170 students' reading speed on four oral reading tests.

In the first semester, students practiced and monitored their oral reading using GVC2, which enabled them to analyze their performance with graphs and scores. Therefore, we anticipated that students would be able to eliminate their reading errors easily and decrease their errors more than the group monitoring activities used in the second semester. However, more errors in phonemes, accents, and intonations were observed than in the second semester. According to Fujita (2010), whose research was conducted on university students, groupmonitoring strategies were positively correlated with active learning and autonomous requests for assistance to peers, rather than to the teacher. Hence, group monitoring practice should have worked on eliminating reading errors more effectively than individual monitoring with GVC2.

As for the peak values of WPM on the four oral reading tests, the second mid-term score was the highest, followed by the first semester final, the first semester mid-term, and the second-semester final. Some students gradually increased their reading speed on each test: however, overall results do not indicate improvement of reading speeds as a whole.

To measure students' learning aptitude, we conducted the Academic Adjustment Inventory (AAI) at the end of April, 2017, before starting the self-monitoring activities, and at the end of January, after finishing the self-monitoring activities of 2017. AAI is a questionnaire method developed by Tasuno (2006) and published by Tosho Bunka to measure student learning aptitude in terms of learning motivation and attitude, learning skills and strategies, learning environments, and the physical and psychological factors interfering with learning. We focused on students' meta-cognition, self-control, and self-efficacy. AAI measured each of these three areas for each student on a scale of 1 (the lowest score) to 5 (the highest score). The following graphs compare the frequency of each score before and after the self-monitoring training activity.

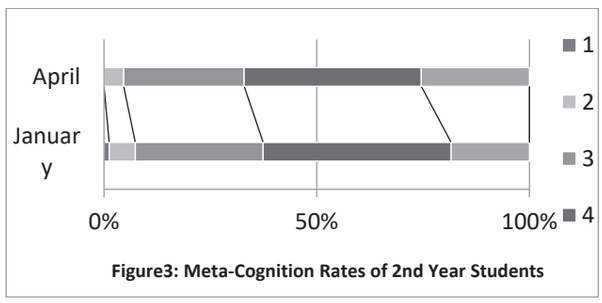

Figure3: Meta-Cognition Rates of 2nd Year Students

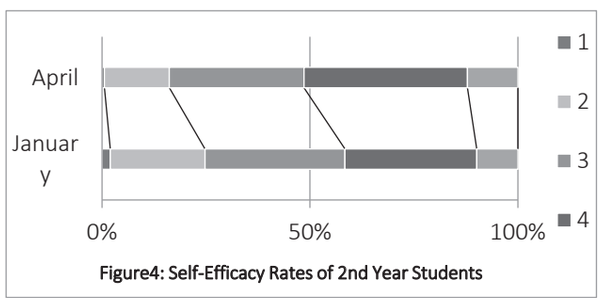

Figure4: Self-Efficacy Rates of 2nd Year Students

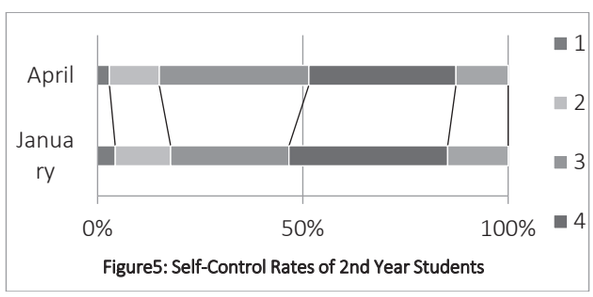

Figure5: Self-Control Rates of 2nd Year Students

There were fewer scored of 4 and 5 in meta-cognition (Figure 3) and self-efficacy (Figure 4) in January than in April; however, high scored for self-control (Figure 5) slightly increased in January. AAI defines self-efficacy as the power of believe in oneself, meta-cognition as self-awareness or the ability to review oneself, and self-control is self-sustainability. The overall procedure of oral reading, self-monitoring, and the oral reading test might have been effective for fostering students' self-

control, but ineffective for building meta-cognition and self-efficacy.

Next Steps

To foster students' learning autonomy to improve their oral reading skills with self-monitoring practices in and after class, their meta-cognition and self-efficacy should be developed along with their self-control in class. According to Ikebe & Mikuni (2014), self-efficacy is the potential for self-accomplishment, which means an anticipation of rather than execution of an action. Fujita (2010) described monitoring strategies as corresponding to meta-cognition that relates to one's acts of procrastination. Maeda (2015) noted that, in English learning, autonomy and self-confidence have the strongest connection with learning outcomes, followed by metacognitive awareness and cooperation. Thus, eagerness has no correlation with learning outcomes. Hence, in the next fiscal year, in addition to self-monitoring training practices, oral reading materials that promote anticipation of better reading among students should be provided with practical deadlines to control procrastination.

Onodera (2015) argued that Japanese students need to practice English articulation mechanisms regularly by training themselves in the correct tongue and tooth positions, lip movements, and breath control skills to pronounce the seven vowels and 25 consonants accurately. However, while it is difficult to practice all the above, Japanese students can still acquire to a certain extent of English pronunciation skills by learning to discriminate similar sounds clearly, such as the five vowels [ʌ /æ/ ə/ɑ/ ɔ], or consonants [r / l], [θ/ð], [s / ʃ] and pronouncing fricative sounds [f / v] repetitively. We will introduce pronunciation drills which help students connect English letters with phonetic symbols directly in oral reading practices.

In oral reading training activities, we should follow the chorus reading training procedure suggested by Yamaguchi, et. al (2014), which comprises practicing reading English chunks aloud from a computer screen with the reading speed controlled and displayed on the screen to improved reading speed. In particular, we should keep in mind that the phonological loop comprises a temporary phonological store in which auditory memory traces decay over a period of a few seconds (Baddeley, 2000), and the auditory memory limitation as "7±2 morae" (Miller 1956, Kohno 1998). Thus, following the observation by Yasuki (2009) that practicing at slow speeds leads to difficulties keeping English syllables in working memory and thus hinders memorization, we should limit the chorus reading speed and self-practices speed to less than 2 s per chunk. Furthermore, as Ogiwara (2013) proposed, weak forms of English phonetic features should be enforced by helping students practice English prosody within the time span of 2 s, trying not to read English with Japanese morae.

Suzuki at al. (2016) recommended speed dictation, overlapping, and shadowing for activating listening practice in class. According to Oki & Izumi (2015), students feel shadowing is more difficult than speed dictation. Therefore, speed dictation should be conducted before overlapping and shadowing. As Hamada (2015) argued, shadowing practice strongly affects student self-confidence and motivation. Providing a learning material appropriate for students' proficiency levels helps students feel at ease with shadowing and helps cultivate positive attitudes toward oral reading and self-monitoring practices. Maheiu (2015) proposed numerous suggestions on shadowing, such as letting students choose either a slow mode (120WPM) or normal mode (150WPM) of model English, clarifying the practice goal, recording the shadowing for self-evaluation of their performance by the checkpoint method, and content-shadowing (to deliver the meaning through shadowing to a partner with eye-contact). We would like to put those points into practice for improving students' active oral reading and autonomous self-monitoring attitudes both in and out of English class.

Summary

This paper investigates whether students' oral reading and self-monitoring training activities improve their reading skills and their learning aptitude. We found the group monitoring activity was effective for eliminating reading errors but had no effect on oral reading speed. The number highly self-controlled students increased but numbers of those with high meta-cognition and self-efficacy rates were reduced at the end of the year. Shinogaya (2012) argued that Japanese educational discussion has not focused enough on how a teacher's specific background, such "how to teach" interacts with learners' specific backgrounds, such as "how to learn." We would like to pursue this research direction to cultivate Japanese students' autonomous self-learning attitudes through English monitoring training activities to bring about a new consistency between the teaching and learning strategies.

Notes*

On the basis of the recommended curriculum provided by the Ministry of Education, Culture, Sports, Science and Technology, high schools should offer students 175 h of English instruction per year, which means 350 h in two years and 525 h in three years. However, our school is allowed to provide 150 h in the first year, 270 h in two years, and 360 h of English instruction by the end of the third year. Even though we have a five-year curriculum, this provides 450 h of English instruction in total, which is still 85% of the total hours of typical high school English instruction. (http://www.mext. go.jp/)

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Additional Statement

This research was approved as making adequate provisions for the safety and privacy of participants by the Life Ethics Committee of NIT, Hakodate Collage.

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DEVELOPMENT OF NEURAL NETWORK EXPERIMENT USING FOOD TEXTURE ESTIMATION

S. Kato* and N. Wada

National Institute of Technology, Niihama Collage, Japan

* skatou@ele.niihama-nct.ac.jp

Abstract

This paper describes an experiment for students in an electrical and information engineering course in order to learn an application of neural network model. The input to the neural network model is parameters in the load and the sound which occur when a vegetable is probed by an equipment. The output is the numerical value ranged [0,1]. The value means strength level of food texture words such as "munching-ness" or "crunchiness". The equipment originally has been developed in order to examine textures of the vegetables in our previous study. The equipment mainly consists of an air cylinder, a sharp metal probe, a sound sensor and a load sensor. The probe is attached on the tip of the rod of the air cylinder. The probe is moved down by the cylinder to cut the vegetable. The vegetable is put on the load sensor. The electrical signals in the sound and the load are recorded simultaneously. The signal data is preserved in PC. The proposed experiment is divided into several steps. Firstly, the students have to make about 20 vegetable samples such as a cucumber and a radish. These samples are made in which the students cut the vegetables in the same size by using a knife and a ruler. Secondly, they have to learn the structure and usage of the equipment. Thirdly, they will carry out an experiment to obtain the sound and the load data of the vegetable samples by using the equipment. They have to memorize the temperature, the humidity, the size of the samples, the sampling rate, the range of the amplifiers, the cylinder air pressure and so on. After the data of all the vegetable samples is acquired in the experiment, they must make a program to analyse the acquired data and construct the neural network model to estimate the textures. The training data is numerical value of the textures such as "munching-ness" and "crunchiness". They have to determine the appropriate value of the texture of the cucumber and the radish by tasting them. After training the neural network model, they should confirm whether the moderate output is obtained when the test sample data is inputted.

Keywords: *neural network, food texture, human sensibility, artificial intelligent, soft computing*

Introduction

The feedforward artificial neural network model has been employed in many practical problems using the back propagation algorithm proposed by Rumelhart (1986). In recent year, the neural network model is recognized as effective AI technology. Especially the convolutional neural network (CNN) is recognized as the effective method in the image recognition proposed by LeCun (1998). The soft computing including the neural network also has been applied to engineering design which involves human feelings (Nagamachi, 1995). We have realized the texture estimation system (Kato & Wada, 2018) using soft computing such as neural network and fuzzy logic (Zadeh, 1965). This paper proposes an engineering experiment applying typical neural network model to human sensibility such as food texture.

As shown in Fig.1, the vegetable such as a cucumber is cut by the probe of the proposed original equipment. The sound and the load signal are observed by the sensors and the sensed signals are amplified. The amplified signals are fetched and transferred to PC. The parameters in the signal are converted to parameters W1~W5 in the load and F1~F5 in the sound, which are the input of the neural network model. The model outputs the texture level ranged [0,1] of "munching-ness" and "crunchiness".

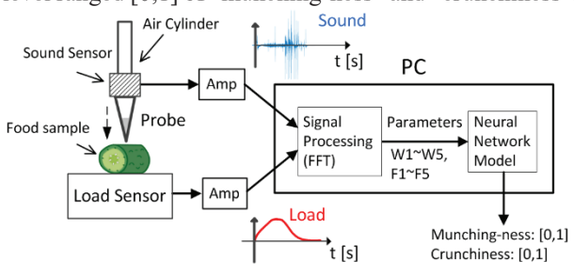


Figure 1 The proposed experiment system.

The students are required to perform following tasks.

(a) The students have to make about 20 vegetable samples such as a cucumber and a radish. The samples are made in which the students cut the vegetables in the same size by using a knife and a ruler.

(b) The students have to learn the usage of the equipment such as the air compressor, the air regulator, the air valve, the signal amplifier and the

data acquisition device, in order to accumulate the load and the sound signal data in the *data store* for all vegetable samples. The students have to carry out an experiment to obtain the sound and the load signal data of each sample by using the equipment. The data of each sample is saved in the *data store*. In addition, they have to memorize the temperature, the humidity, the sizes of the samples, the sampling rate, the range of the amplifiers, the cylinder air pressure and so on.

(c) After the data of all vegetable samples is saved in the *data store* in the above experiment, they must make a computer program to analyse the signal data and calculate parameters W1~W5 and F1~F5, which are the input of the neural network model.

(d) The students program the neural network model to estimate the textures. The training data is the numerical value of the textures such as "munching-ness" and "crunchiness". They have to determine the appropriate value of the texture of the cucumbers and radishes by tasting them. After they implement the training of the neural network model, they should confirm whether the moderate output is obtained when the test sample data is inputted. The test result is accumulated in the *estimation result data store*.

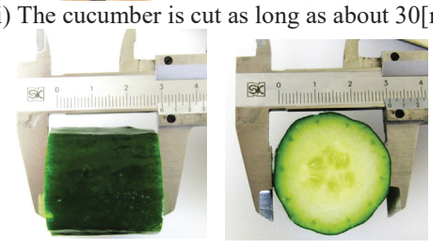
The idea of the proposed experiment is derived from a graduation research in the last year i.e. 2017. We gave a theme of the research to a student who was fifth grade in the Niihama Collage, National Institute of Technology. We taught him the mechanism of the neural network model. He learned the usage of our equipment and engaged in the given study with interest. He carried out the experiment to obtain the data of the vegetables. We conceived of an idea to design the engineering experiment in which the student can experience our research. In the presented paper, the experiment is performed by a teacher in our collage in order to confirm the reproducibility and to show the reliability of our proposed experiment. In following section, the detail in the performed experiment is described.

(a) Preparation of Vegetable Samples

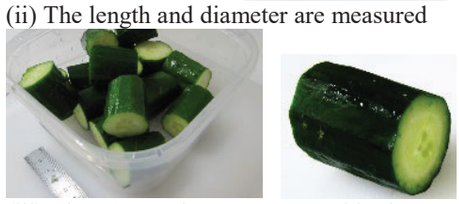
We regard the cucumbers and the radishes as food samples. Because these vegetables are easy to be processed in the same size and form. The students have to cut the cucumber using a knife as shown in Figure 2. The cucumbers are cut as long as about 30 [mm]. The diameters are between 24 and 31 [mm]. Twenty cucumber samples are prepared and preserved in the container and stored in the refrigerator. The process of the radish samples is shown in Figure 3. The radish is cut as long as about 30 [mm] and stamped out with the diameter 30 [mm]. The twenty radish samples are prepared and preserved in the container and stored in the refrigerator. Table 1 shows the summary in the samples. The cucumbers are numbered from 1 to 20 and the radishes are numbered from 21 to 40 in this paper. The students have to comprehend the importance to take information of the samples in their note books.



(i) The cucumber is cut as long as about 30[mm]

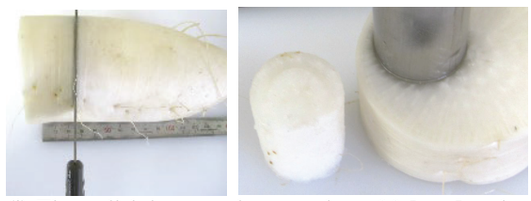


(ii) The length and diameter are measured

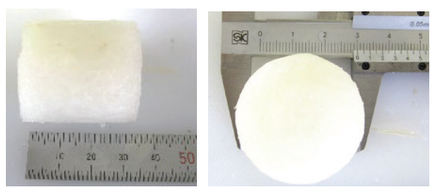


(iii) The 20 samples are preserved in the container

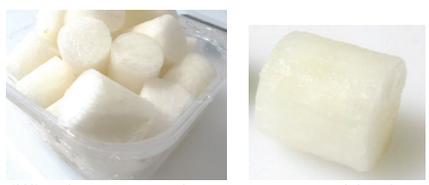
Figure 2 The process producing cucumber samples



(i) The radish is cut as long as about 30 [mm] and stamped out with the diameter 30 [mm]



(ii) The length and diameter are measured



(iii) The 20 samples are preserved in the container

Figure 3 The process producing the radish samples

Table 1 The details of samples

	Cucumber	Radish
Length [mm]	approx. 30	approx. 30
Diameter [mm]	24 ~ 31	30
Number	20 (No.1~20)	20 (No.21~40)

(b) Understanding the usage of the equipment and data acquisition

It is assumed that the students use the equipment shown in Figure 4 in order to obtain the data to infer the texture level of the sample. There is the sound sensor on the metal probe and the load sensor under the food sample such as the cucumber as shown in Figure 4. The equipment can measure the sound and the load simultaneously while the sharp metal probe is stabbing the food when the rod of the cylinder moves down. The air pressure is controlled by the hand valve and regulator shown in Figure 4. The students can set the required air pressure of the air cylinder manually using the air regulator.

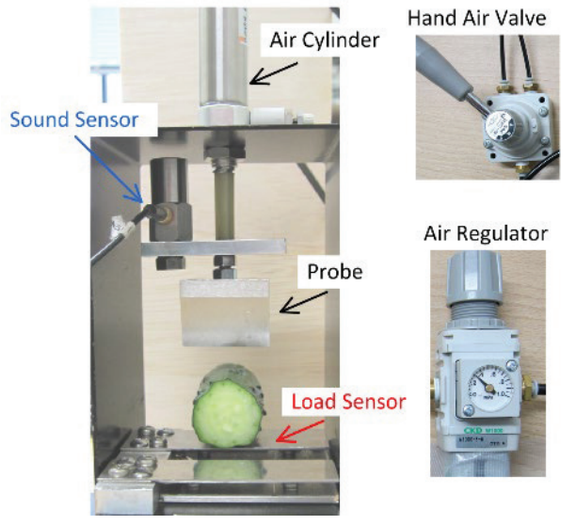


Figure 4 The picture of the equipment

The experiment is carried out under the condition shown in Table 2. Figure 5 shows the pictures when the samples are probed. The students should put the sample in an appropriate place so that the centre of the sample is cut with the probe in every trial. The sampling rate is 25[kS/s] and the period is 10 [s].

Table 2 The condition of the experiment

Condition item	Value / Condition
Cylinder air pressure	0.3 [MPa]
Temperature	27 [deg C]
Humidity	66 [%]
Weather	Clouding

Finally, the data of the 20 cucumber samples and the 20 radish samples is obtained in our implementation and preserved in the *data store*. We should make a manual to use the equipment in the future.

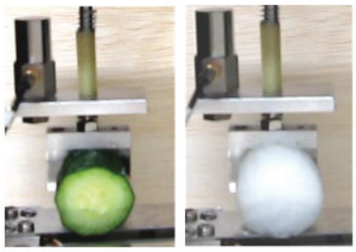


Figure 5 The moment when the samples are probed

(c) Analysis of the data in the *data store* and calculate the parameters

Figure 6 shows the result of the cucumber (sample No.1) in the *data store*. The top graph illustrates the curb of the load with a red line and the sound with a blue line. The middle graph shows signals for 4 [s] time period which is automatically extracted by considering the maximum load point. The start point of the period is when the probe begins to touch the sample. The extraction method is explained in our previous paper (Kato & Wada, 2018).

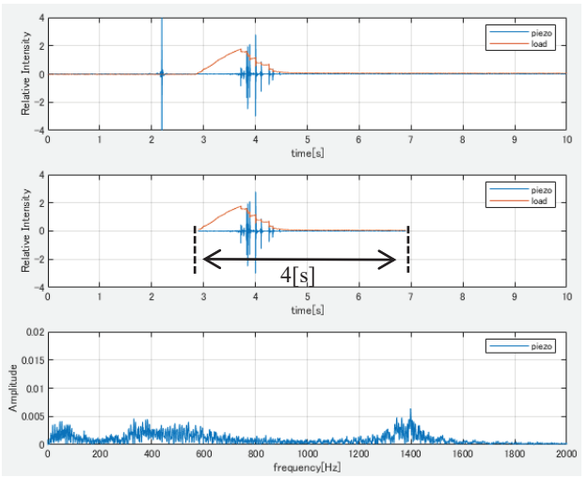


Figure 6 The load and the sound of the cucumber (No.1)

It is found that the small sound occurs while the probe starts to cut inside the sample. On the other hand, when the probe cuts off the sample, the loud sound occurs. The bottom graph shows the FFT result of the sound signal which is extracted for 4 [s] time period. The students have to make the program to show the graphs from the obtained data. They have to comprehend the signal processing such as the FFT through the programming.

Figure 7 shows the result of the radish in the *data store*. It is found that the radish is hard to cut compared with Figure 6. The students will understand that the sound of the cucumber and radish are not same because the FFT results have the different characteristic.

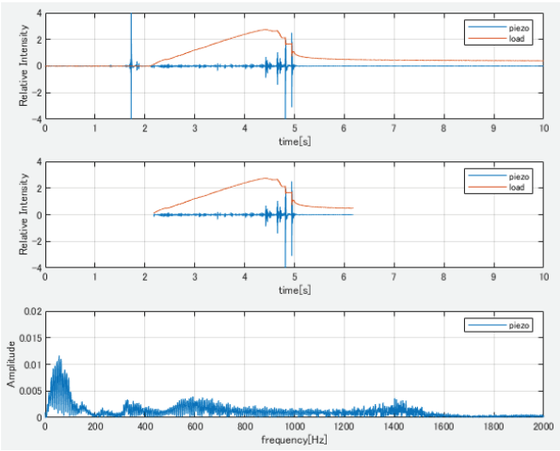


Figure 7 The load and the sound of the radish (No.21)

The extracted 4 [s] load curb is divided into five sections as shown in Figure 8. The parameters in the load W1~W5 are calculated as follows.

(1) W1 is the average of the load from 0 [s] to 0.8 [s].
(2) W2 is the average from 0.8 [s] to 1.6 [s].
(3) W3 is the average from 1.6 [s] to 2.4 [s].
(4) W4 is the average from 2.4 [s] to 3.2 [s].
(5) W5 is the average from 3.2 [s] to 4.0 [s].

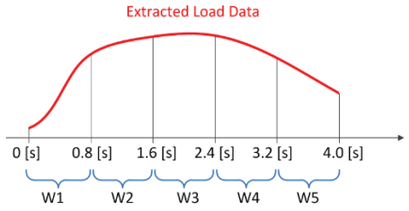


Figure 8 The calculation of W1 ~ W5

The extracted sound data for 4 [s] is converted by the FFT (Fast Fourier Transform). The FFT result between 1[Hz] to 2000[Hz] are divided into five sections as shown in Figure 9. The parameters in the sound F1~F5 are calculated as follows.

(1) F1 is the summation from 1 [Hz] to 400 [Hz].
(2) F2 is the summation from 400 [Hz] to 800 [Hz].
(3) F3 is the summation from 800 [Hz] to 1200 [Hz].
(4) F4 is the summation from 1200 [Hz] to 1600 [Hz].
(5) F5 is the summation from 1600 [Hz] to 2000 [Hz].

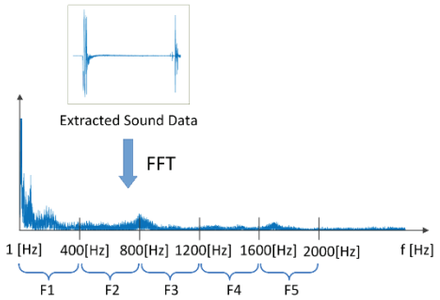


Figure 9 The calculation of F1 ~ F5

The W and F are the inputs of the neural network model. Table 3 and 4 show the average and STD (Standard Deviation) of W and F of the cucumber and radish samples, respectively. Figure 10 and 11 show the graphs of Table 3. Figure 12 and 13 show the graphs of Table 4.

Table 3 Average of W and F in cucumber samples

	W1	W2	W3	W4	W5
Average	0.769	1.29	0.496	0.202	0.178
STD	0.203	0.579	0.452	0.147	0.129
	F1	F2	F3	F4	F5
Average	4.67	1.99	0.99	2.04	0.454
STD	2.17	0.364	0.216	0.613	0.128

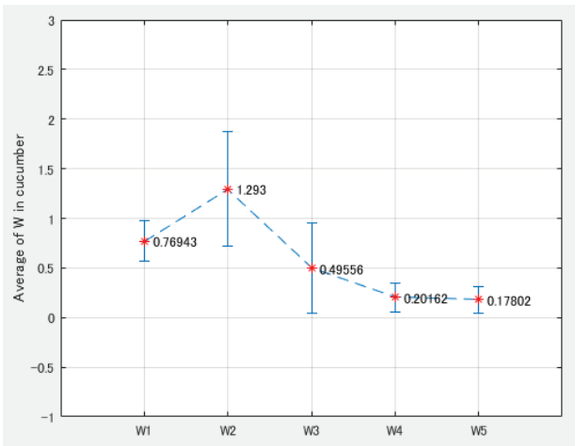


Figure 10 The average of W (cucumber)

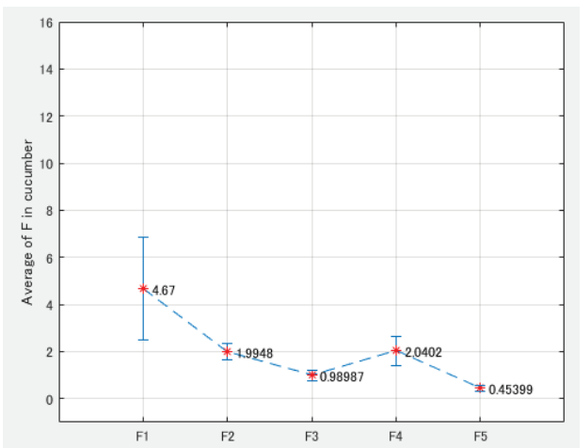


Figure 11 The average of F (cucumber)

The parameters W1~W5 and F1~F5 have dispersion as the STD values show. The sizes, the forms and the fibre densities of the samples are slightly different even in the same samples. It is found that the averages of W2 is the highest in the cucumbers among W1~W5.

Table 4 The average of W and F in the radish samples

	W1	W2	W3	W4	W5
Average	0.714	1.83	2.11	0.692	0.495
STD	0.212	0.536	0.821	0.927	1.03
	F1	F2	F3	F4	F5
Average	9.57	1.85	1.09	2.15	0.405
STD	5.23	0.87	0.584	0.85	0.138

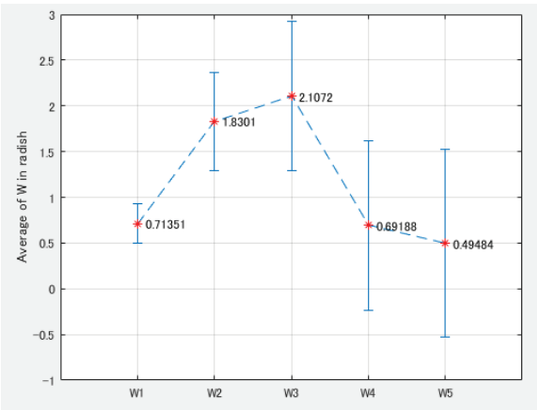


Figure 12 The average of W (radish)

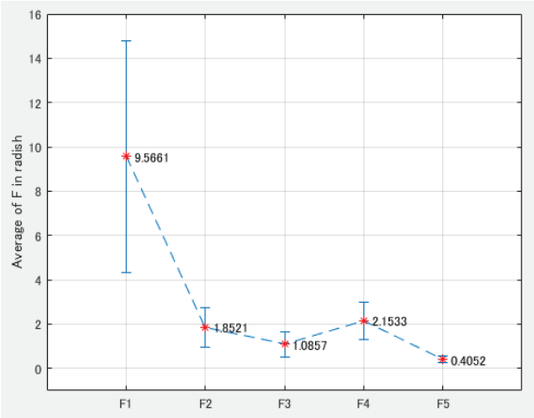


Figure 13 The average of F (radish)

It is found that W3 is the highest in the radishes among W1~W5. The dispersion of F1 is high in both of the cucumber and the radish.

(d) The neural network model for the estimation of the texture of vegetables

The value of the textures "munching-ness" and "crunchiness" of all the samples will be determined by the students who will eat the samples. In this implementation it is assumed that the texture values are given as shown in Table 5.

Table 5 The texture value of all the samples

	Cucumber	Radish
Munching-ness	1.0	0.7
Crunchiness	0.7	1.0
Sample number	1~20	21~40

The texture "munching" sounds like "boliboli" and "crunchy" sounds like "kalikali". Since the cucumber has the peel, the cucumber can be munching. On the other hand, the radish is considered crunchier than the cucumber. The neural network model for the estimation of the textures is constructed as shown in Figure 14.

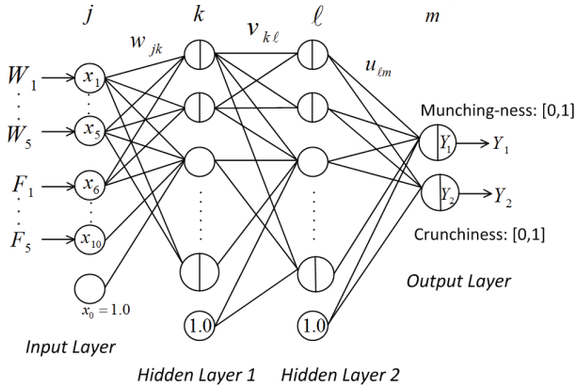


Figure 14 The neural network model for estimating the food texture

The model is the typical feedforward neural network. The input layer consists of 10 nodes for W1~W5 and F1~F5, and one bias node. W1~W5 and F1~F5 are normalized in [0,1]. The hidden layer 1 and 2 consist of 10 nodes and one bias node, respectively. The output layer consists of two nodes expressing the degree [0,1] of "munching-ness" and "crunchiness". The transitional function of the hidden layer 1, 2 and output layer are the sigmoid function. The detail is described in the previous paper (Kato & Wada, 2018).

Only one sample out of 40 is selected for testing the trained neural network model. The rest 39 samples are used for training. The training and the test are carried out as follows:

Step 0: $i \leftarrow 1$

Step 1: Select i-th sample data out of 40 samples

Step 2: Prepare following the 39 train input vectors except i-th data

$$X_{train}^{(n)} = \begin{bmatrix} W_1^{(n)} \\ \vdots \\ W_5^{(n)} \\ F_1^{(n)} \\ \vdots \\ F_5^{(n)} \end{bmatrix} \quad \text{for } n = 1, 2, \cdots, 39 .$$

Step 3: Prepare following the 39 correct output vectors

$$Y_{train}^{(n)} = \begin{bmatrix} Y_1^{(n)} \\ Y_2^{(n)} \end{bmatrix} \quad \text{for } n = 1, 2, \cdots, 39 .$$

where, when n is the sample data of cucumber $Y_{train}^{(n)} = \begin{bmatrix} 1.0 \\ 0.7 \end{bmatrix}$ is assigned, otherwise $Y_{train}^{(n)} = \begin{bmatrix} 0.7 \\ 1.0 \end{bmatrix}$ is assigned. These values are accordance with Table 5.

Step 4: Initiate the connection weights w, v and u. Train the neural network model by the back-propagation algorithm. The training process is carried out by adjusting the connection weights w, v and u so that $Y_{train}^{(n)}$ is outputted when corresponding $X_{train}^{(n)}$ is inputted.

There, the iteration to train the network is 30 epochs. It is necessary to observe whether the error declines as the epoch proceeds.

Step 5: Input W1~W5 and F1~F5 of *i*-th sample data into the neural network model trained in **Step 4.** The output vector is registered in the *estimation result data store*. When $i = 40$ the routine is completed, otherwise $i \leftarrow i + 1$ and go to **Step1**.

Table 6 shows the average and STD of the *estimation result data store*. Although the sample data not used for training is inputted to the neural network model, the model outputs generally moderate texture values.

Table 6 Summary of the *estimation result data store*

	Cucumber (No.1~20)	Radish (No.21~40)
Mean of Munching-ness	0.978	0.736
STD	0.0579	0.158
Mean of Crunchiness	0.715	0.948
STD	0.0873	0.113

Regarding the result of this implementation, it is found that the neural network model estimates the expected textures almost correctly, even though the W1~W5 and F1~F5 have the dispersion. Figure 15 shows the *estimation result data store*. The asterisk shows the estimated texture value for each sample.

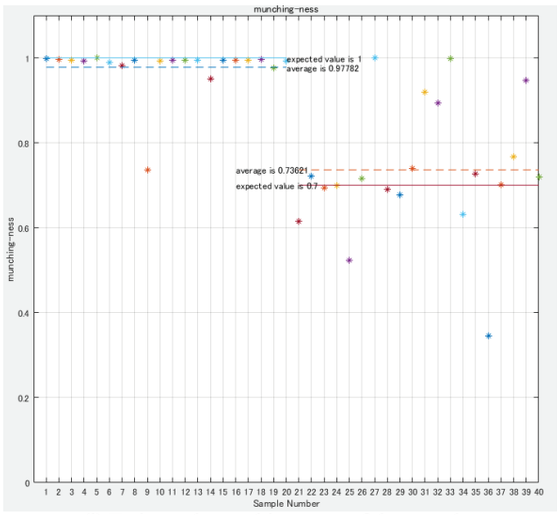
Our implementation shows the possibility of the realization of the proposed students' experiment.

Result and discussion

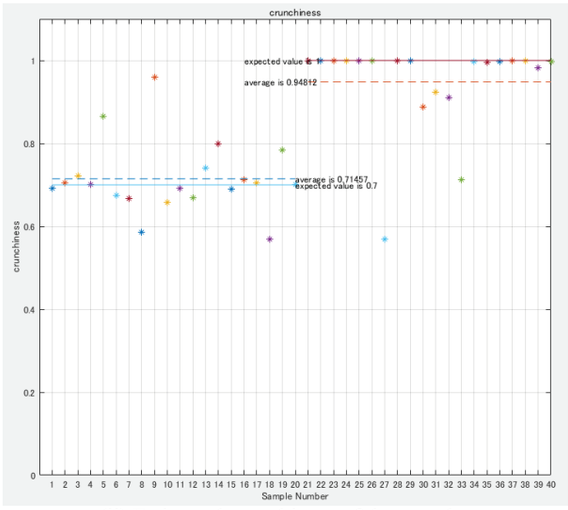
The students can experience various topics from producing the vegetable samples to programing. In the data acquisition task, they have to understand the mechanical structure of the equipment and electrical mechanism of the sensors and amplifiers. In the programing task, they have to make the graphs representing the signal data. They have to learn the FFT. In addition, they will recognize the dispersion among the samples. After the neural network model implementation, they will recognize the flexibility of the neural network model. The model can infer moderate texture value after training.

Conclusions

This paper proposed the experiment which includes the sample production, the equipment manipulation, the data acquisition, the sensory test for the food texture, the data analysis and the modelling of the neural network. Through all the experiences, the students will recognize the essential sensibility for the research. In the future, we will realize the proposed student experiment environment by making the manual.



(i) Estimated munching-ness of the samples



(ii) Estimated crunchiness of the samples

Figure 15 The graphs of the *estimation result data store*

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ENHANCING INTRINSIC MOTIVATION IN AN ENGINEERING MODULE - AN EVIDENCE-BASED APPROACH

Mark Wan* and Chong Siew Kee**

Singapore Polytechnic, Singapore

*mark_wan@sp.edu.sg; **chong_siew_kee@sp.edu.sg

Abstract

This paper documents part of a government funded research project, conducted at Singapore Polytechnic, in which an Evidence-Based Teaching (EBT) approach was employed to enhance students' intrinsic motivation (IM). The aim of the research was to explore in depth, over a significant time period, how students perceived and experienced various aspects of their teacher's instructional strategy and communication style, and its impact on intrinsic motivation and learning. The wider research encompassed 7 case studies in which academic teaching faculty systematically infused EBT practices and principles into their lesson planning and teaching for a sustained period of time – one full term of a 14-week module. The authors are an academic teaching faculty, who taught an engineering module as one of these cases, and an educational technologist. This research built upon on a previous 3-year research project in which EBT was applied to the design and facilitation of flipped classroom learning. The results of which have been presented and published elsewhere. The findings found that EBT was potentially impactful both in terms of attainment levels and the student's learning experience. Of particular significance, it established EBT as a pedagogically sound theoretical base for selecting and combining technology tools into a blended (e.g., flipped classroom) instructional strategy. In this research the focus was on ascertaining the impact of EBT, calibrated to an Autonomy Supportive teaching style (Reeve, 2015), on the student learning experience in terms of engagement (e.g., behavioral, cognitive, emotional, agentic), interest, and self-efficacy. The research employed a range of quantitative and qualitative methods. A quantitative-based student survey, administered prior and post the intervention, comprising items across a range of EBT practices and IM principles, provided measures of students perceptual change over the duration of the intervention. Qualitative methods, including focus group interviews, 'student co-participants' (volunteers from the class who were interested and prepared to provide ongoing feedback to the research team) and evidence-based reflective practice, facilitated the intended in-depth analysis necessary to identify, unpack and make sense of components of the students subjective experience. The research findings strongly support the use of EBT practices and IM principles as a sound pedagogical framework for enhancing many aspects of the student learning experience. This contributes to the challenge of providing high impact learning (both in terms of attainment opportunities and intrinsic motivation) for students through utilizing our enhanced understanding of human learning, what teaching methods work best, and leveraging on technology affordances.

Keywords: *intrinsic motivation, autonomy supporting style, flipped classroom learning, evidence-based reflective practice*

Introduction

This paper is part of an ongoing government funded research project, conducted at Singapore Polytechnic, in which an Evidence-Based Teaching (EBT) approach was employed to enhance students' intrinsic motivation.

The aim of the research was to explore in depth, over a significant time period, how students perceived and experienced various aspects of their teacher's instructional strategy and communication style, and its impact on intrinsic motivation and learning. The wider research encompassed 7 case studies in which academic teaching faculty systematically infused EBT practices and principles into their lesson planning and teaching for a full module of 15 weeks duration.

The paper documents the experience of the authors for one of the cases involved in the project, illustrating the approach and methodology involved, and the specific findings for this research component.

Motivating Students

Motivation is recognized as fundamental to learning, but there is much debate about how it works and, more significantly, how teaching professionals can harness such human energy in the pursuit of educationally desired learning goals. While there is much by way of models and theories of human motivation in the literature (e.g., Maslow, 1962; Herzberg, 1966; Deci and Ryan, 2002; Dweck, 2006), the famous management guru Peter Drucker made a damning assertion:

> We know nothing about motivation. All we can do is write books about it.

Furthermore, it seems that that student motivation is far from prevalent in many educational contexts. As Levin (2008) concluded:

> …boredom and lack of engagement remain endemic in schools around the world, and seemingly unmotivated students are a main complaint of teachers. (p. 99)

Certainly, whatever the underpinning bases of human motivation entail, especially in the context of the school environment, there seems to be a real problem which has not been sufficiently addressed to date. For example, Wagner (2010) made the point that:

> In countless focus groups I've conducted with high school students, "boring classes"- which include so-called advanced classes – are among the main complaints about school. (p. 114)

Towards an Evidence-Based Teaching Approach

It is now firmly established that there are sound evidence bases relating to how best to design and facilitate the various practices we call *teaching* that, when thoughtfully applied, can significantly enhance student learning opportunities and attainment levels. This change is an inevitable result of our increasing knowledge relating to how humans learn, what teaching methods and practices work best, and why. Such research is well documented in the literature (e.g., Bransford, 1999; Marzano, 2007; Mayer & Alexander, 2010; Hattie & Yates, 2014; Sale, 2015). Collectively it provides an increasing Evidence-Based Teaching (EBT) approach for the design and facilitation of learning experiences. We can now start to talk about professional practices in teaching from a more validated empirical base, which is typical for more established professions (e.g., medicine and engineering). As Darling-Hammond & Bransford (2005), from surveying the research findings, concluded:

> There are systematic and principled aspects of effective teaching, and there is a base of verifiable evidence of knowledge that supports that work in the sense that it is like engineering or medicine. (p. 12)

EBT constitutes an emerging 'science of learning' or what Sale (2015) refers to as *Pedagogic Literacy*. A major focus of EBT is on what Willingham (2009) identifies as 'Cognitive Scientific Principles'. These are universal ways in which the human brain takes in, processes and uses information to learn effectively. Willingham's (2009) uses an analogy with engineering to illustrate how this works in practice:

> Principles of physics do not prescribe for a civil engineer exactly how to build a bridge, but they do let him predict how it is likely to perform if he builds it. Similarly, cognitive scientific principles do not prescribe how to teach, but they can help you predict how much your students are likely to learn. If you follow these principles, you maximize the chances that your students will flourish. (p. 165)

In the book 'Creative Teaching: An Evidence-Based Approach', Sale (2015) outlined and illustrated 10 cognitive scientific principles (Core Principles of Learning) that underpin effective learning design and teaching. Furthermore, while each Core Principle of Learning focuses attention on a key area or process relating to how humans learn and the specific implications for planning instruction, they are not discrete or separate in that they should be considered independently of each other. In fact, they are mutually supporting, interdependent and potentially highly synergistic. As Stigler & Hiebert (1999) highlighted:

> Teaching is a *system*. It is not a loose mixture of individual features thrown together by the teacher. It works more like a machine, with the parts operating together and reinforcing one another, driving the vehicle forward. (p. 75)

For brevity in this context, the 10 Core Principles of Learning are only listed (the interested reader can refer to the original text for extended explanation and illustration):

1. Motivational strategies are incorporated into the design of learning experiences
2. Learning goals, objectives and proficiency expectations are clearly visible to learners
3. Learners prior knowledge is activated and connected to new learning
4. Learning is enhanced through multiple methods and presentation modes that engage the range of senses
5. Content is organized around key concepts and principles that are fundamental to understanding the structure of a subject
6. Good thinking promotes the building of understanding
7. Learning design utilizes the working of memory systems
8. The development of expertise requires deliberate practice
9. Assessment is integrated into the learning design to provide quality feedback
10. A psychological climate is created which is success orientated and fun

Another major focus of EBT owes much to Hattie's definitive work in the book 'Visible Learning' (2009). He synthesized over 800 meta-analyses of the influences on learning and was particularly interested

not just in what factors impacted learning, but the extent of their impact - referred to as *Effect-Size*. Effect size is a way to measure the effectiveness of a particular intervention to ascertain a measure of both the *improvement* (gain) in learner achievement for a group of learners and the *variation* of learner performances expressed on a standardized scale. By taking into account both *improvement* and *variation* it provides information to which interventions are worth having.

Hattie firstly identified the typical effect sizes of schooling without specific interventions, for example, what gains in attainment are we likely to expect over a one-year academic cycle? Typically, for students moving from one year to the next, the average effect size across all students is 0.4. Hence, for Hattie, effect sizes above 0.4 are of particular interest. As a baseline an effect size of 1.0 is massive and is typically associated with:

- Advancing the learner's achievement by one year
- Improving the rate of learning by 50%
- A two grade leap in GCSE grades

Table 1 illustrates some high effect strategies/methods from Hattie's Meta-analysis.

Table 1: Examples of Strategy/Method Effect Sizes on Learner Attainment

Influence	Mean effect size
Formative Evaluation to teachers This is where teachers take action to get feedback on their teaching and act on it	0.90
Whole-class interactive teaching (including Direct instruction) A specific approach to active learning in class, which is highly teacher led, but very active for students. This involves summaries reviews and a range of active learning methods, including questioning	0.81
Feedback Students getting feedback on their work from the teacher, peers, self or others.	0.73
Teacher - Student Relationships Building rapport and trust and positive expectations	0.72
Metacognitive Strategies Explicit teaching and use of metacognitive strategies (e.g., conscious planning, monitoring and evaluating of thinking and learning)	0.69
Challenging goals for students Goals that students can meet through effort on their part – specific as possible; meaningful to the students involved	0.56
Advance Organizers Giving students a summary in advance and a purpose for the learning	0.41

However, as Hattie notes, it is important to balance effect size with the level of difficulty of interventions. For example, providing 'advance organizers' (summaries in advance of the teaching) have an effect size of 0.41, which is pretty average, but they only take up a few minutes at the beginning of the lesson, and potentially offer the equivalent of moving up a year in terms of a student's achievement.

Similarly, it is not just the effect size of one intervention that is important, but how a number of effective methods can be strategically and creatively combined to produce powerful instructional strategies that significantly impact student attainment. As Hattie (2009) pointed out:

> …some effect sizes are 'Russian dolls' containing more than one strategy. For example, 'Feedback' requires that the student has been given a goal, and completed an activity for which the feedback is to be given; 'whole-class interactive teaching' is a strategy that includes 'advance organizers' and feedback and reviews. (p. 62)

Finally, in this context, teaching is much more than a technical design activity, but is both an interpersonal and highly ethical activity. As Rogers (1995) argues:

> ...the facilitation of significant learning rests upon certain attitudinal components that exist in the personal relationship between the facilitator and the learner. (p. 230)

Similarly, as Liston and Zeichner (1990), drawing on the arguments of Macmillan, suggest:

> Honesty and trust are inherent in the activity of teaching, irrespective of context or time...Teaching is also an activity in which just relations should predominate. (p. 236)

Approach

The research approach adopted an Autonomy Supporting Style (ASS) as an explicit communication approach in the facilitation of learning (Reeve, 2015). This is consistent with a range of EBT practices and principles, reflected in the high Effect Size of Teacher – Student Relationships (0.72), as it is essentially concerned with building rapport, trust and positive expectations. Reeve (2015) defined Autonomy Support as:

> …a coherent cluster of supervisory behaviours that collectively create the interpersonal tone of support and understanding (p. 407)

Such behaviours conducive to establish this interpersonal tone of support and understanding include:

- Using informational, non-controlling language
- Communicating the purpose/value of the learning (e.g., explanatory rationales)
- Acknowledge and accept students' expressions of negative effect
- Listen to students, and encourage them to ask questions
- Allow students choices / preferences wherever possible on how they learn and the context of learning

Methodology

The research adopted the use of EBT, customized to the content of the module, learning outcomes, learning outcomes, student profile and the situated context. A key focus of the research was to ascertain the impact of EBT (including ASS) on the student learning experience in terms of engagement as framed by Reeve (2013) (i.e.,

behavioural, emotional, cognitive and agentic), interest, and self-efficacy.

The research employed a range of quantitative and qualitative methods. A quantitative-based student survey, administered prior and post the intervention, comprising items across a range of EBT practices and principles provided measures of students' perceptual change over the duration of the intervention. (See Appendix 1: Questionnaires)

Qualitative methods, including focus group interviews, 'student co-participants' (volunteers from the class who were interested and prepared to provide ongoing feedback to the research team) and evidence-based reflective practice, facilitated the intended in-depth analysis necessary to identify, unpack and make sense of components of the students subjective experience.

Of particularly significance in this research was the use of students as "Co-participants" (Lincoln, 1990, p. 78) in the research process. These were student volunteers from each class who expressed an interested in the research and what it might produce, as well as committing to provide regular feedback on their and fellow students experiences through regular (usually every 3-4 weeks) meetings with a member of the research team and situationally (e.g., whenever a new experience or perception came to mind relating to the research purpose) thorough a designated WhatsApp group, which was the preferred mode for students.

Implementation

The research was conducted in 2017/2018 semester 2 (16 Oct 2017 to 15 Feb 2018). The implementation was similar to the previous research as described in Wan & Chong (2017). Key improvements includes: (1) Intrinsic Motivation (IM) reinforcement through evidence-based pedagogic design; and (2) high impact web tools were systematically applied to enhance the learning experience and attainment for the designated student group.

The module, Digital Electronics (ET1004), was chosen for this research. ET1004 is a compulsory module for first year students in the School of Electrical and Electronic Engineering (EEE). Topics covered include counters and shift registers, signed numbers and arithmetic circuits and MSI logic circuits IC's like decoders and encoders, multiplexers and demultiplexers. The flipped class consists of 45 hours of instruction per semester of 15 weeks; divided into 2 hours per week of tutorial, and 2 hours alternate week of laboratory sessions.

The research was implemented for two Electrical and Electronic Engineering (DEEE) classes for 15 weeks. The students for these two classes were students from Institute of Technical Education (ITE) instead of students with 'O' levels. Altogether 36 students were involved in this research.

The overall structure of the implementation had three phases and Table 2 shows an overview of the flipped learning design integrated with the IM components.

Table 2: Overview of the Flipped Learning Design

Flipped Classroom Stages	Cognitive scientific principles	Key teaching methods used	EdTech tools used
Pre-Class	Core Principles of Learning by Sale (2015)	-Video lectures -Two-way feedback -Quiz	-Screen-O-matic -WhatsApp -Socrative
In-Class		-Mini lectures -Application activities -Peer instruction -Mid-point quiz -Learner support for weaker students	-Kahoot/ Socrative
Post-Class		-Exit poll -Two-way feedback -Question and Answer video	-Socrative -WhatsApp -Screen-O-matic

Findings

Initial statistical analysis of the 3 questionnaires for the overall study has been conducted using a paired-sample t-test, comparing the item scores before and after the exposure to the planned teaching approach and strategies. Questionnaire 1 contained items relating to student engagement (i.e., behavioral, emotional, agentic, cognitive); Questionnaire 2 contained items relation to Autonomy Supporting Style & Self-Efficacy; and Questionnaire 3 contained items relating to cognitive scientific principles of learning.

The analysis revealed a significant overall difference before and after its exposure ($M = 6.47$, $SD = 29.90$); $t(181) = 2.92$, $p = <0.01$; $d = 0.28$. Questionnaire 1 ($M = 2.53$, $SD = 15.29$); $t(181) = 2.24$, $p = 0.03$; $d = 0.21$, Questionnaire 2 ($M = 2.13$, $SD = 9.37$); $t(181) = 3.07$, $p = < 0.01$; $d = 0.31$ and Questionnaire 3 ($M = 1.80$, $SD = 8.36$); $t(181) = 2.91$, $p < 0.01$; $d = 0.27$ all saw a significant difference in scores. For Questionnaire 1, emotional and agentic engagement showed significant increases over the implementation period. For Questionnaire 3, which focused on 10 cognitive scientific principles of learning, five showed statistically significant increases over the implementation period. Further, more detailed, statistical analysis is presently

being conducted, but is not available at this time of writing.

In terms of academic attainment, the two chosen DEEE classes (DEEE1B07 and DEEE1A25) achieve better exam results than cohort average. The exam results is shown in figure 1 below.

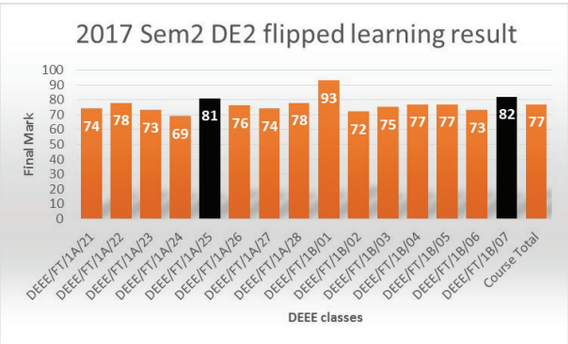

Figure 1: ET1004 2017 Semester 2 exam results for all DEEE classes

Note that DEEE1B01 had the highest score. The students in DEEE1B01 were from 'O' level and they had the best entry qualification so they were branded in class 01 in the cohort.

The qualitative data from the student co-participants suggested support for the approach taken and the evidence-based methods and principles employed. Some salient student agreed comments include:

> "Mr Mark is a very caring and chill lecturer. I enjoyed on how he gave us freedom to design and come up with different unique ideas that our team may have"

> "Great lecturer who makes lessons fun for students and is able to get the message across quick and simple"

> "Best lecturer this semester, he is fun and is very good at making the class a very conducive environment for creativity, like he always say "the sky is the limit""

> "Makes the class very enjoyable"

Conclusion

The research findings strongly support the use of EBT practices and principles as a sound pedagogical framework for enhancing many aspects of the student learning experience. This contributes to the challenge of providing high impact learning (both in terms of attainment opportunities and intrinsic motivation) for students through utilizing our enhanced understanding of human learning, what teaching methods work best, and leveraging on technology affordances. Future research work will involve exploring how specific method blends and technology tool combinations can further enhance instructional effectiveness and efficiency within the context of providing differentiated and intrinsically motivating learning experiences for students.

Acknowledgements

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Appendix 1: Questionnaires

Questionnaire 1

Please respond to each of the following statements by indicating the degree to which you agree or disagree with the statement as it applies to your experience in this class.
Use the following scale:

Not at all True		Somewhat True		Very True
1	2	3	4	5

	Statements	**1**	**2**	**3**	**4**	**5**
1.	When I'm in this class, I listen very carefully.					
2.	I pay attention in this class.					
3.	I try hard to do well in this class.					
4.	In this class, I work as hard as I can.					
5.	When I'm in this class, I participate in class discussions.					
6.	When we work on something in this class, I feel interested.					
7.	This class is fun.					
8.	I enjoy learning new things in this class.					
9.	When I'm in this class, I feel good.					
10.	When we work on something in this class, I get involved.					
11.	I let my teacher know what I need and want.					
12.	I let my teacher know what I am interested in.					
13.	During this class, I express my preferences and opinions.					
14.	During this class, I ask questions to help me learn.					
15.	When I need something in this class, I'll ask the teacher for it.					
16.	When studying for this class, I try to explain (make sense of) the key concepts in my own words (e.g., through self-talk).					
17.	When learning about a new topic in this class, I usually try to summarize it in my own words (e.g., make notes; do a concept diagram/mind-map).					
18.	When studying for this class, I try to connect new learning to what I already know.					
19.	When thinking about the concepts in this class, I try to generate examples to help me understand them better.					
20.	I ask myself questions to make sure I know the material I am studying.					

Questionnaire 2

Please respond to each of the following statements by indicating the degree to which you agree or disagree with the statement as it applies to your experience in this class.
Use the following scale:

Not at all True		Somewhat True		Very True
1	2	3	4	5

	Statements	**1**	**2**	**3**	**4**	**5**
1.	My teacher provides me with choices and options.					
2.	I feel understood by my teacher.					
3.	My teacher conveys confidence in my ability to do well in this class.					
4.	My teacher encourages me to ask questions.					
5.	My teacher listens to how I would like to do things.					
6.	My teacher tries to understand how I see things before suggesting a new way to do things.					
7.	My teacher explains the reasons why we need to learn the subject content.					
8.	I can master the work (e.g., assignments/tests) for this class.					
9.	I can work out how to do the most difficult work for this class.					
10.	I can do almost all the work for this class if I don't give up.					
11.	Even when the work is hard I can learn it.					

Questionnaire 3

Please respond to each of the following statements by indicating the degree to which you agree or disagree with the statement as it applies to your experience in this class.
Use the following scale:

Not at all True		Somewhat True		Very True
1	2	3	4	5

	Statements	**1**	**2**	**3**	**4**	**5**
1.	My teacher explains the purpose, goals and learning expectations for this class.					
2.	My teacher finds out what we already know about a topic area before introducing new information for us to learn.					
3.	My teacher uses methods/activities that help us to understand the important concepts for this class.					
4.	My teacher encourages us to think about what we are learning so that we can develop a good understanding of the topic areas.					
5.	My teacher uses a variety of teaching methods and media that make the learning/lessons more interesting for us.					
6.	My teacher clearly structures the lessons and breaks the content down into manageable chunks for us to learn effectively.					
7.	My teacher provides us with useful practice activities to develop the skills we are learning.					
8.	My teacher provides helpful feedback to help us develop and manage our learning effectively					
9.	My teacher encourages us to believe in our ability to be successful learners.					
10.	My teacher encourages humour and fun in class.					

KOSEN SECURITY EDUCATIONAL COMMUNITY (K-SEC) AND RELATED ACTIVITIES IN TOMAKOMAI COLLEGE

Shigeo DOI*,[a] and Takuya MUKOHIRA[b]

[a] Department of Engineering for Innovation, National Institute of Technology, Tomakomai College, Tomakomai, Japan
[b] Advanced Course, National Institute of Technology, Tomakomai College, Tomakomai, Japan

*doi@tomakomai-ct.ac.jp

Abstract

Information security skills are basic for engineering students. These skills are acquired not only practice classes by teachers but also collaborations with regional agencies and citizens. The National Institute of Technology, Tomakomai College has participated in the KOSEN Security Educational Community (K-SEC)[1] since 2016. In this paper, we report the recent activities related to the program. In 2016, we mainly practiced three activities. First, we provided children with a QR-code puzzle derived from Capture The Flag (CTF) at a public regional lecture. Second, some students participated in the Security Mini-camp in Hokkaido to learn and practice the newest information security techniques and their related ethics. Last, Hokkaido Prefectural Police had a lecture about information security and usage of communication tools such as SNS (Social Networking Service) for the fourth year students. In 2017, we continued to take part in the public regional lecture and Security Mini-camp in Hokkaido. In addition to this, we started two new approaches. First, we signed an agreement of human development on the cyber security field with Hokkaido Prefectural Police. This agreement has been in effect since April 2018. As the subject to the agreement, both Hokkaido Prefectural Police and Tomakomai College collaborates to nurture engineering students who have basic information security skills. Last, the K-SEC program has been developing and improving teaching materials about information security. We also have been developing an experiment material using an IoT car derived from the K-SEC project. The scope of the experiment material will be the third year students. This means that the material should include not only information security but also basic computer network and configuring skills. Not only a teacher but also a laboratory student in an advanced course has been involved in the development. The laboratory student can aquire the information security skills through the development. We will firstly provide the material with the students after October 2018 and improve the material through the questionnaire result of the experiments.

Keywords: *Information Security, Human Development, K-SEC, Regional Collaboratives, Experiment Materials Development*

Introduction

As IoT devices have been used in various fields, for example, agriculture, forestry, fishery, and so on, the number of IoT devices has been increasing and will reach 30 billion in 2020[2]. It is shown in Fig. 1. Therefore, engineering students should acquire some basic information security skills. However, Ministry of Economy, Trade and Industry reported that the number of information security engineers in Japan will be shortage of about 193,000 in 2020[3], so the development of information security engineer has been desired.

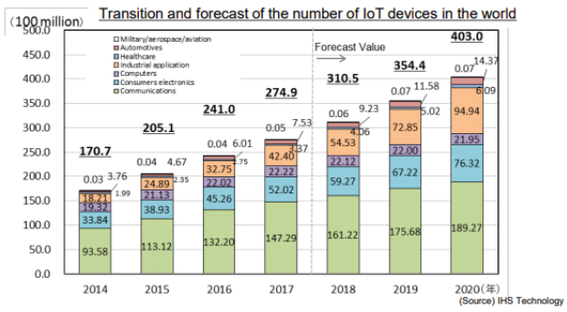


Fig. 1 The demand of number of IoT devices [2]

To accommodate the demand for security engineers, National Institute of Technology (NIT) launched a project to nurture security engineers in April 2016 and will end until March 2019. To produce the desired security engineers, the K-SEC project classifies students into three categories:, First, general students will practice and acquire basic information security skills; Second, students who belong to ICT related department will practice and acquire secure configuration and system development in addition to the basic information security skills; Last, students who want to pursuit security skills can acquire higher level practices not only our lectures but also external security events and lectures.

NIT Tomakomai College has been taking part in the project since the beginning of the project and has been working on many activities related to the project for two years. In this paper, we summarize our activities and future work.

The K-SEC Project

The K-SEC project [1] launched in 2016 to nurture students who have a discipline of information security. Recently, ICT has an important part in communications among individuals and organizations using the internet. However malicious hackers run attacks on the internet to get money or critical information. To protect ourselves from the attack, the demand of nurturing information security persons has been increasing. The K-SEC project has a part in nurturng students who have a discipline of information security. A logo of K-SEC is shown in Fig. 2.



Fig. 2. The Logo of K-SEC.

This project aims at the following three points. First, this project identifies skill sets of information security and develops teaching materials. Second, this project constructs a framework to produce students who have the information security discipline. To achieve this, this project prepares for the newest learning environments related to information security, including computer hardware, computer software and know-how. Last, this project consolidates hubs of security practice at some colleges. By utilizing the hubs, the colleges should conduct information security education for elementary schools, junior high schools, municipalities or companies.

Public Regional Lecture (Kagaku-no-Tobira)

NIT Tomakomai College holds the public regional lecture “Kagaku-no-Tobira” every year. The purpose of the lecture is that elementary school or junior high school students learn the fun of science and engineering from the lecture. All departments and technical staffs exhibit at least one theme for the lecture.

Department of Computer Science and Engineering exhibits a QR-code puzzle, which is derived from Capture the Flag (CTF). The procedure of QR-code puzzle is as follows: First, we generate a QR-code and split it into four square parts; Second, we present four parts to a student; Last, the student constructs the original QR-code until the constructed QR-code is readable. A scene of the QR-code puzzle is shown in Fig. 3.

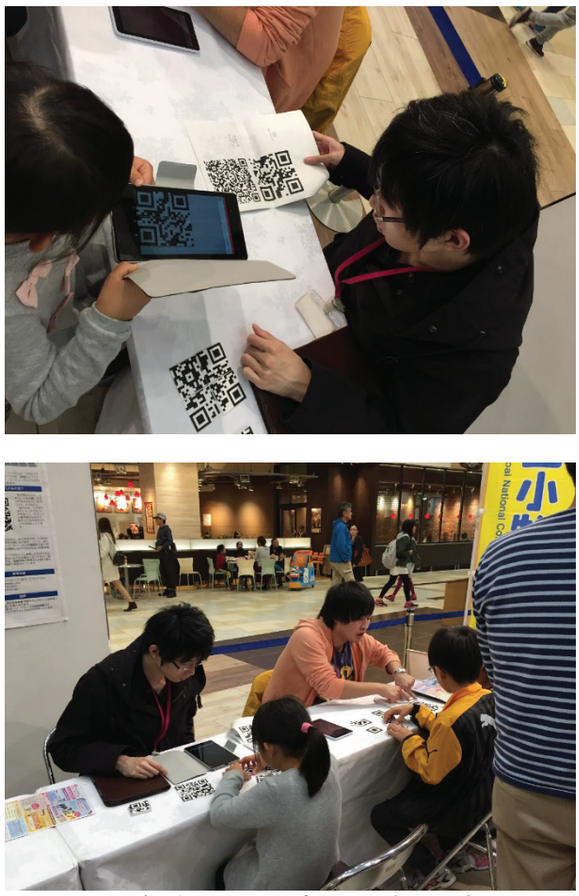


Fig. 3. A scene of QR-Code Puzzle.

It was difficult for the attendants by the result of questionnaire, but some attendants felt fun.

External Security Events from College

It is also important for students to take part in security practice events. One of the representative events is Security Mini Camp. Security Mini Camp has been organized by Information-technology Promotion Agency (IPA). The purposes of the camp is to find nurturing talented young students, and therefore, the aim of the camp concurs that of K-SEC. Security Mini Camp consists of a national convention and local conventions. In this event, participants attend some advanced security lectures and practices. Lecturers teach the current security situations and backgrounds. As a result, they can acquire the newest security technologies and ethics. This event in Sapporo recruits at most about 25 students under 22 years old.

Five students in 2016 and eight students in 2017 from NIT Tomakomai College participated in the event. As the maximum number of attendees was 25, NIT Tomakomai College has enough students who are interested in information security.





Fig. 4 The students who attended Security Mini Camp in Sapporo in 2016 (top) and 2017 (bottom)

Collaboration with Hokkaido Prefectural Police

NIT Tomakomai College has taken participate in Hokkaido Area Information Security Liaison (HAISL) since 2016. Hokkaido Prefectural Police (HP) hosts an officer of HAISL. HP made a special lecture for students in the department of Computer Science and Engineering about the crimes using SNS, targeting mail attack, Man-In-The-Browser attack and how to conduct an investigation of cyber security crimes. The lecture is shown in Fig. 5.

After this participation, NIT Tomakomai College and Hokkaido Prefectural Police reached an agreement to cultivate students who have cyber security skills in March 2018. The ceremony of agreement about the collaboration was shown in Fig. 6.

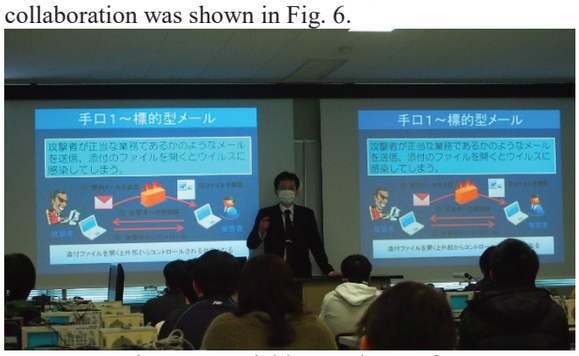


Fig.5 A Special lecture by HP for



Fig.6. Ceremony of an agreement with HP.

HP talked SNS and its risk for 200 students in the first year orientation on April 2018. This orientation aims to understand how students' life at the college goes on. Many students often start to use smartphones at the entrance of the college at latest, but some trouble occurred through communications on SNS at college. Therefore, it is important to learn how to use SNSs. This lecture was shown in Fig. 7.



Fig. 7. A Lecture from HP.

HP also talked about the information security risks for the Association for Tomakomai College in June 2018. The association was founded in April 1993, for the purpose of forming a close relationship between local industries and our college.

Collaboration with National Police Agency

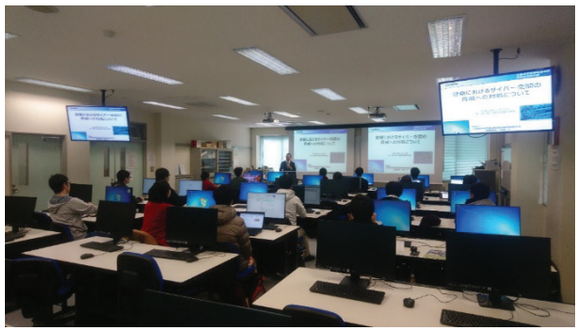
The K-SEC project and National Police Agency (NPA) have been working together closely. NPA visits NIT colleges and performs a special lecture about the current information security. In 2017 the special lectures were held at NIT Oyama College and Tomakomai College.

In Tomakomai College, eighteen students participated in the special lecture. The special lecture consisted of the following two sections:

1. A lecture and a demonstration about the current cyber security situation.
2. A practice using a virtual scenario to arrest a criminal person.

The practice was composed of a log analysis on a proxy server and a disk image analysis. Some of our

students often used the virtual private server (VPS), so it is easy for them to retrieve important information from the log. However most students didn't experience the disk image analysis. After the special lecture, the students seemed to feel new and fun about the disk image analysis.



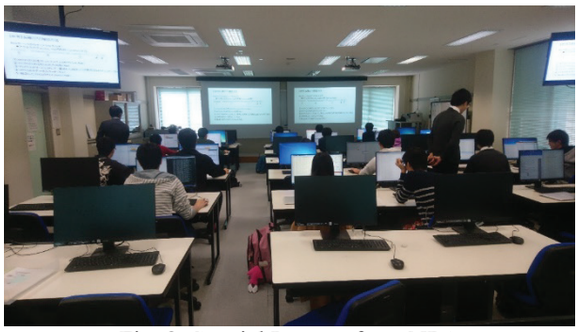


Fig. 8. Special Lecture from NPA

Experiment Material Development of IoT Security

We have been designing and constructing experiments about IoT security. We plan to use the IoT security car derived from the K-SEC project. The picture of the IoT car is shown in Fig. 9.

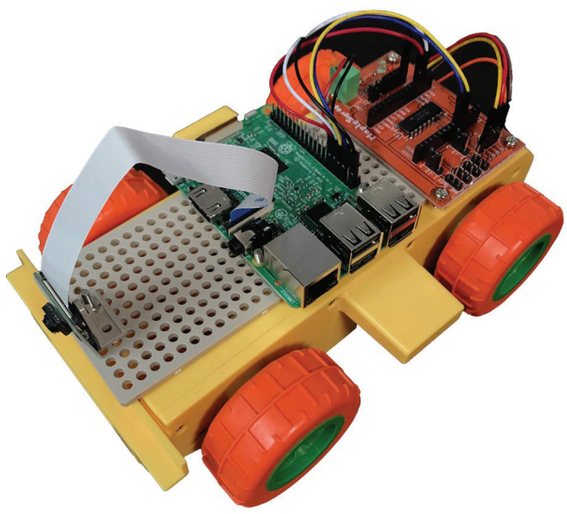


Fig. 9 A overview of IoT car

The IoT car consists of a Raspberry PI 3, a camera connected to the Raspberry PI and a motor driver Maple Syrup, so configuration of the IoT car conforms to a standalone Raspberry PI.

Now we prepared the following materials:

- Text References
  - Slides used at the experiment
  - A set up manual for IoT car
- Vulnerable application programs
  - A web user interface for user operation of IoT car.
  - A protected management console that is required to pass an authentication.

An example of vulnerable applications includes a web user interface. A snapshot of the web user interface is shown in Fig. 10. A snapshot of the management console is shown in Fig. 11.

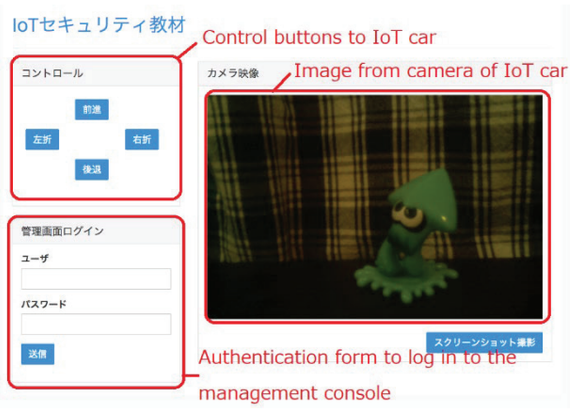


Fig.10 A snapshot of the vulnerable web user interface



Fig.11 A snapshot of the management console.

This web user interface consists of a panel of operating IoT car, a preview of capturing from a camera connected to Raspberry PI 3 and a login form to access management console. Once you press a button either "forward", "backward", "left" and "right", a request is sent to a Web Application Programming Interface (API) of the IoT car. This API constructs a command instruction from a query string and invokes a shell program to run. This involves a command injection

vulnerability. To attack the vulnerability, a user sends a special string to the API with a certain command. Once a user sends the string, the web interface will dump information to the web application unintentionally.

The login form of the web user interface has a Structured Query Language (SQL) injection vulnerability, so an attacker may get login information or may intrude the management console after sending a special query string. Moreover, the connection between a client and a server isn't encrypted, an attacker may get a capturing picture from the camera easily.

We developed the materials described above and will use the materials on a six week experiment for the third year students in the department of computer science and engineering. The protocol of the experiment is as follows: First, in the first and second week the students set up an IoT car as a Linux machine. After the setup students access their IoT car through SSH, so the students configure the SSH server appropriately and securely. To be secure, the students should set up the SSH server using public key infrastructure (PKI) as an authentication process and change the port using SSH from its default port 22. The students report different authentication processes and why users should change the default port;

Second, in the third and fourth week, a teacher gives a lecture including existing general vulnerabilities such as command injection attack and SQL injection attack because most third year students in the department don't know what vulnerabilities exist and how to fix the vulnerabilities. After the lecture, the students attack the vulnerabilities and get control of another IoT car. Now we plan to use a CTF style contest to gather their motivations;

Last, in the fifth and sixth week, the students think and practice how to fix the vulnerabilities. Finally, they submit a report of the thought and the practice. For example, to prevent themselves from a command injection attack, one of solutions for a command injection attack is that a system must not launch a shell program if possible. Another solution is that developers should rather use libraries than launch another program.

After the experiment, we will make a questionnaire about the experiment and improve the experiment. Items of the questionnaire is now developing.

enPiT2 Security involvement

NIT Tomakomai College takes part in enPiT2 Security, which is the curriculum for university students to learn and practice information security. enPiT2 security resembles the K-SEC project. Our advanced course students were admitted to join to a special lecture from the professors at Hokkaido University and they will go to the university on August 2018. In this lecture, students will practice the log analysis using Unix CUI environment.

e-Net Caravan

NIT Tomakomai College trains teachers who can teach information security and the Internet literacy for elementary and junior high schools. The e-net caravan is operated by Foundation for Multimedia Communications (FMMC). When a school requests a e-net caravan lecture to FMMC, FMMC recruits and asks a lecturer from registered teachers. Once a lecturer is admitted to talk, the lecturer performs a lecture on the scheduled time. This framework is useful for NIT Colleges because teachers combine the lecture with publicity at the requested school. We had the lecture at Tomakomai Misono elementary school on June 2018.

A questionnaire about cyber security in Tomakomai Regional Companies

As a research project, NIT Tomakomai College has started a questionnaire project to bring enlightenment to the regional companies. There are many regional companies in Tomakomai area, but they are often small. Large companies can afford to pay for information security, but the regional companies may not afford to pay. The regional companies may perceive the necessity of information security, but they may not know what to deal with risks of information security.

To clarify the consciousness of information security around the regional companies, we will make a questionnaire. After the questionnaire, the information will be useful to make an effective plan for information security. The fifth year student has been working on the questionnaire project as a graduation study.

Conclusions

We described the K-SEC project and related activities at NIT Tomakomai College. The K-SEC project aims to have teaching materials used by all colleges in NIT. NIT Tomakomai College cooperates fully with the project.

Now NIT Tomakomai College is going to plan special lectures related to information security and the K-SEC project. We hope that the education of information security will be widespread.

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[3] Ministry of Economy, Trade and Industry. Findings of METI's Study of Recent Trends and Future Estimates Concerning IT Human Resources Released, http://www.meti.go.jp/english/press/2016/0610_01.html , 2018. (Last Access: Jul/01/2018)

SPATIAL EXPLORATION, THE NEW SOCIAL SERVICE PROGRAM OF GUANAJUATO UNIVERSITY

Gonzalo Enrique Bernal Rivas*

* Guanajuato University/Salamanca high school, Full time professor, Salamanca, Mexico

artkitectonic@gmail.com

Abstract

The social service is a mandatory training activity for every student at Guanajuato University. It is linked to social responsibility and it allows students to join the social groups that require their contribution.

We are proud to share in this paper the foundation of a new social service program called *Spatial exploration*, the first one of its kind in the State of Guanajuato, which purpose is to allow students to conceive and present pieces of performance art. The program was accepted by the Salamanca Highschool academy on June 29th, 2017, but students from the whole Guanajuato University are welcome to enroll. The group can be formed each semester by twenty students from different high schools and departments, and the methodology used to support their production, is the one called artistic process by Lluis Racionero. As a result of the group work in 2017, three pieces, described briefly in this text, were developed, *¡Tepalcates!, Type AB blood retribution and Plant death*. An article about the first one was published at the Universidad Autónoma de México (UNAM) .925 peer-reviewed journal and two articles were written about the other two performances for the *Radar* magazine. The third piece was presented in the *Death on billboard* festival, held in Guanajuato city. In 2018, a piece that is also depicted in this essay, *Holy Mary of confetti*, was done, which was presented by the group in Salamanca and Guanajuato city in two different dates. An article about this last piece was written for *.925* as well. The conclusions section explains how performance art has proved to be a very powerful tool to help students and citizens reflect on social issues, presenting some of the students' testimonies on one piece. Finally, this paper strongly recommends professors from other universities and countries to create and promote new activities that make students think about how we must all commit to solve those issues to move towards a fairer and more humane society.

Keywords: *social service, performance art, Mexico, Guanajuato, social issues*

Introduction

This text has been structured in three sections. The first one is called *Materials and pedagogy*, in which two concepts that are fundamental at Guanajuato University are reviewed according to its academic bylaw, extension and social service. Also, the four objectives of social service and some of its main characteristics are revised. Once this background has been set, *spatial exploration*, a new social service program, is presented, as well as its objective and features. At the end, the methodology to create each of the performance art pieces, the one created by Lluis Racionero (1986), is briefly described.

The second part is named *results and discussion*. Here, four performance art pieces that were carried out by some of the members of *spatial exploration* are portrayed. The first two, *¡Tepalcates!* (2017) and *Type AB blood retribution* (2017), were restitutions of actions that had been done before. The last two, *Plant death* (2017) *and Holy Mary of confetti* (2018), were new. Moreover, the articles that have been written about each one of the pieces for the *.925* peer-reviewed journal or for the *Radar* magazine are mentioned. Three of those articles have been published and the fourth one has already been accepted.

Finally, the *Conclusions* section recalls the topics that were analysed in each one of the actions that were done. Furthermore, some testimonies of some of the students enrolled in *spatial exploration* about *Holy Mary of confetti* are presented to support that in our new social service program, performance art has proved to be a very powerful tool to help artists and citizens reflect on certain social issues.

Materials and Methods or pedagogy

Guanajuato University has three substantive functions, according to its academic bylaw, teaching, research and extension. That same document points out that extension "relates the University to its social context though the

diffusion of culture and services" [1] . Also, that text mentions that there are ten programs for the extension development, among which, the first one is social service. "Social service is the set of activities that train the students in the commitment toward the community and that project their action to benefit it."[2]. and it has four objectives:
"I. to favour the integral training of the college student and to raise awareness of his/her commitment toward the community;
2. to generate academic projects, based on concrete social issues, that support the substantive functions and contribute to solve the community, the region, and the country needs;
3. to be a means that links the university to the public, private, educative and social sectors; and
4) to enable the student to get knowledge of reality and its issues."[3]

At Guanajuato University, college students and high school students must join a social service program. They can freely choose it or even bring one forward. Professors can also propound a social service program and must advise students to carry it out properly. Social service is temporary, it must be accomplished during each school cycle, and it can be individual or collective; interdisciplinary or multidisciplinary; and it can be done at any campus or school of Guanajuato University or be interinstitutional.

Having this background, a new social service program called *spatial exploration*, which main objective is to favor the enrolled students reinstate or create new performance art pieces, was proposed last year at Salamanca high school. It was approved on June 29th by that school academy, and now it is the first social service program devoted to the production of performance art pieces at Guanajuato University and in the State of Guanajuato.

The top number of students that can join the program is twenty and they can come from any Guanajuato University campus or school. During the 2017 August-December semester, *spatial exploration* had ten members, eight from Salamanca high school and two from college (Digital art department). In the 2018 January-June semester seventeen joined the program, ten from Salamanca high school and one from college (Visual art department).

The reinstitution or creation of each performance art piece requires research, which is supported by the methodology called artistic process, proposed by Lluis Racionero (1986) and formed by four basic steps: 1) Reality. The artist takes some phenomena and relates them to each other to create a metaphor; 2) Shapes. The artist selects some data and turns them into shapes, intensifying some details of the reality. He/she translates information into matter (words, sounds, movements, etc.); 3) Work of art. It must generate a reflection on the viewer, and; 4) Spectator. He/she perceives the work, internalizes it and reaches the same or a different reflection than the artist. The spectator sets his/her reflection against reality and approaches it with a different frame of mind caused by the artwork.

Results and Discussion

From its creation, in June 2017, to the present day, June 2018, five actions have been done by the members of *spatial exploration*. In this text we will describe the three performance art pieces that were developed in 2017 and the first one that was done in 2018. The first action is called *¡Tepalcates!* and it was presented by some of the members of *spatial exploration* on September 12th 2017 at Salamanca high school in Mexico. *¡Tepalcates!* was the reinstitution of the original action called *Trencadissa* that was done by the artists Santiago Rusiñol and Ramón Casas in 1889 in Olot, Catalunya. An earlier reinstitution of *Trencadissa* was done by the artists Juan Castellas and José Juan Martínez in 2012 in Valencia, Spain.

For *Trencadissa*, Rusiñol and Casas bought a clay pots stall at the Olot market and put the items on sale at exorbitantly cheap or expensive prices. If a client thought that an item was too cheap, the sellers complained that the business was not working and said that it would be better to finish it, throwing the pot to the floor. If a client offered a lower price that the one asked, the sellers said that they would rather break that pot than selling it at such a low price, tossing it away. All the pots ended up broken. Molina (2015) explains that this action was carried out to generate a reflexion about the prevalence of the creative interest over the economic interest of the craftsmen, as well as to consider the value that the buyers give to crafts.

Having *Trencadissa* (1889) and its reinstitution (2012) as a benchmark, a fact that inspired us to reinstate that action for the first time in America was a conversation that we listened between professors Rosa del Carmen Regalado and Cuitláhuac Rodríguez about how cathartic it would be to break plates. We proposed them to do *¡Tepalcates!* in collaboration with some of the students enrolled in

[1] Universidad de Guanajuato (2008). *Estatuto académico*, p. 20. Retrieved from: http://www.ugto.mx/images/pdf/normatividad/estatuto-academico-universidad-guanajuato.pdf [last checked by the author, June 2018]

[2] Universidad de Guanajuato (2008). *Estatuto académico*, p. 21. Retrieved from: http://www.ugto.mx/images/pdf/normatividad/estatuto-academico-universidad-guanajuato.pdf [last checked by the author, June 2018]

[3] Universidad de Guanajuato (2008). *Estatuto académico*, p. 21. Retrieved from: http://www.ugto.mx/images/pdf/normatividad/estatuto-academico-universidad-guanajuato.pdf [last checked by the author, June 2018]

spatial exploration, Abisaí González, Itzamara Vázquez, Jesús Galavizo and Alejandra Jiménez.

The mexican context strongly fed the 2017 reinstitution. First, the new name. *Trencadissa* means breakable in Catalan, while *Tepalcates* comes from the náhuatl word *tepalcátl*, which means "a piece of any clay pot"[4]. Second, the location of the 2017 reinstitution. *Trencadissa* and its 2012 reinstitution took place in a market, but *¡Tepalcates!* was presented on a sidewalk close to one of the pedestrian access of Salamanca high school, where street vendors are commonly located.

A street stand was set up, in which fifteen vitrified clay jugs were put up for sale. The jugs were made by craftsmen from the State of Michoacán and they were bought at Guanajuato city crafts market. After collecting these and other elements for the performance and making the arrangements with the school authorities, *¡Tepalcates!* was presented on September 12th, 2017 at Salamanca high school. All the pots were broken as in *Trencadissa*. The action was registered in video by Itzamara Vázquez and an article called as the action was published in the Universidad Autónoma de México (UNAM) .925 peer-reviewed journal in 2017.



Figure 1. Professor Rosa Regalado (right) in *¡Tepalcates!* Salamanca, Mexico, 2017

The second action of 2017 was named *Type AB blood retribution*. This action was also a reinstitution of another performance art piece called *Blood retribution*, which was presented on September 21st, 2017 at Ngee Ann Polytechnic in Singapur while the ISATE was being held there.

The original piece reflected on the blood type discrimination or *bura-hara* in Japan, a theory supported by authors such as Tokeji Furukawa (1927), who states that there's a relationship between the people's blood type and their personality. Acoording to Furukawa, the worst blood types are AB, that belongs to people who have a mixed temperament; and B, that corresponds to the people who are impulsive. The goal of *Blood retribution* was to make up for any discrimination that people with type B blood may have suffered. The B type was chosen as a matter of empathy, since my blood type is B. *Blood retribution* was planned as an exchange. The participants had to demonstrate their blood type was B with any ID, and in return they would get a melon slice, something valuable, expensive, in Japan. The proposal to do this exchange was written in Japanese (so it could only be understood by people who spoke that language) in the front and back of the red t-shirt that I was wearing: 血液型がＢ型の方、証明書を見せて賞品をゲットしよう [5] The people's reaction was a strange look and asking some questions like "do you know what your t-shirt says?" "where did you buy your t-shirt?" or "why are you wearing that t-shirt?" Only two people proved to have type B blood.



Figure 2. B blood type person ID in *Blood retribution*. Singapur, *2017*

It was proposed to the *spatial exploration* members to reinstate the original action within a different context, in Salamanca, Mexico, where a Japanese community is living. *Blood retribution* changed its name since it was no longer a piece with which I was personally related, and considering people with AB blood type has been the

[4] Real Academia Española dictionary. Retrieved from: http://dle.rae.es/?id=ZjD1ubu [Translation by the author]

[5] Demonstrate with an ID you have blood type B and get a prize for free. [Translation by Miyuki Takahashi]

most affected by discrimination. The t-shirts reminded written in Japanese because the action was specially designed for Japanese people, and because blood type discrimination doesn't exist in Mexico. The melon reminded as an element of the action, but half melon was offered. *Type AB blood retribution* was carried out outside Walmart Jardines del country, Salamanca (Japanese people who live in Salamanca frequently visit this supermarket) on October 30th, 2017 by two of the students enrolled in *spatial exploration*, Judith Flores and Sergio Baca. Any of the Japanese approached the students, but their look was clearly affected by the action. An article called as the message on the t-shirt was published in the *Radar* magazine.



Figure 3. Sergio Baca (left) and Judith Flores (right) in *Type AB blood retribution*. Salamanca, Mexico, 2017

The third piece of 2017 was named *Plant death* and it was presented by some of the students enrolled in *spatial exploration*, Abisaí González, Guadalupe Villegas, Itzamara Vázquez, Sergio Baca, Monserrat Flores, Jesús Galavizo, Alejandra Jiménez, Azalea García, Carla Vázquez and Jacqueline Gallardo, on November 2nd, 2017 in the *Death on billboard* festival in Guanajuato city. To participate in the festival, it was necessary to fulfil three requirements. First, every artwork should be about death; second, every piece should fit a two-dimensions format of a maximum of one square meter, and; third, every artwork should be ephemeral. A performance art piece didn't seem to match the festival's conditions, but it was accepted because our proposal was about the death of a tree (a rare topic, considering most of the projects concern about the human or the animal death); because our action consisted on the distribution of flyers (two-dimension pieces); and, because the flyers disappeared at the moment they were delivered, a feature that was emphasized as the flyers were eatable.

This action's goal was to reflect on the mezquite protection, a native Mexican tree. Many of these trees have lately been infected by a parasite, a mistletoe variety, which bright orange flowers can be easily seen. When the mistletoe infests the mezquite, it causes its death. According to the León cultural institute, the city's growth has caused 65% of the urban trees of our State to get affected by the mistletoe plague[6]. Our action consisted in delivering 200 10x10cm-flyers. We wanted the flyers to be eatable, so we didn't make them on paper, but on a wheat wafer. On the front of each flyer we drew a dead mezquite tree using mezquite syrup and on the back, we added some facts about the drawing and about the lack of actions to protect the mezquites. An article called "Death, two-dimensionality and caducity" was published by the Radar magazine in 2017.



Figure 4. Jesús Galavizo (right) in *Plant death*. *Death on billboard* festival. Guanajuato city, 2017



Figure 5. *Plant death* production process. Salamanca high school, Mexico, 2017.

Finally, the first performance art piece done in 2018 was *Holy Mary of confetti*, which was done in two different places and dates. It was presented on February 25th, 2018 at the Constitution garden in Salamanca by Fátima Hernández, Elián López, Cristo Banda, Itzel Ramírez,

[6] Abúndez, Anahí (2016). Muérdago: una amenaza para nuestros árboles. León: Instituto Cultural de León. Available at: http://institutoculturaldeleon.org.mx/icl/story/4437/Muerdago-una-amenaza-para-nuestros-arboles#.Wf0EbNCWbIU [last checked by the author, June 2018]

Leonardo Serrano; and then, on mars 9th 2018, at the Baratillo plaza in Guanajuato city by Jorge Villaseñor.

Although this action was new, it had its referent in a popular custom. Every year, on February 2nd, there's a party to celebrate the Candelaria virgin in Pueblo Nuevo, Mexico. The oldest document that registers the presence of the virgin sculpture in the town church was written on february 2nd, 1773[7]. Each year, the party begins with the serenades nine days before the 2nd of February, in which single women walk counterclockwise around Pueblo Nuevo's main plaza, while single men are distributed in two rings, one inside and another one outside of the circunference formed by women. In certain locations, close to men, confetti, flowers and beer sellers are placed, as well as musicians. While women walk, men watch them and throw confeti over the head and shoulders of those that men consider to be beautiful. Confetti can be only one color or multicolor, and it is always used by one person (a man) to comunicate that his personal appreciation about the beauty of another person (a woman) is positive, having as a witness a meaningful part of the community. This fact is an analisis topic from different perspectives as it originates questions like "why is only the femenine beauty pointed?" or "who is allowed to point beauty?" It is interesting to see in the restrooms, how women look at themselves in the mirror to touch up their make-up and to make sure the confetti is still on their head and shoulders. They expect to be marked, recognized as beautiful, and to show the community that someone has seen in them this value. Some women even cheat and put confetti on themselves. Other facts surround the celebration, for instance, in Pueblo Nuevo, not few children are baptised with the name of Candelario or Candelaria.

Our performance aimed to help the spectators setting the questions mentioned above, but also others, broadening the perspective to a more artistic one, such as "who decides what is beautiful?" "Who decides what has artistic value?" pointing at the white cube aesthetics that was born at the beginning of the 20th century among the *Bauhaus* and the *De Stijl* artists, and that was interested in highlighting their pieces by showing them in front of white walls. Since then, the exhibition spaces have sacralised what is shown in them[8].

All the students that participated in *Holy Mary of confetti* were dressed in white as a gesture to the white cube aesthetic, that was reversed in our action. The white is outside instead of inside, the artist decides what is valuable, not the institution. Also, each student has a mirror on his/her front and/or chest, having as a referent the women we saw standing in front of the mirror in Pueblo Nuevo and hoping spectators could see themselves being pointed with confetti as someone valuable.

During *Holy Mary of confetti*, students approached people in the two public places mentioned before and asked their permission to put confetti on them to mark them as someone valuable. Confetti was also put on animals, spots or things. This can also be related to the baptism ritual. After, students gave the spectators a bag containing confetti and the instructions "Put the content of this bag on someone or something that you consider to be valuable". Spectators took control and marked who/what they chose. An article named after the action was written for .925 peer-reviewed journal. It has been accepted, and it will soon be published.

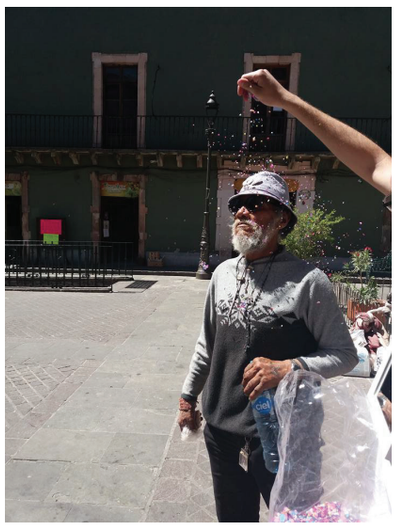

Figure 6. Jorge Villaseñor (not in the picture) putting confetti on a spectator in *Holy Mary of confetti*. Baratillo plaza, Guanajuato city, 2018.



[7] *Rionda Arreguín, Isauro* (2010). *Colección monografías municipales de Guanajuato.* Guanajuato: Gobierno del estado de Guanajuato, p. 30-31

[8] http://www.tate.org.uk/art/art-terms/w/white-cube

Figure 7. Two spectators putting confetti on each other in *Holy Mary of confetti*. Revolución walkway, Salamanca, 2018.

Conclusions

The four topics that were analyzed though actions were the rapport between the profitable and the creative value of handcrafts in *¡Tepalcates!;* blood discrimination in *Type AB blood retribution*; the lack of protection of mezquites, a particular species of a native Mexican tree, in *Plant death*, and; beauty and value through borrowing elements from a specific popular custom in *Holy Mary of confetti*.

Though *spatial exploration*, performance art has proved to be a very powerful tool to help artists and citizens to reflect on some social issues. A good way to prove that the students enrolled in *spatial exploration* achieved this reflexion on the actions they carried out is by sharing their testimonies. These are some of the students' experiences about *Holy Mary of confetti*:

"This was a new experience to me, I had never done something like this before. I liked to observe the people's behaviour and how they react to situations related to a topic" Elián López

"It was a fun experience for me. The best part of this program is that we are able to see the people's reaction to unexpected events" Cristo Banda

"It was a very fun experience for me and I would like to repeat it. Something that drew my attention was that you can find people with different personalities. Some couple and families were very nice and flexible, while some others just said no. When I asked a woman if I could carry on an action with her she told me she had no money on her" Fátima Hernández

"It doesn't matter if people forget about us when time goes by. What matters is that the people who we put confetti on don't ever forget their value as human beings" Itzel Ramírez

We are satisfied with the results we have gotten so far from *spatial exploration*. We are very proud to have been the first in our State to propose a social service program that approaches students to an artistic genre such as performance art to help them appreciate it and to widen their conception of what art is.

We strongly recommend professors from other universities and countries to create and promote new activities that encourage students think about how we must all commit to solve those issues to move towards a fairer and more humane society.

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I would also like to express my gratitude to Guanajuato University for believing in this project and for allowing me to present many of the performance art pieces within its facilities.

I am also thankful to ISATE, at its different seats, for its openness toward topics that are related to education from a different standpoint.

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A CASE STUDY ON BLENDED LEARNING IN TECHNICAL ENGLISH TEACHING AT THE NATIONAL INSTITUTE OF TECHNOLOGY

Takuro FUJITA*

Course of General Education, National Institute of Technology, Fukui College, Japan

*t-fujita@fukui.kosen-ac.jp

Abstract

This study introduces a case study on blended learning that was conducted at the National Institute of Technology, Fukui College. The study starts with the theoretical concept of blended learning—in particular, the theoretical advantages and the role of web-based training. It is argued that introducing blended learning will enhance the quality of pedagogy, bring a flexible learning environment, and increase cost performance. Here, the role of web-based training is categorized into four types: presentation, practice, collaboration, and distance learning. Furthermore, a case study on teaching technical English has been introduced, based on Fujita's (2018) research. In the case study, third year students of the Department of Mechanical Engineering were targeted and two cycles of English lessons were conducted. To understand the learners' stance, a reaction paper was used as data and was analyzed qualitatively. The results showed that most of the learners were in favor of web-based training and technical English classes. In web-based training, comments such as "the usability of the learning management system, the simplicity of instructional videos, flexibility, and accessibility" were received. Comments on technical English classes included "the importance of preparing for classes, activities that required learners to apply content knowledge, a positive attitude toward classes, a positive attitude toward quizzes, and challenging tasks." In addition to these positive comments, some insightful comments were also seen. Based on the case study, some practical tips for implementing blended learning have been suggested, which are related to instructional videos and a learning management system. With regard to instructional videos, suggestions included making shorter instructional videos, spending less time on perfecting videos, and considering a number of ways to distribute videos. In terms of the learning management system, it was proposed that utilizing essential elements of the management system should be recommended. It was also suggested to effectively employ the import function; in particular, the Aiken format and the GIFT format have been introduced as examples of importing data.

Keywords: *blended learning, Moodle, instructional videos, web-based training, NIT*

Introduction

Engineers face situations where they are required to use English extensively. For example, they need to introduce their companies and products, socialize, and conduct business (e.g., arranging schedules, reporting the progress of work, and giving instructions and advice). Moreover, they are required to conduct research (e.g., reading articles, collecting information, making presentations, etc.) from the academic and technical viewpoints. This means that engineers should acquire both general and professional English skills (Fujita, 2017).

However, it is uncertain whether the National Institute of Technology (henceforth, NIT) grants sufficient time for English learning. In the case of the NIT, Fukui College, English classes are conducted three times a week for first year students, twice a week for second and third year students, and once a week for fourth and fifth year students. In order for students to acquire sufficient language skills to deal with diverse communicative situations, additional time for English learning, a systematic teaching approach, and a highly organized curriculum are crucial.

Based on this, the study aims to introduce the concept of blended learning (henceforth, BL), and share practical tips for carrying out BL. The study starts with a discussion on the theoretical perspectives of blended learning, followed by a case study conducted at the NIT, Fukui College. Based on the results of the case study, this study aims to dispense some practical tips for implementing the BL approach.

Theoretical Perspectives of Blended Learning

Although BL is generally considered a combination of face-to-face classroom interaction and use of technology, its definition slightly varies among studies (Sharma, 2010). Some of the definitions of BL are as follows:

> "…a language course which combines a face-to-face (F2F) classroom component with an appropriate use of technology" (Sharma & Barret, 2007, p.7).

> "…the term most commonly used to refer to any combination of face-to-face teaching with computer technology (online and offline activities/materials)" (Whittaker, 2013, p.12).

> "…face-to-face plus web-based learning" (Sharma, 2010, p.457).

Sharma and Barrett (2007) and Whittaker's (2003) definitions are considered "broad" definitions, whereas Sharma's (2010) definition is regarded as a "narrow" definition.

According to Sharma (2010), these two types of definitions are qualitatively different. It is possible that the broad definition entails a variety of combinations. For example, using CD-ROM and PowerPoint presentation can be BL if they are considered "appropriate use of technology." On the other hand, in the narrow definition, BL is referred to as a combination of face-to-face classroom interaction and web-based training (henceforth, WBT). According to this definition, simply using technology is not considered BL. In other words, the narrow definition regards BL as a specific type of teaching approach. This study employs the narrow definition.

According to Graham (2006), BL brings at least three advantages to a classroom. Firstly, it enables teachers to enhance the quality of their teaching, as BL allows teachers to combine the advantages of face-to-face teaching and WBT. For example, Enokida (2015) conducted a dictogloss activity (i.e., a type of listening activity where learners are required to listen to a passage with their partners and reconstruct the passage collaboratively) in a face-to-face classroom. Then, using the same listening material, the learners were required to practice English dictation in WBT as their homework. This enabled the learners to undergo an intensive listening practice. Therefore, by combining the two different approaches, this study states that there is an opportunity for learners to engage in a variety of activities.

Secondly, BL provides learners with a flexible learning environment. It enables learners to access learning materials at their own convenience. All they need is an Internet connection and an electronic device such as a computer or a smartphone. Learners can also engage in WBT flexibly, according to their learning conditions. For instance, they can continuously watch an instructional video on grammar to understand it fully or, when watching the video, they can skip the explanation that they have already understood. As a result, learners can focus on the section they need to learn in a limited time.

Thirdly, BL may increase cost performance. That is, a web-based platform allows teachers to provide course materials instantly to a large number of learners who are in different places. If teachers use a learning management system (henceforth, LMS) such as Moodle, learners have only to access the LMS, so that they can get all the material that the teachers have prepared. Besides, once the course material is ready, it is possible to use it repeatedly. For instance, videos, quizzes, and other content can be used again and again, once they are made.

In BL, the role of WBT can be classified into four types (Fujita & Miyamoto, 2017). These are: (1) presentation, (2) practice, (3) collaboration, and (4) distance learning. For presentation, teachers provided instructional videos on target grammar, and the learners were required to learn them before class (Ueda, Shinozaki and Ueda, 2017). At the beginning of the class, the learners were required to take a quiz on target grammar. In this case, WBT is used as a presentation for learning materials.

With regard to practice, Enokida (2015) conducted a listening activity called dictogloss. After the class, using the same listening material, he instructed the learners to practice English dictation on WBT. It is clear that Enokida (2015) utilizes WBT for listening practice.

Eydieman (2013) used wiki as a collaboration tool for essay writing. In his study, the learners were required to work on an academic essay. They had the opportunity to discuss topics and to outline their essays in face-to-face classes. Then, they wrote a draft of their essays on wiki at home. Once their drafts were shared on wiki, other students and teachers gave feedback for each essay.

Sugie and Mitsugi (2014) conducted distance learning in a Chinese class. The learners assembled in a face-to-face classroom and worked on a theme-based study and Japanese-Chinese translation practice. Then, they engaged in WBT and prepared for distance learning. After that, the learners had the opportunity to have a real-time exchange through video chat. In this study, WBT is employed as a way of communicating with remote learners.

Case Study

Based on the concept of BL discussed in the previous section, a case study was conducted at the NIT, Fukui College. Its outline is summarized in Fujita (2018). Focusing on the use of WBT, this section introduces the case study.

Participants: The participants included 47 third year students of the Department of Mechanical Engineering at the NIT, Fukui College. Out of them, 42 learners were male, and five were female. A total of 46 learners were Japanese and one was an overseas student from Malaysia. I was a homeroom teacher in this class at the time they were second year students.

The Context and Educational Setting: Third year students at the NIT, Fukui College, have English classes twice a week. Each class is 90 minutes long.

Kameyama, Aoyama and Takeda (2017) was chosen as the textbook. The aim of the textbook is to teach elementary-level mathematics and science in English. The content includes numbers and calculations, figures, functions, electricity, heat, and ions. Lesson 6 (electricity) and lesson 7 (heat) were targeted in the case study. Since the purpose of the class was to teach basic-level technical English, this textbook was considered suitable for the learners in this study.

In the first semester, the PPP approach (presentation-practice-production) was employed. However, it took longer than expected to explain passages and practice target grammar, so it was impossible to take enough time for additional communicative activities. In order to deal with this problem, BL was introduced. It was thought that it might enable learners to study passages of the textbook and target grammar at home, which would make it possible to free up time in the classroom for additional communicative activities.

English Courses: Before classes, the learners were required to watch instructional videos and work on vocabulary practice. In the videos, the textbook passages were shown one by one, and explicit instructions were given for syntax and expressions (i.e., idioms and vocabulary) in Japanese. An example of an instructional video is shown in Figure 1.

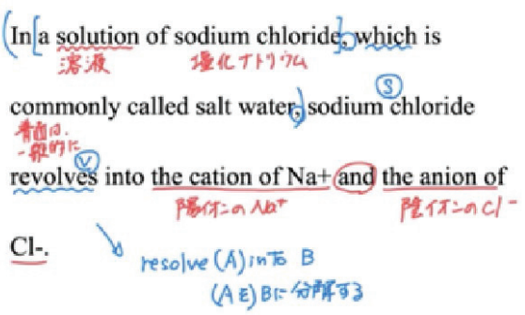

Figure 1. An example of an instructional video.

After watching the videos, the learners worked on two types of vocabulary practice. These were multiple-choice questions and match-the-following questions. The questions were set on Moodle. Examples of the practice are shown in Figures 2 and 3.

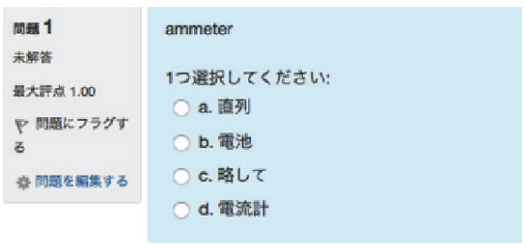

Figure 2. An example of a multiple-choice question.



Figure 3. An example of a match-the-following question.

In addition to instructional videos and vocabulary practice, additional exercises were set by using quizlet[1]. This enabled the learners to work on a variety of vocabulary exercises such as match the following, dictation, translation, and some games. The content for lessons 6 and 7 had already been created by one of the authors of the textbook. In order for learners to access the content easily, a quizlet was provided with the content embedded on Moodle. Figure 4 shows an example of a quizlet.



Figure 4. An example of a quizlet. When a study mode is changed, learners can experience a variety of activities.

Each face-to-face class started with a vocabulary and grammar quiz. The quiz was carried out to check whether the learners had studied the textbook before the class. The learners had agreed to take a quiz at the beginning of each class. Therefore, the quiz was also used as a motivator for studying the textbook at home.

After the quiz, the learners worked on two types of linguistic practice; one was reading aloud and the other was a translation activity. The learners were told to read a passage out after the teacher. Then, they read it aloud, sentence by sentence, in pairs. After that, the learners were paired again, and one learner was made to convey the Japanese meaning of a sentence in the textbook while the other learner was required to translate the Japanese sentence into English orally.

After the quiz and linguistic practice, communicative activities were implemented in pairs. In lesson 6, the learners mainly engaged in a production task. In lesson 7, they worked on a comprehension task and a production task. Examples of production tasks are as follows:

1. Describe the phenomenon that is caused by static electricity (Lesson 6-1).
2. Describe the characteristics of a parallel circuit (Lesson 6-2).
3. Describe the nature of a conductor, semi-conductor, and insulator (Lesson 6-3).
4. Explain how water in a kettle boils (Lesson 7-2).

In comprehension tasks, the learners were required to read the sentences on heat and judge whether the sentences were correct or not (lesson 7-1 and 7-2). The

learners were also told to read the fill-in-the-blank passages related to convection and radiation, and to fill the blank spaces with appropriate vocabulary and expressions.

Data Collection and Analysis: After each class, reaction papers were collected and used as data in the study. The learners were told to write comments, questions, and requests related to the class and WBT freely. Google forms were used to collect the learners' response (see Figure 5), and the data was analyzed qualitatively.



Figure 5. An example of a reaction paper. Using Google forms makes collecting and sorting data much easier. Most of the learners used their own smartphones to enter comments.

Results: The qualitative analysis of the reaction papers revealed that, overall, the learners were satisfied with both WBT and technical English classes. The comments for WBT were categorized and summarized as follows:

1. *Usability of LMS*: Learners commented favorably on the usability of LMS.
2. *Simplicity of grammar instructions in instructional videos*. A number of students commented that instructional videos were easily comprehended.
3. *Flexibility*: WBT enabled learners to watch instructional videos, work on vocabulary exercises, and check new words repeatedly at their own pace.
4. *Accessibility:* WBT made it possible for learners to study regardless of location.

The comments related to technical English were categorized and summarized as follows:

1. *Importance of preparing for classes*: The learners realized the importance of preparation as it brought a better understanding of the content.
2. *Activities that require learners to apply the content knowledge they learned*: Tasks that required learners to apply content knowledge were useful as they were related to their specialized field of study.
3. *A positive attitude toward classes*: Learners stated that they enjoyed the English classes. Some of them also mentioned that they would work hard to learn English.
4. *A positive attitude toward quizzes*: Some learners commented that they studied hard to get a good score on the quiz.
5. *Challenging tasks*: Learners stated that the production tasks were challenging but felt a sense of achievement when they could work them well.

There were many favorable comments and some insightful ones too. For example, a learner stated, "Since the instructional videos were really helpful, I was wondering whether it is necessary to have a face-to-face class. But I thought a certain kind of practice such as pronunciation practice should be conducted in a face-to-face class." Another learner stated that in a face-to-face class he wanted to learn more technical words and expressions that were related to the passage. Such comments indicate that the role of face-to-face classes and WBT should be carefully considered.

Tips for effective BL

Based on the case study introduced above, this section suggests some practical tips on the efficient implementation of BL, in relation to instructional videos and LMS.

Instructional videos: Three tips for making instructional videos are stated here. First, videos should be as short as possible. Learners will be required to watch numerous instructional videos if a certain type of BL (e.g., flipped approach) is introduced in earnest. This might put an enormous burden on them. In such a situation, getting learners to watch 50-60 minute videos each time is impractical. Thus, the purpose of instructional videos should be made clear.

Second, perfecting videos is not recommended. The more teachers try to make a video without any trivial errors, the more time it takes to make it. This demotivates teachers from preparing videos. If lessons are based on instructional videos, a large amount of videos will be required. Therefore, it is advisable to make videos and not care about tiny errors such as a stutter.

Third, it is essential to consider the number of ways to distribute videos. In Fujita (2018), I basically used YouTube as a platform for providing videos to learners. However, there were some students who had difficulty in accessing YouTube due to the restriction on the use of cellular network and/or unavailability of an Internet network at home. To deal with this problem, Office 365 was used as an alternative to YouTube. Since Office 365 is contracted in almost all the NITs, the learners at the NIT, Fukui College, could use it at the time they

were on campus. Moreover, USB drives were also used to distribute the instructional videos. This enabled learners to watch the videos offline. Distributing videos in these three ways made the learners in my classroom watch them one way or the other.

The use of LMS: LMS has the potential to assist teachers' work and promote learning as it enables them to do many activities on the Web. It also allows teachers to give learners different kinds of homework (e.g., watching videos, quizzes, listening, and speaking activities), make an announcement, distribute teaching materials, take attendance, and much more. Moreover, LMS makes it possible to gather a variety of information in one place. The more tools and web services teachers try to use, the more websites the learners are required to access. This makes web-based learning complicated. If teachers gather all the information on LMS, all learners have to do is access the LMS and receive all the information that was provided by the teacher.

Although LMS makes it possible for learners to accomplish various activities, teachers do not need to utilize all the functions thoroughly. In Fujita (2018), I used LMS as a site for gathering information and presenting instructional materials (i.e., instructional videos and quizzes). Rather than using LMS exhaustively, teachers need to consider the purpose of using LMS, and how it can help their work.

One of the biggest problems of using LMS, especially Moodle, is that it takes teachers a huge amount of time to put questions into it as questions need to be entered one by one. To deal with this problem, using an import function is recommended. Moodle supports various kinds of formats to import data. These are shown in Figure 6.

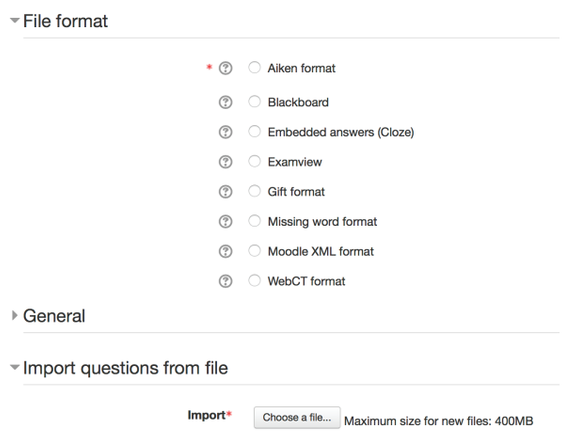

Figure 6. File formats for importing question data.

Although Moodle supports various formats to import data, two types of formats are introduced in this paper. The first is the Aiken format. This format is used to enter multiple-choice questions. This is one of the simplest formats. All teachers have to do is enter questions, options, and the correct answers. It is not necessary to learn a specific programming syntax. While it is not possible to enter explanations for questions, this format is suitable for creating a volume of simple multiple-choice questions efficiently. An example of the Aiken format is shown in Figure 7.

```
He ----- table tennis after school.

A. plays
B. play
C. playing

Answer: A
```

Figure 7. The Aiken format.

The other format is called the GIFT format[2]. This format is used to create various types of questions, such as multiple choice, true or false, match the following, and other questions. Moreover, comments, titles, and feedback of questions can be added. Although it is necessary to learn a specific programming syntax, this format allows us to enter questions with various settings.

Conclusions

This study presented the theoretical concept of BL and the case study conducted at the NIT, Fukui College. Based on the case study, some practical tips for conducting BL were also suggested. It was observed that BL has the potential to improve the quality of pedagogy, create a flexible learning environment for learners, and enhance cost performance. The role of WBT was classified into presentation, practice, collaboration, and distance learning. In the case study, the author's technical English teaching was presented with the use of electronic tools. It was reported that learners mostly commented favorably about BL. Based on the case study, some practical tips for carrying out BL were proposed. With regard to instructional videos, it was proposed that the videos should be as short as possible, teachers should not try to perfect videos, and the distribution of videos should be carefully considered. As for LMS, an efficient way of making question database was shown. Moreover, it was suggested that a careful consideration of the role of face-to-face classroom interaction and WBT is essential for BL.

Further research should examine the effectiveness of BL from an empirical point of view. As Whittaker (2013) states, there are few studies that investigated its effectiveness empirically. Moreover, although a certain type of BL (e.g., flipped approach) is widely studied, different varieties of BL should also be examined. Such future research will bring insightful perspectives not only of BL, but of the use of technology in education as a whole.

Acknowledgements

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Notes

[1] For details of the quizlet, see http://quizlet.com/

[2] For details of the GIFT format, see the following website. https://docs.moodle.org/23/en/GIFT_format#Question_format_examples

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USING SENTENCE DIAGRAMMING TO TEACH COMPLEX SENTENCE STRUCTURES TO NON-NATIVE ENGLISH SPEAKERS STUDYING ENGINEERING

Grumbine, Richard

[a] National Institute of Technology, Ariake College/General Education Department, Associate Professor, Omuta, Japan

*richard@ariake-nct.ac.jp

Abstract

Non-native speakers often struggle with complex sentences in English. However, effective methods for teaching complex sentences has rarely been addressed, especially to Japanese engineering students. Effective methods are lacking and the normally employed grammar translation approach has been only marginally successful. Sentence diagramming has long been overlooked in recent TESOL teaching methodologies (it is absent from most all Japanese government approved textbooks and most other EFL textbooks for that matter too). In an attempt to employ sentence diagramming to address this and other difficult grammar structures, a simplified sentence diagramming technique loosely based on Chomsky's X-Bar theory has been created by the author. This sentence diagramming technique is briefly introduced here along with methods on how to use this technique to teach complex sentences to engineering students. The full technique is featured in a beta text book currently in use at Ariake Kosen and being refined based on student/teacher input and results (Engineering English: A Sentence diagramming approach). This simplified diagramming method was used over a 4-year period to teach 5th year KOSEN students over the course of one academic year at Ariake Kosen. Student self reporting via survey shows that students felt the technique to be about as useful and enjoyable as their usual English classes, but their performance on a short test showed marked improvement a full 2 months after taking any English classes when compared to students exposed to more traditional English classes.

Keywords: *ESL, EFL, Sentence Diagramming, ESP, TESOL, Complex Sentences, KOSEN*

Introduction

English education has been an ongoing challenge for teachers at KOSEN, where students frequently lack motivation and/or ability as reflected in their poor TOEIC scores, often scoring even lower when they finish their 5-year education with a KOSEN than when they began, Tokuda et. al. (2008). One area of particular difficulty is processing complex sentences, Norris (2000). The 5th year students who participated in this study had a mean score of 326 on the TOEIC before beginning their last year at KOSEN. This puts them well behind the already minimal goal of 400 set by the institution - a score very few students successfully achieve. It is assumed that teachers have tried many different techniques over the 8-year course of English education that these students have received both at KOSEN and before arriving at KOSEN. Most classes in Japan are taught by non-native speakers using a grammar translation technique, only rarely supplemented by native each speaking assistants and other methods. This is apparently ineffective as indicated by the poor scores reported above.

To try to improve KOSEN student English ability, a completely different approach rooted in both sound pedagogical theory and suitable for students with an engineering mindset and engineering ambitions was created and implemented by the author. A method that should be comfortable for teachers and amenable to the larger system in which it has to be used: sentence diagramming. This method is meant to raise student consciousness of English grammar and help students visually process grammar including complex sentence patterns. And since the material is "familiar" on a certain level, it can be taught in English by Japanese English teachers as well. The example sentences used heavily feature COCET vocabulary aimed at science and engineering students, Kameyama et.al (2011). There was no particular attempt to teach vocabulary outside of relevant word usage in the sentences examined by students. Instead the focus was on grammatical structures, taught via sentence diagramming. The students in this study were 5th year students, divided into 5 groups based on their majors (all various engineering majors). Four groups were taught using the above-mentioned Sentence Diagramming Technique while the last group was taught using a standard grammar translation technique. After the break between school years (approximate 6 weeks later plus two more weeks for other introductory course work), the students that returned to the graduate program were then tested using a short multiple-choice test to check if they understood how to use subordinating conjunctions in complex sentences. All students also took a self-report survey concerning their attitudes towards the two different techniques, Sentence Diagramming and Grammar Translation.

Method

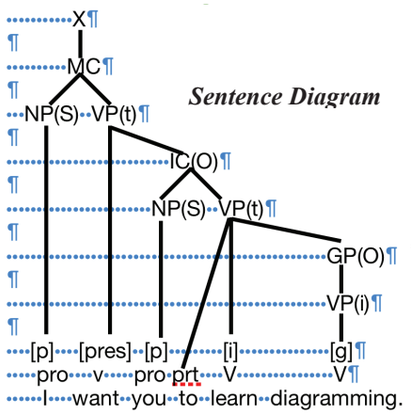
The students in the experimental group were taught in English how to diagram sentences for one year. It was

hoped that this approach would both improve upon and scaffold on the grammar translation method that they had already been exposed to in their prior English classes and reinforce the vocabulary Engineering students need for success in their fields. Since Japanese teachers of English already often use many of the concepts required in sentence diagramming due to their normal grammar translation pedagogy it was hoped that students would be comfortable with the idea of learning sentence diagramming in English and that they would already have the basic knowledge needed to succeed. Grammar being one of the main thrusts of Grammar Translation. Also engineering students likely already use other kinds of diagrams in their major course work, so they may find a certain amount of comfort in using diagrams to help them with English grammar. Sentence diagramming is also a more interactive and visual technique than grammar translation, so it actively engages students in ways they have not previously used in English class before but in which they have had success in their major course work. The students in the control group were taught using the traditional grammar translation approach (neither teacher was aware of the experiment being performed as it was conceptualized after the fact).

The approach around which the diagramming method is built, is a modified version of tree style sentence diagramming based loosely on Chomsky's X Bar theory, Chomsky, N. (1980) and as presented in Burton Roberts, N. (2011). The material was introduced to the students using a textbook created by the authors, Engineering English 2nd Edition, Grumbine, Furuike (2017). As mentioned before, the hope was that this approach would appeal to engineering students as sentence diagramming is more analytical and visual in its method and scaffolds on the grammar translation system to which they have already been exposed but with which they have generally had little success. The basic concepts and vocabulary presented should already be familiar to the students but the technique itself is new. This combination of both familiar and new material, it was hoped, would allow the students to build on past knowledge, increasing their ability to learn the new material presented. While the exact diagramming technique is new information for the students, the idea of diagramming itself to make complex systems easier to understand should be a familiar exercise for them, as each discipline has its own diagrams.

An original system for diagramming sentences was created by the authors with the aim of raising grammatical consciousness of the diagrammer. The first step is to identify and label the basic grammatical building blocks that make up a sentence - the parts of speech. From these blocks, the students learn how to identify larger chunks or phrases which are also labeled for both form and function. Lines are drawn connecting these chunks to one another showing relationships between various phrases and clauses. Students must label the forms (clauses and phrases), functions (subjects, objects, complements, adverbials etc.), and other details (tense, voice, count, plural, etc.) and show relationships in the diagram. Students are forced to pay attention to many important aspects of grammar normally not noticed, and come to understand how parts are related without learning a lot of cumbersome grammar rules. This hopefully serves to raise students' grammatical consciousness and helps them better understand common patterns of English in a new way. The rules of grammar will take on a more analytic and visual form, making this information more accessible and memorable. The puzzle like aspect of diagramming may make the activity more interesting and can be done in small groups, encouraging team work and the sharing of knowledge. See the diagram in Fig. 1, below for an example of a basic sentence diagram featuring a complex sentence.

Fig.1.



In the diagram above, Fig.1, students have to label many parts and show relevant connections and functions (See Appendix A). First, they label the parts of speech with lower case letters. Then they have to identify details in brackets. Then they have to chunk the sentence into larger parts (phrases and clauses) labeled in capital letters, mostly working top down and drawing lines to show relationships. Then they must identify the associated functions in parentheses. In this way students become aware of the forms and functions of clauses and phrases and come to see their functions and relationships to each other. They also have to show the hierarchical structure of the sentences by connecting the parts appropriately using straight lines, showing which forms are parents, daughters, or sisters etc... Recognizing these relationships draws student attention to the forms, functions, and important details of a sentence that they might otherwise ignore and they can come to see how independent clauses and dependent clauses are related to each other and what phrases constitute each clause. This makes students much more aware of how clauses are built and function in a sentence.

This diagramming technique was used to teach 4 of the 5 engineering classes while the 5th class was taught using a more "standard" grammar translation technique. The students were taught in groups of roughly 40 by a single teacher in 90min blocks once a week for 32 weeks with each class focusing on a particular grammar fea-

ture. The diagramming classes generally followed a regular procedure: A short review of the previous weeks work conducted mostly in English (usually in the form of interactive Q&A). Then several example sentences are presented that feature the grammar point being explored that day with students encouraged to discover the patterns and relevant details and to build on what they already know by labeling the parts of the sentence. Then the remaining "new" forms or ideas are explored and taught including any new labels and diagramming techniques required. After this has been presented thoroughly, the relevant grammar vocabulary is reviewed. Finally, the students are broken into small groups (4-6 students) to work on diagramming more example sentences. When they are finished, groups are called to the board to present their diagrams which are then examined as a class for accuracy. A short review of the important points follows and finally a quick Q&A to check for understanding. Tests were given quarterly to both the control and experimental groups. Clauses are among the last grammatical forms to be examined and are given 5 weeks of time, roughly one week per clause type. Students who enrolled in the advanced course the next year semester were later given a survey that contained 5 questions about their attitudes towards the English class and 10 questions about subordinators. This survey and quiz were given about 8 weeks after their last English class.

Results and Discussion

After 8 weeks the students were asked to take a short 7-point Likert like attitude survey to measure how they felt about sentence diagramming or grammar translation and then a short quiz on subordinators in complex sentences. The survey was presented in both English and Japanese to make sure students fully understood what was being asked of them. The ten questions concerning complex sentences were TOEIC style and presented in English only. Students had to choose the correct subordinators to correctly complete the sentences (See Appendix B).

When students were asked about their previous English class, the differences were minimal with a slight preference for the grammar translation technique (2.28 vs 2.17 on a 7-point scale).

But performance on the quiz showed a marked difference of ability between the two groups. With the students who learned sentence diagramming scoring much higher. The quiz was comprised of 10 sentences, 9 of which were complex sentences and one which was compound. For the complex sentences, 3 contained noun clauses, 3 contained adjective clauses, and 3 contained adverb clauses (72% correct vs 54%). However, the samples sizes were far too small to generate statistically significant results, so a repeat of the experiment with larger number of students would be required (but is not possible on our campus alone due to size). The experimental group and the control groups contained 18 and 7 students respectively.

The survey can be found in the appendix.

Conclusions

Sentence diagramming was seen as slightly less enjoyable, having scored slightly lower on self-reports of enjoyment and challenge when compared with their usual grammar translation classes. But the performance of the students on TOEIC style questions involving complex sentences were much higher. Thus, it seems fair to say that the technique shows promise for the classroom. Larger sample sizes and a variety of teachers using the technique would be helpful in appraising the effectiveness of the technique more accurately.

Acknowledgements

The authors would like to thank the students, faculty, and staff of Ariake National College of Technology for their patience and goodwill in regards to this project.

APPENDIX A

Parts of speech

noun	n
verb	v
adjective	adj
adverb	adv
pronoun	pro
preposition	pre
conjunction	con
interjection	int
auxiliary	aux
particle	prt

Verb Details

past	[past]
present	[pres]
future	[fut]
plain	[plain]
perfect	[perf]
progressive	[prog]
passive	[pass]
infinitive	[i]
gerund	[g]

Noun Details

count singular	[cs]
count plural	[cp]
non-count	[nc]
proper singular	[ps]
proper plural	[pp]
proper non-count	[pn]

Conjunction Details

coordinating	[c]

subordinating	[s]

Pronoun Details

personal	[p]
indefinite	[i]
demonstrative	[d]
question	[q]
relative	[r]

Clauses

Main Clause	MC
Adverb Clause	AvC
Adjective Clause	AjC
Noun Clause	NC
Gerund Clause	GC
Infinitive Clause	IC

Phrases

Noun Phrase	NP
Verb Phrase	VP
Adjective Phrase	AjP
Adverb Phrase	AvP
Prepositional Phrase	PP
Gerund Phrase	GP
Infinitive Phrase	IP

Functions

Subject	(S)
Object	(O)
Complement	(C)
Adjunct Adverbial	(AA)
Adjectival Modifier	(AM)
Disjunct Adverbial	(DA)
Conjunct Adverbial	(CA)
Question	(Q)
Appositive	(A)

Predicate Patterns

intransitive	(i)
transitive	(t)
ditransitive	(d)
complex	(c)
linking	(l)

Other

null	∅
possessive	POS

Appendix B

Survey as presented to the students:

Survey - This is NOT for a grade. Fill in your class only (M=1 E=2 I=3 C=4 A=5)
アンケート - あなたの成績には関係ありません。クラスのみ記入してください。

Part I

Using a scale of 1 through 7 how much do you agree or disagree with the following sentences (1= completely agree and 7 = totally disagree):
下の文章にどのていど同感できるかを１から７の尺度で表して下さい。（１はとても同感できる、７は全く同感できない）

1. I found my English class last year to be more interesting than my usual English classes.
去年の英語の授業は、従来の英語の授業よりも興味深いと思った。

2. I felt my English class last year was more helpful than my usual English classes.
去年の英語の授業は、従来の英語の授業よりも英語学習に役立つと感じた。

3. I found my English class last year to be more enjoyable than my usual English classes.
去年の英語の授業は、従来の英語の授業よりも楽しいと思った。

4. I feel that my English class last year will help me with my future English studies.
去年の英語の授業は、今後の英語の学習に役立つと思う。

5. I preferred my English class last year to other English classes.
去年の英語の授業は、他の英語の授業よりも好きだ。

Part II

TOEIC style questions. Select the best answer to correctly complete the following sentences:

6). _____I ate curry for breakfast was a mistake.
1. Because; 2. And; 3. So; 4. That
7). Tell me_____ you like about English.

1. what; 2. because; 3. if; 4. and

8). The man of _____ you speak is not here.

1. but; 2. what; 3. whom; 4. so

9). I will go to the movies with you _____ you pay.

1. while; 2. that; 3. if; 4. whom

10). _____ you bought the drinks, I will pay for dinner.

1. While; 2. Because; 3. So; 4. That

11). I took a shower _____ she studied.

1. while; 2. whom; 3. however; 4. only

12). The woman _____ came to dinner was my sister.

1. while; 2. moreover; 3. who; 4. when

13). I couldn't start the car _____ is in the garage.

1. when; 2. while; 3. that; 4. but

14). Bob made dinner _____ Sally made dessert.

1. and; 2. that; 3. whom; 4. really

15). That is the place _____ I broke my leg.

1. so; 2. where; 3. when; 4. what

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GROWING CHARACTERISTICS OF GENERIC SKILLS OF STUDENTS OF NATIONAL INSTITUTE OF TECHNOLOGY, SENDAI COLLEGE AND A PROPOSAL OF AN EVALUATION METHOD OF GENERIC SKILLS

K. Kawasaki *[, a], K. Yajima [a] and A. Takahashi [a]

[a] Department of General Engineering, National Institute of Technology, Sendai College, Sendai, Japan

* E-mail: kawasaki@sendai-nct.ac.jp

Abstract

It is very difficult to quantitatively evaluate the Generic Skills (GSs), because GSs cannot be evaluated only through school examinations. In order to quantify GSs, evaluation methods using rubrics are the most common. These methods, however, still have the following problems: 1) the results of the evaluation cannot avoid including the teachers' and/or the students' subjective views and 2) there may be some differences of the recognition in the evaluation between the teachers and the students.

Since the academic year of 2014, we have conducted "Progress Report on Generic Skills (PROG) test[1]," as a method for confirming the educational effects and evaluating our college students' GSs accurately and objectively. From the results of PROG tests in the last 4 years, the growth of our students' GSs has been found to have the following tendencies:

1. **In the Literacy part, all graders have shown the steady growth in their abilities every year.**
2. **For the Competency part, upper graders (the fourth-, fifth-grade and advanced-course students) have shown the steady growth in their abilities, while lower graders (the first-, second- and third-grade students) have not.**

Meanwhile, National Institute of Technology (NIT) has proposed the Model Core Curriculum (MCC)[2] of the learning contents. In the MCC, the corresponding skills to GSs are defined as Cross-sectoral skills (CSs) required for engineers, by 16 components. NIT has been trying to obtain quality assurance of its education by utilizing these components. However, its evaluation method has not been established yet, because some elements cannot be evaluated only through classes in the school. Therefore, as one of CSs evaluation methods, we propose to evaluate CSs by converting the PROG results to the CSs scores. Since it has been found that CSs can be sufficiently evaluated by using the PROG results, we introduce the converting method.

Keywords: *Engineering Education, Quantitative Evaluation of Generic Skills, Utilization of PROG test, Active Learning, Problem/Project Based Learning*

Introduction

The development of the students' GSs has long been required in educational institutions, in addition to the acquisition of expert techniques and knowledge in particular fields. To meet the requirement, educational institutions of any generations have been enthusiastically working on developing the GSs. However, it is very difficult to quantitatively evaluate the GSs in accurate and objective manners, because GSs are abilities acquired through their experiences and some components of GSs cannot be evaluated only through school examinations. In order to quantify GSs, evaluation methods using rubrics are the most common. These methods, however, still have the following problems: 1) the results of the evaluation cannot avoid including the teachers' and/or the students' subjective views and 2) there may be some differences of the recognition in the evaluation between the teachers and the students.

Since our proposal was adopted as the Acceleration Program for University Education Rebuilding (AP)[3] in 2014, our college has strongly promoted the introduction of AL techniques and PBL to regular lessons and experimental practices and we have been working on developing students' GSs. To evaluate our college students' GSs accurately and objectively, we have conducted PROG tests since the first year of AP. From the results of PROG tests in the last 4 years, we have observed the growing tendencies of our students' GSs. In this paper, therefore, we report the growing tendencies of our students through the reform of the teaching methods.

Meanwhile, National Institute of Technology (NIT) has proposed the Model Core Curriculum (MCC) of the learning contents. In the MCC, the corresponding skills to GSs are defined as Cross-sectoral skills (CSs) required for engineers, by 16 components. NIT has been trying to obtain quality assurance of its education by utilizing these components. However, its evaluation method has not been established yet, because some elements cannot be evaluated only through classes in the school. Therefore, as one of CSs evaluation methods, we propose to evaluate CSs by converting the PROG results to the CSs scores. Since it has been found that CSs can be sufficiently evaluated by using the PROG results, we introduce the converting method. We show that the PROG test can be used to quantitatively evaluate the

elements of GSs which are defined independently by each educational institution.

An Evaluation method of Generic Skills (PROG test)

We adopted the PROG test to evaluate our students' GSs. The PROG test was originally developed by KAWAI-JUKU[4] and the test consists of two parts: the Literacy part which evaluates the ability to apply knowledge to solve new or inexperienced problems and the Competency part which evaluates decision making or action principle characteristics that are developed through the experience of adapting to surroundings. Evaluation components of PROG test were defined by reference to key-competencies determined by DeSeCo project[5] of OECD. The evaluation contents of the Literacy part were classified into six categories, and those of the Competency part were classified into three categories that consist of 9 contents and 33 components.

The questions of the Literacy part are similar to those of Synthetic Personality Inventory (SPI)[6], while, in the Competency part, a number of questions are given in a questionnaire format, to examine the characteristics of behaviours. The scores of components in the Competency part were evaluated, by comparing the answers of the examinees with statistically processed exemplary answers from many Japanese businesspersons who were classified into the high level. The scores of PROG test are quantified with values from 1 to 7 (or 5, depending on the components), indicating that larger numbers are better results.

Results (Growing characteristics of Sendai College)

Sendai College consists of 7 departments of regular five-year training courses (Associates' Degree Course) and 2 majors of advanced two-year training courses (Bachelors' Degree Course). Since 2014 (the first year of AP), we have conducted the PROG test for our students. Table 1 indicates the grades of students who took the PROG test in each year.

Figure 1 shows the annual changes of the overall scores of the Literacy part for four years from 2014 to 2017. And this figure tells us that the students' abilities have steadily grown up every year regardless of their grades. In addition, in comparison with the average score (4.80) of the first-grade students at University in 2017 who study at departments of engineering, the average score of regular second-grade students in our college (the grade corresponds to the second-grade of high school) is higher.

Similarly, in the case of the Competency part, the annual changes of the overall scores for four years from 2014 to 2017 are shown in figure 2. For the Competency part, it is observed that upper graders (the fourth-, fifth-grade and advanced-course students) have shown the steady growth in their abilities, while lower graders (the first-, second- and third-grade students) have not. Furthermore, the average score (3.07) of the first-grade students at University in 2017 who study at departments of engineering is equivalent to those of our lower graders. And, the average score of our upper graders is higher than those of the first-grade students at University.

Table. 1 The grades of students who took the PROG test in each year

Grade	Year			
	2014	2015	2016	2017
Regular 1	○	○	○	○
Regular 2	○	○	○	○
Regular 3	○	○	○	○
Regular 4	○	○	○	○
Regular 5	○	△	○	×
Advance 1	△	△	○	○
Advance 2	△	△	○	○

○: Students of every department and major took the PROG test
△: Only students of some departments and a major took the PROG test
×: Students did not take the PROG test
*In the analysis in this paper, the data of △ are not included because the numbers of samples are very different.

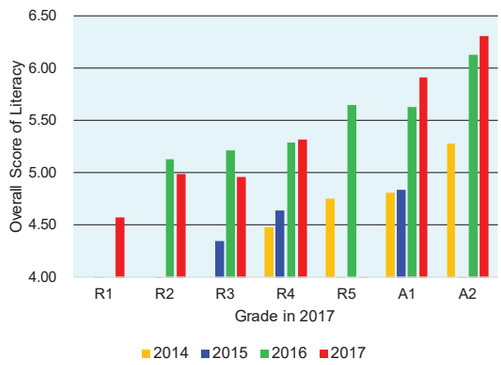

Fig. 1. Annual changes of the overall scores of the Literacy part for four years from 2014 to 2017.

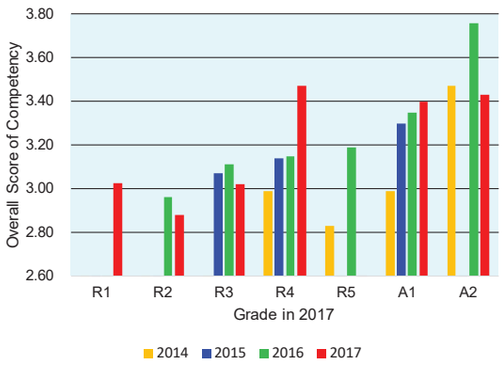

Fig. 2. Annual changes of the overall scores of the Competency part for four years from 2014 to 2017.

Both the results of the Literacy and the Competency part tell us that the education of GSs at our college is sufficiently effective.

Next, we will explain the results of the analysis by using subdivided components rather than the overall scores of both the Literacy and the Competency part. Figure 3 shows the result of the analysis of subdivided components of the Literacy part of the fourth-grade students in 2017, who never failed to take the test for all four years from 2014 to 2017. In figure 3, coloured line charts indicate the scores of each year for all six components of the Literacy part and yellow bar charts indicate growth from the first grade for the components. It is obvious from the bar charts that our students' abilities have grown up for all components as they promote from the first grade to the fourth grade. However, some differences in the growth rate of individual components appear to exist. Our students tend to show steady improvement in the skills of (A) Collecting information and (B) Analysing information, while not in the skill of (E) Linguistic processing.

For the Competency part, the result of the analysis of subdivided components of the fourth-grade students in 2017 is shown in Figure 4. Figure 4 tells us that the skills of (A-2) Cooperating with others, (B-2) Self confidence and (C-1) Identifying problems show steady improvement, while the skill of (C-2) Planning solutions does not. The reason for little improvement of the skill of (C-2) Planning solutions might be that there had been only a small number of classes to grow the skill until the fourth grade, but we need to examine this result closely, including effects of the reform of the lesson curriculum.

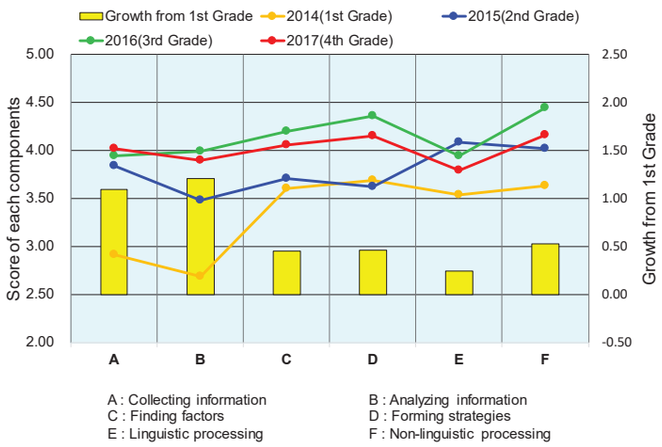

Fig. 3. Scores of subdivided components (colored lines) and growth from the first grade (yellow bars) of the fourth grade students in 2017 in the Literacy part.

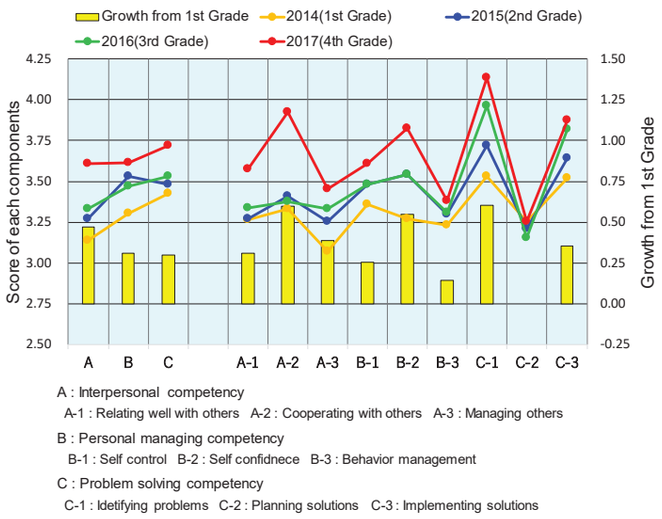

Fig. 4. Scores of subdivided components (colored lines) and growth from the first grade (yellow bars) of the fourth grade students in 2017 in the Competency part.

Utilization of PROG test for evaluation of Cross-sectoral skills in the Model Core Curriculum

The MCC of the learning contents has been proposed by NIT to obtain quality assurance of its education. In the MCC contents, CSs unrelated to specialized fields are included as corresponding to GSs. The CSs are made up of 16 components listed in the right side of Figure 5. NIT has been trying to evaluate the CSs by using rubrics. However, due to the present situation that activities outside classes (e.g., activities at the student coucil, clubs and dormitories that not all students belong to) are objects of the evaluation and that in some components the rubrics have not been determined, its evaluation method is not said to have been established yet. Fouthermore, in additon to a great deal of burden of a small number of teachers required to evaluate many students' CSs, there might be some differences between the teachers' evaluation and the students' self-evaluation. Therefore, it is very important to evaluate the students' CSs accurately, excluding the evaluators' (both teachers' and students') subjective views. Hence, as one of accurate and objective evaluation methods of the CSs that can reduce the burden of the teachers, we propose an evaluation method of the CSs which converts the PROG results to the CSs scores.

In Figure 5, the outline of PROG components and 16 components of the CSs are shown. As an example of converting the PROG results to the CSs scores, we will explain about two cases of (A) Communication Skills and (E) Logical Thinking Skills of the CSs. Since evaluation components of PROG related to (A) Communication Skills of the CSs are considered to be (E) Linguistic processing in the Literacy part and (A-1) Friendliness and

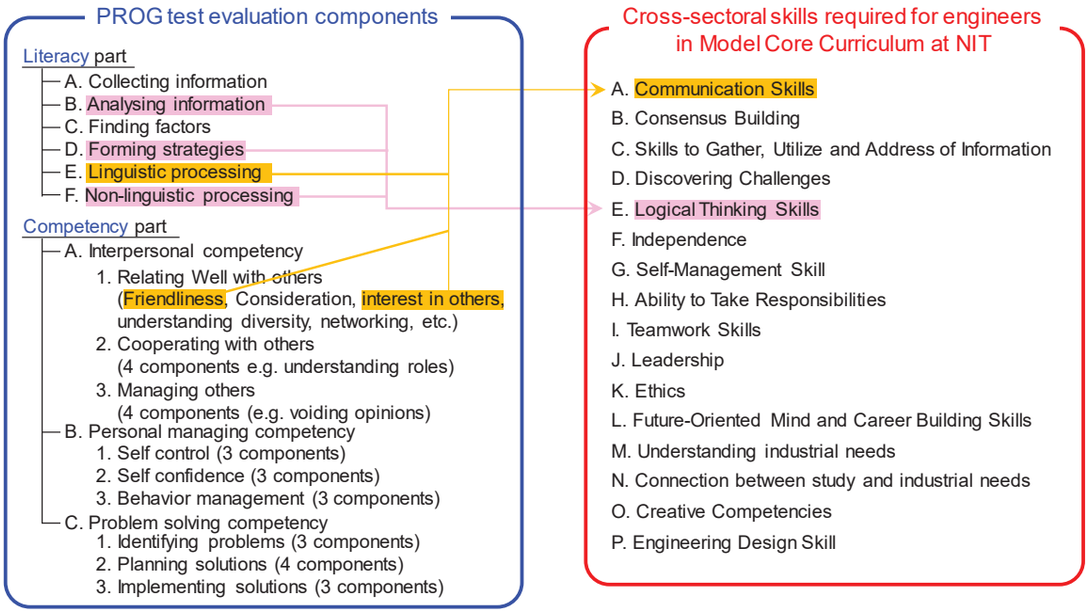

Fig. 5. Outline of PROG components, all (16) components of CSs and two examples of converting the PROG results to the CSs scores.
Orange arrows indicate that score of Communication Skills of CSs in MCC is determined by the average score of three components (Linguistic processing, Friendliness and interest in others) in PROG test. Pink arrows indicate that the score of Logical Thinking Skills of CSs is determined by the average score of three components (Analyzing information, Forming strategies and Non-linguistic processing) in PROG test.

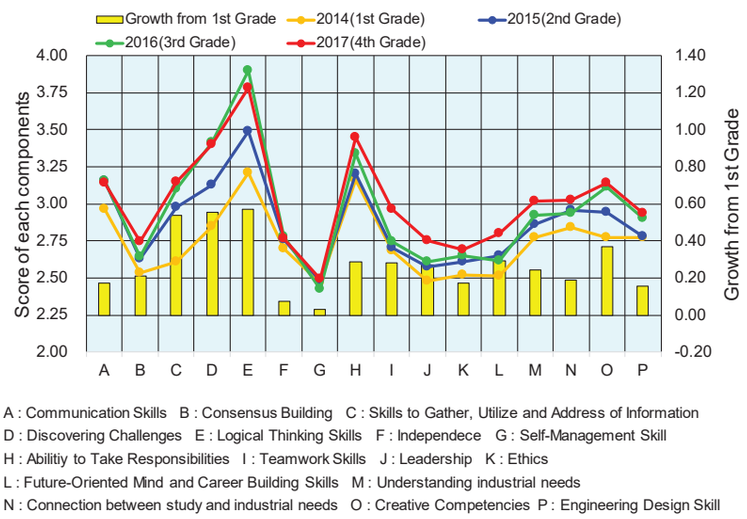

Fig. 6. An example of evaluated results of CSs in MCC by using PROG results. The growing characteristics of the fourth-grade students in 2017.

interest in others in the Competency part, the average score of these 3 components was detemined as the score of the Comunication Skills of the CSs. Similarly, the score of (E) Logical Thinking Skills was determined by the averege score of (B) Analysing information, (D) Forming strategies and (F) Non-linguistic processing in the Leteracy part. The scores of all components of the CSs are determined by converting the average score of the related PROG components in the same way as the scores of the Communication Skills and Logical Thinking Skills.

Figure 6 shows the result of fourth-grade students in 2017 evaluated by the components of the CSs. Obviously, from the figure, the growing characteristices of the students can be obserbed even if the components of the CSs are chosen for evaluation components. The components of (C) Skills to Gather, Utilize and Address of information, (D) Discovering Chanllenges and (E) Logical Thinking Skills show great improvements, while the components of (F) Independence and (G) Self-Management Skill show only slight improvements. It does not mean that the analysis of growing characteristics is not possible for two components that do not show steady improvement, because these componets also show little improvement in the PROG results. Hence, we can say that the CSs can be sufficiently evaluated by using the PROG results.

Figure 6 shows the results of the simplest coversion form which uses the average scores, as described above. When we actually evaluate the CSs by using the PROG results, however, it is necessary to carefully consider the

selection of the relevant components of the PROG test to the individual components of the CSs and the determination of factors involved in converting the PROG results to the CSs scores.

Conclusions

As a method for confirming the educational effects and evaluating our college students' GSs accurately and objectively, we have conducted PROG test since the academic year of 2014. From the results of PROG tests in the last 4 years, the growth of our students' GSs has been found to have the following tendencies:

1. In the Literacy part, all graders have shown the steady growth in their abilities every year.
2. For the Competency part, upper graders (the fourth-, fifth-grade and advanced-course students) have shown the steady growth in their abilities, while lower graders (the first-, second- and third-grade students) have not.
3. The PROG scores of our college students are not inferior to those of the students at University who study at departments of engineering.

As a method to accurately and objectively evaluate the CSs of MCC at NIT, we propose an evaluation method of CSs by converting the PROG results to the CSs scores. It is found that CSs can be sufficiently evaluated by converting PROG results that are related to the CSs components. This result indicates that the PROG can be used for quantitative evaluation of the GSs elements that are defined independently by each educational institution.

Acknowledgements

This survey was supported by the Acceleration Program for University Education Rebuilding, Ministry of Education in Japan. We are deeply grateful to the principal, teachers and support stuffs of our college for their contribution to this project. In addition, we appreciate Mr. Kondo at RIASEC Inc. for helpful cooperation in the analysis of data.

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DEEPENING BUSINESS COMMUNICATION SKILLS FOR A 21ST CENTURY WORKPLACE

R. Song [a], H. Koh [a], P. Kaur [a], D. Tan [a], V. Koh [a] and C. Lim [a]

[a] Ngee Ann Polytechnic, School of Business & Accountancy, Singapore

*Ruth_SONG@np.edu.sg

Abstract

Communication skills are indisputably important for the 21st-century workplace, a non-negotiable hiring prerequisite across employers and industries. The Business Communication (BCOMM) modules at the School of Business and Accountancy (BA) at Ngee Ann Polytechnic aim to develop students' mastery of relevant communication competencies to adequately prepare them for the future workplace. BCOMM comprises three compulsory sequential modules (BCOMM1, BCOMM2, and BCOMM3) taken from Year 1 to Year 3 by all BA students. BCOMM has defined four hallmarks in the communication skill sets - Oral Communication, Written Communication, Interpersonal Skills and Persuasion Skills. These skills are uniquely scaffolded for increasing level of competencies and rigorously reiterated through BCOMM's teaching and learning pedagogy and assessments structure across the three years.

Scenario-Based Learning is used extensively both in learning and assessments to simulate real-world situations. Unique to BCOMM's role-play strategy is the use of 'Immersive Participation' where the tutor takes on a 'role' and is 'immersed' in the role-play assessment with the students. Students learn to effectively and professionally respond to real-world situations such as in job interviews, networking sessions, data-gathering meetings and boardroom presentations. Blended learning (in the form of both flipped and remote learning) is also employed to support the diversity of learning styles and the differing abilities of students. Timely feedback is used as a tool for learning where students get validation for their effort and are guided to improve in future assessments.

Besides mastering communication skills, students also gain other fundamental workplace skills such as critical thinking, global awareness, situation awareness, personal branding and professionalism through BCOMM. Students are able to apply and transfer the skills to other polytechnic modules and future work functions and industries.

Keywords: *business communication, scenario-based learning, experiential learning, 21st-century competencies, industry relevant, blended learning, workplace skills*

Introduction

In a survey done in 2017 with more than 100 employees, Ngee Ann Polytechnic's (NP) Office of Internship & Careers (OIC), found out that communication skills such as the abilities to communicate verbally, write for work, relate well to others and persuade or influence others were highly valued by employers (Ngee Ann Polytechnic, 2017).

Communication skills are key hiring requirements in a 21st century workplace as the ability to communicate effectively can potentially improve customer experiences, build brand awareness and most importantly, increase sales. These are all key factors for the long-term sustainability of businesses in a globally competitive economic landscape.

Furthermore, for the 21st century worker, communication skills support the development of other critical workplace values like teamwork, leadership and workplace diversity, which are necessary for thriving in an environment where the concept of work is rapidly changing.

Considerations for Curriculum Design

a. Importance of Business Communication for work

In a 2017 report, the Committee on the Future Economy in Singapore highlighted the need to 'acquire and utilise deep skills' as a strategy to keep Singapore competitive. A superficial grasp of communication skills cannot meet the needs a 21st century workplace. If Singaporean students are to succeed in a 21st century workplace, they need to acquire and master the communication skills demanded by employers.

However, possessing excellent communication skills is not an innate ability (Wilczynski, 2009). Like any other skill, communication skills need to be practised over time for the learner to deepen his knowledge and skills, preferably with a facilitator who can connect real-

world situations to key learning points. Wilhelm, Logan, Smith, & Szul (2002, p.45) recommends multiple practices with an experienced practitioner under realistic working conditions as repeated practice helps the learner get the "feel of doing it proficiently."

The School of Business & Accountancy (BA) at Ngee Ann Polytechnic in Singapore recognised the importance of in-depth, rigorous communication skills training and developed the Business Communication (BCOMM) module to help its students master key communication skills through an iterative process.

b. Learning Needs of BCOMM Students

BCOMM 1, 2 and 3 reach an average of 2,400 students in total every year. The teaching team noticed that most students, who were taking the module, were divided into two main groups.

The first group consist of students who do not see the necessity of mastering BCOMM because they feel that they know the English language well. A leading reason could be that all students go through at least ten years of primary and secondary education in Singapore, which is primarily conducted in English. As English is also the vernacular of business in Singapore, some students think that excelling in English at the secondary school level automatically means that they can communicate just as well in business situations.

The second group of students are those that struggle with BCOMM. They are unable to express their ideas effectively and confidently in both written and spoken form due to inherent weaknesses in their grasp of the English Language. As a result, this group of students feel disadvantaged and unmotivated to invest themselves in BCOMM.

Both groups also seem to lack understanding of real-world workplace demands and are unaware that effective business communication is mutually beneficial not self-serving, nuanced not blatant, tailored not 'one-size-fits-all'. The expectations are far more advanced than what students have to demonstrate at a secondary school level.

With the knowledge of the students profile and the importance acquiring good business communication skills, the BCOMM team had to re-look at their curriculum design to ensure that both their learning objectives and the students' needs are considered in the design.

Overview of BCOMM

BCOMM is a core module for all students from BA's six diplomas, consisting of three sequential modules offered in each year of their studies. BCOMM 1 sets the foundation for first year students. BCOMM 2 expands on those skills for second year students. BCOMM 3 is a culmination of learning for final year students and challenges them in more advanced business situations.

a. Scaffolding the Learning

Based on updated environment scans and feedback from industry partners and alumni, BCOMM has defined four key communication skill sets as hallmarks of its curriculum - Oral Communication, Written Communication, Interpersonal Skills, and Persuasion Skills. This was further validated in the survey done by NP's Office of Internship & Careers (2017) as communication skill sets that employers highly value in the 21st-century graduates they want to hire.

Instead of learning one skill set in isolation, all four hallmark skill sets are taught in BCOMM 1, 2 and 3 - setting up a dynamic structure for students to reiterate and expand on previously-learned skills. Students have to learn and master basic skills before moving onto more advanced skills.

In BCOMM 1, students build foundational writing skills by learning how to write meeting minutes and business letters. In business letter writing, they are also evaluated on their ability to influence the reader's decision via the written form (integrating the persuasion skill set). Students learn the fundamentals of interpersonal skills by learning how to conduct business meetings. They are also taught how to give persuasive presentations in teams and individually.

In BCOMM 2, the focus is on the deep practice of these four skills. Students are taught to use primary and secondary data to discuss a business proposition in a logical and professional fashion through writing a business report. This is linked to students learning how to deliver an impromptu speech, utilising their skills of logical argument to deliver a clear and compelling speech in a very short amount of time. BCOMM 2 culminates with students learning how to write a persuasive cover letter and resume and handling a variety of interview questions during the interview process.

By the time students reach BCOMM 3, they would have sufficient practice in both the written and oral communication skill sets through their three years in the various modules of their diploma. Hence, in BCOMM 3, students are given more opportunities to work on their interpersonal skills. They learn to interact professionally in a networking situation and also how to manage different personality types in a business meeting. Through these, students hone their situational awareness in order to respond appropriately. In their final presentation to a group of "board members" (usually consisting of fellow classmates and the tutor), students use all the communication tools and strategies they have learnt to convince and convert the "board members" to their business propositions. Figure 1 highlights how the scaffolding process is applied specifically in the Oral Communication skill set. This intentional scaffolding process, weaved into all four skill sets, provides students with a logical learning progression, which in turn produces more confident and skilful student communicators (Popham, 2007).

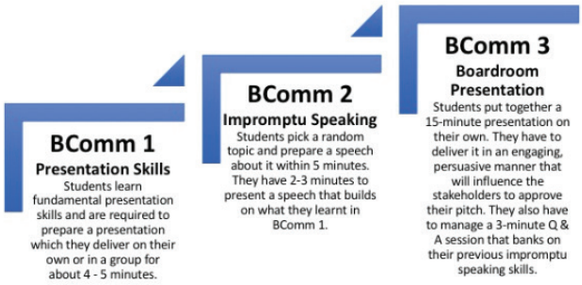

Figure 1. Scaffolding in the Oral Communication skill set

In the Director's Course Experience Dialogue (conducted in April 2017 semester), students were positive about the intentional scaffolding of the modules across all three years and they could see that BCOMM 1 topics were more generic whereas BCOMM 2 and 3 topics were more specific, which required greater depth and difficulty. This dialogue is organised for the Director of the school to meet students from the different diplomas to garner feedback on their experience in their respective courses.

Teaching and Learning Innovation

As BCOMM is a module that is for all BA students, it was designed to reach out to students of different abilities with a curriculum that brings the business world into the classroom, making learning applicable and engaging and most importantly, helping them to acquire and deepen their communication skills to succeed in the future workforce.

Scenario-Based Learning

In most real-world communication situations, the trajectory of the situation could change at any point in time, depending on the timing, people and context of the situation.

Hence, for students to learn how to communicate successfully in any business communication situation, mixing the right verbal and non-verbal strategies, they need to personally experience the complexity of human interaction on a business level to learn the techniques of handling such situations in the future (Kindley, 2002).

Scenario-based learning was picked as the most effective pedagogical approach in BCOMM. To support both teaching and assessment, the teaching team constantly develops a variety of brief business scenarios (to meet the industry needs of the different diplomas) with endings deliberately left open for students to explore in the role play. This means that BCOMM role-plays could have numerous trajectories and endings, depending on the interaction of the role-playing students.

This method differs slightly from traditional case study methods which present a comprehensive and detailed overview of the "problem" and students act out a well-scripted role-play as part of a controlled exercise to guide them to an in-depth understanding of the topic (Center for Innovation in Research and Teaching, n.d.).

The nature of this pedagogical approach puts tutors in the best position to assess students' actual mastery of the four skills. Through the direct observation of students in action during the scenario, tutors can accurately assess the level of expertise and accuracy of the skills students have learnt.

BCOMM also employs "immersive participation" (Farmer, 2014) in its scenario-based learning situations. Immersive participation occurs when the tutor plays an actual role in student role-plays to facilitate their learning in specific assessment scenarios such as job interviews in BCOMM 2, and the business networking, business meeting and boardroom presentation in BCOMM 3.

For example, in the BCOMM 3 business networking assessment, groups of students are required to interact with a Very Important Person (VIP), role-played by their tutor. Students need to introduce themselves and others, exchange name cards with each other as well as with the VIP, and sustain conversations with the others and the VIP. At the end of the meeting, students are to send a warm and positive follow-up email to the VIP within 24 hours. The objective of this assessment is for the students to create a positive impression on the VIP and make a connection that could turn into a mutually beneficial business relationship.

Actual scenarios have included:

- a junior banker who is attending a Formula One (F1) party and meets the Marketing Director of F1
- a HR executive attending a training at a well-known hotel and meets the General Manager of the hotel

Immersive participation in real-world role-plays enable tutors to nudge, cajole, prompt and manage students' dialogue and interaction especially when students are tongue-tied, veer off-topic or are not strategic during interactions in a business setting. This controlled yet realistic human behaviour based on tutors' industry experience provides an authentic learning experience as students can be subtly guided to more accurately apply concepts and frameworks through behavioural modification and adaptation as a result of real-time action-reaction. Feedback on performance by the tutor is provided immediately after the role-play to validate the student's decisions and actions or suggest corrective measures. This Tutor feedback comes from a personal point-of-view which exponentially enhances students' learning of how their actions affect another person's thoughts and impression.

Scenario-based learning has helped students experience Krathwohl's (2002) Six Levels of Learning

(which is based on Bloom's Taxonomy). When students apply their understanding of communication skills so that they can formulate the best communication strategy for a positive outcome, they are effectively synthesising the different elements of their learning. Learners are able to connect the relevance and significance of the learning to their personal aspirations and are thus more engaged to in further learning. In a BCOMM evaluation survey, one third-year Business student recognized the value of what he learnt to help him in actual situations in the future:

> "*BCOMM better prepared us for the future, whether in our workplace or (externally) at events. It teaches us ways to network with people which is an essential skill in today's context. Furthermore, I enjoyed the simulated context of the networking assessment as it gave me a better sense of the way to approach it.*"

Through and informal tracking of students from their first year to their last and anecdotal evidence from the teaching team, students seemed to have shown improvement in their ability to logically extrapolate the learning into different situations. They have also grown more confident and willing to try in more advanced communication situations.

Industry partners have also noted the relevancy of using scenario-based learning for the module. Jason Horkin, Senior Vice President of Attractions at Singapore's Resorts World Sentosa and external examiner for BCOMM 3 said this:

> *"Combination of assignments appears to be able to provide students with a variety of situations and requirements that will apply directly to real-world interactions."*

Using Technology for Learning

As a core module serving the entire School of Business & Accountancy, BCOMM has to consider the learning needs across a large spectrum of students, which would include "weaker" students. Instead of making the learning more "basic", the team implemented measures to make BCOMM more accessible to students of all learning styles, learning abilities and learning motivations.

As a pilot initiative in April 2017, the teaching team curated five Massive Open Online Courses (MOOCs) specialising in English Grammar to be opened to first year students who were, results-wise, weak in English. The MOOCs meant that they could practise as much as desired, until they reached the level of fluency that is expected of them in various modules they take and in the workplace.

All first year students were introduced to the MOOCs on NP's Learning Management System, "MeL". 221 students were specifically selected by their tutors to participate in these MOOCs. These students either scored a C5 or C6 in the English Language in their GCE 'O' Levels, or graduated from the Institute of Technical Education.

Five activities from the MOOCs were chosen for participating BCOMM 1 students to complete during the June holidays. Completion rate of the activities was 90.2% with an average score of 80.1% for those who tried the activities.

A feedback survey was conducted with the group of participating BCOMM 1 students. 54.8% found the online platforms helpful in improving their English language in comparison to attending actual classes, and 90.4% would definitely explore or consider exploring the links further should they require more practice. Through the survey, some first-year students also expressed the usefulness of the activities to their learning:

> *"I find that these online practices are quite useful and it allows us to know English standards."*

> "*I feel that these online practices help me to identify the mistakes that I make in normal writing*."

There are plans in BCOMM to better integrate these MOOCs into the main curriculum where students are clearer on how these courses support and supplement their success in BCOMM and other modules. The teaching team will also set up more robust metrics to track participation and progress of these students.

With limited in-class time and the perpetual need from students for more practice and feedback to achieve BCOMM's learning objectives, the teaching team saw the potential of moving certain curriculum content online to maximise face-to-face interactions between tutors and students.

In the first stage of development in 2015, topics that were not part of the assessed curriculum but beneficial to the students' whole learning were first to be converted into online lessons. BCOMM 1 created a learning package to teach students the APA Referencing Style and BCOMM 2 rolled out an e-course to teach students how to create their own LinkedIn profile.

As students demonstrated that they benefitted from the bite-sized nature of the courses, tutors felt confident to begin adapting parts of assessed curriculum into online material. Topics that were more instructive and where students would benefit from revisiting the information a number of times were part of the second stage of development in 2017. This included writing meeting minutes in BCOMM 1, job interview preparation in BCOMM 2 and how to handle objections in a meeting in BCOMM 3.

In April 2018, the BCOMM 2 team launched "Report Writing Made Simple" – a report writing e-course hosted on Blackboard Learn. Previously, the BCOMM 2 team taught report writing in class as the

assessment was worth 30% of the students' total grade, the largest assessment component of BCOMM 2. With the introduction of the e-course, in-class teaching time was reduced by 75%. Students accessed all other material online and more teaching sessions were converted into project consultations.

The BCOMM 2 teaching team felt that the online materials provided to the students did not differ in quality compared to classroom face-to-face interaction and students were provided with more materials online (than face-to-face) to ensure they did not lack the necessary support to complete the report writing project. A preliminary survey of the report writing project results have also shown that students who intentionally engaged (based on the quality of their consultation discussions) with the e-course performed better compared to students of the previous semesters who were taught the topic in class.

With technology, students are no longer restricted to their ability to learn in a fixed class setting. They are now able to customise their learning in a way that fits them best. Students with differing abilities are now able to participate equally in practice sessions that help them further deepen and broaden their communication skills.

Assessments in BCOMM

Assessments in BCOMM, set in the context of practical and realistic business scenarios, are designed to evaluate students fairly, authentically and holistically in the four skill sets and other critical workplace skills like situational awareness, teamwork, and professionalism.
As BCOMM is a practical life skill, assessments are typically based on real-world business scenarios that have no fixed approach to solving. Students have to 'do' the skill, with the liberty to incorporate their judgement, past experiences, and unique ideas to further accentuate their competency in the skill.

Students are evaluated using a set of BCOMM marking rubrics, created in discussion with industry partners and reviewed regularly to keep in line with industry trends. Criteria and their descriptors are based on industry standards which mean students are judged by the same markers of quality as in the real world.

Most importantly, BCOMM assessments are not 'once-off' evaluations. Prior to assessment, BCOMM students get to practise in class and tutors will provide feedback on their performance and provide an opportunity for students to clarify their doubts before the actual assessment. For assessments like Impromptu Speaking, students are graded on the better of two speeches. This gives time for students to act on feedback and so they can refine their performance (Hattie & Timperley, 2007).

One of the most important components of BCOMM to improve student performance and engagement is the use of immediate and comprehensive feedback. Hattie (2012) advises that for feedback to truly affect students, it needs to be "clear, purposeful, meaningful and compatible with students' prior knowledge, and to provide logical connections."

This is evident in BCOMM 2 where students have to go through the same impromptu speech assessment three times – the first time is a practice under assessment conditions, the second and third are actual assessments. A second year banking student was physically nervous and found it difficult to remain composed during the speech. After the practice session, the student was advised to channel his anxiety away from his hands and feet as those caused him to look anxious. He was also reminded of the strategies taught in class to structure a logical speech and end powerfully. In the first assessment session, he was visibly more confident and even used visual aids (his personal clothing) to convey his point effectively. His speech was clear, logical and engaging. In the second assessment session, the student applied all the feedback given to him regarding his nervous verbal/nonverbal signals and delivered a punchy, impactful speech that garnered him high marks. This example highlights how frequent feedback and the opportunity to apply the feedback can result in better student performance.

Students also noticed that feedback was pivotal in deepening their learning of communication skills. In the Director's Course Experience Dialogue (conducted in April 2017 semester), an International Business student pinpointed that the timely feedback given promptly post-assessment was the most treasured as it helped in his personal growth.

Effectiveness of Curriculum Transformation

The annual Module Evaluation Survey (MES) evaluates the effectiveness of the module based on six areas which include 'Thinking', Feedback' and 'Skills & Knowledge". Since the re-design of BCOMM, the MES score across all three BCOMM modules has been gradually improving from 4.84 to 5.28 from AY 14/15 to AY 16/17 (Table 1).

Section	AY 14/15	AY 15/16	AY 16/17
BCOMM 1	4.84 (Sem 1) 5.26 (Sem 2)	5.10 (Sem 1) 5.24 (Sem 2)	5.17 (Sem 1) 5.28 (Sem 2)
BCOMM 2			
BCOMM 3			

Table 1. An overview of BCOMM's MES Score

This upward trend shows that students are getting an overall classroom experience and they are also seeing how the modules support their future aspirations. This is due to BCOMM's innovative teaching method which include the use of feedback for learning, a strong communication transformation focus and relevance to the 21st century workplace.

The success of BCOMM is best experienced by students who have completed their six-month internship. Applicable to job roles and industries, communication skills learned in BCOMM have become extremely useful in actual work situations. Reflecting in her internship report, Ong Jing Ting, an International Business student and intern at Bake-It-Yourself wrote how BCOMM built the foundation for her to succeed at work:

> *"…as learnt in BCOMM, there are certain methods of asking questions without having to come off as impolite. The intonation of how you ask questions could make a big difference. On top of that, I learnt in BCOMM to always be prepared. … I finally understood how important it is to speak well and strive for an excellent first impression."*

Conclusion

BCOMM is constantly reviewed and updated to meet the latest industry trends through discussions with industry partners. Through a three-year program designed to give students time to practise their skills, industry-oriented T&L activities that makes the learning relevant, and authentic assessments that help students level up their ability to handle realistic business communication situations, students deepen their understanding of the four critical communication skill sets and a range of workplace skills that easily transfer across functions and industries.

Equipped with the ability and experience of handling realistic business communication situations, students will be able to thrive and succeed in a rapidly-changing global workplace.

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TRANSFORMING POLYTECHNIC ENGINEERING EDUCATION THROUGH PROJECT BASED LEARNING

Chee Chin TNG*, Kok Bin Alex SEE, Yinbei LI and Yun Long GOH

Ngee Ann Polytechnic/School of Engineering, Singapore

*tcc3@np.edu.sg

Abstract

The curriculum of the Electrical Engineering (EE) Diploma in Ngee Ann Polytechnic (NP) has undergone transformative changes in recent years. This is in response to the declining students' interest to pursue engineering, the need to stay relevant in the 21st century, and the changing education landscape. The Project-Based Learning (PrBL) approach dovetails seamlessly with engineering education as the engineering profession can hardly be practiced outside of project domains. From mass transit infrastructure and trains to energy efficient buildings, from power distribution systems to healthcare products and innovations, engineers work on projects to create, develop, value-add, and ensure that everything works to deliver quality systems, products and services to people and communities. Besides gaining technical competencies, students develop transferable skills that are highly valued by employers and industry. As students work on challenges in teams, they apply creativity, critical thinking, teamwork, communication skills, and time and project management skills, essentially simulating the real work environment they will eventually find themselves in.

EE's curriculum reform efforts started with the focus on the horizontal integration of three Year 2 modules centred on a real-world engineering project using the Project Based Learning approach (PrBL). This approach enabled students to connect classroom instruction with real-world problem solving. It also deepened their interactions with peers and lecturers. The early indications of success of this led the team to proceed to build PrBL into the curriculum to include other levels. The implementation is such that the project focus progressively deepens in terms of open-endedness, innovation, and complexity from level 1 to 3. The level one implementation anchors on a year 1 module, Analogue Electronics & Applications (AEA), culminating in an Arduino-based project demo on Smart Systems during the School of Engineering's Creativity and Innovation Week. PrBL finds its fullest expression in a level-3 specialisation option, Engineering Product Development where four core modules are integrated to enable students to develop an engineering product.

Preliminary evidences show that the PrBL implementation is promising in transforming engineering education and better prepare students for the profession. Further deepening and widening of PrBL in the curriculum are vital for full transformation. However, careful planning of staff and learning resources is critical as the project pedagogy is resource intensive. Furthermore, learner-centred learning is key as instructors move away from teacher-centred to a more facilitative style of teaching.

Keywords: *Project-based learning, critical thinking, engineering education, communication skills*

Introduction

The world is facing a shortage of engineers across multiple industry sectors and technology areas. Singapore's renewed focus on STEM and engineering in response to the shortage is but a reflection of the wider trend observable in other major economies, according to a report commissioned by UNESCO (Beanland and Hadgraft, 2013). The shortage of practicing engineers is of grave concern even as nations grapple with the grand challenges posed by climate change and environmental sustainability, shortage of food, clean water and renewable energy sources. In the VUCA (volatile, uncertain, complex, and ambiguous) world of the 21st century, engineering education can no longer remain business-as-usual. Educators must address the factors that turn students away from engineering, perceived as a difficult field of study with uninteresting job descriptions, unattractive career advancement and rewards (Beanland and Hadgraft, 2013).

This paper documents curriculum reform efforts undertaken by the Ngee Ann Polytechnic (NP) team for the Diploma in Electrical Engineering (EE). The team seeks to invigorate the learning of engineering and change the perceptions of engineering students especially the significant number who did not choose engineering as their top choice. Central to the curriculum change is the Project-Based Learning (PrBL) that holds much promise in getting students to engage in deep learning, gain a better appreciation for the engineering profession, and thus be better prepared for the industry. Many engineering schools in other parts of the world have adopted the PrBL approach to transform the conventional instructor-based teaching into student-centric learning; for example, Olin College of Engineering, Aalborg University, and Singapore University of Technology & Design, to name just a few.

Inspired by these trailblazers in the midst of a changing education landscape, in April 2014, Ngee Ann School of Engineering (SoE) piloted its first PrBL project linking three Year 2 modules centred on a real-world washing machine. Students implemented knowledge and skills acquired in the three modules and built sub-systems for the washing machine. Seeing an actual washing machine operate using the sub-systems designed and built by students themselves is a source of motivation for their learning. Building on this early success, the PrBL was subsequently applied to Year 1 and 3 curriculum as well. The outcomes of the initial reform efforts have been encouraging and paved the way for a more complete implementation of the PrBL approach.

PrBL in the Electrical Engineering (EE) Curriculum

The EE PrBL projects are real world in nature for all three years. This provides a powerful motivation for learning. Traditional engineering instruction is deductive, however, the PrBL approach is inductive (Prince and Felder, 2006); that is, a problem or project is used as an integrative driving question to facilitate the learning of one or more modules relevant to the project. In this way, learning is contextualised and meaningful to the learner.

In the curriculum for Diploma in Electrical Engineering, the PrBL is implemented with progressive scaffolding in terms of open-endedness, creativity, and complexity from Year 1 to 3. The PrBL is implemented in a more structured manner so that students are able to take on more challenging problems as they progress to higher levels. Year 1 real-world projects are simulated and scaled down to facilitate effective learning at the introductory level. Due to the simplified and approximated real-world project models, students are provided with more room to explore different innovative ideas. An overview of the PrBL implementation for the different modules from Year 1 to Year 3 is given in Table 1.

The freshman year project serves as an appetizer to induct students into the world of engineering. The challenge here is to use an interesting "hook" for the project, yet basic enough to engage all learners who are new to the course. The interesting range of sensors for year 1 Arduino control allows students to implement smart systems; these include motion sensor, ultra-sonic sensor, temperature sensor, shaft encoder, soil humidity sensor, gas sensor, and so on. Once students try their hands on such basic sensors and electronic controls, they will have more confidence to move on to the real-world engineering systems.

In Year 2, students work on real-world systems with real constraints such as the washing machine which requires much deeper knowledge of electrical engineering. As mentioned previously, students will have to link knowledge from 3 different modules to re-engineer a home washing machine using their own subsystems. Instead of learning the topics in isolation, this project enables students to see the practical application of the different modules and how they are linked together. In future implementation, students will design and build the different subsystems that make up an electric vehicle (EV).

When it comes to Year 3, students are free to innovate and build projects that have the potential for commercialisation, that is, highly innovative and with complexities befitting the final year level. Students are free to choose the type of projects for this module; they are also supervised by lecturers who are teaching the supporting modules. When students encounter problems with modules or project, they can immediately seek help and work together with "experts" to solve their problem. Student motivation for learning the modules is high because the content is highly relevant to the project they are working on.

Table 1. PrBL Implementation from Year 1 to 3

Year	Module & Description
1	Analogue Electronics and Applications (AEA): Students work on an Arduino-based smart system using Lego, electronics, sensors and microcontroller programming to simulate smart real-world applications.
2	Power Electronics and Applications (PEA), Sensors and Instrumentation (SIN), and Microcontroller and Applications (MA): Students build sub-systems of a real washing machine linking these three modules.
3	Integrated Project (IP), Intelligent Motion Control (IMC), Applied Analogue Electronics (AAP), and Embedded Systems and Applications (ESA): Students anchor the PrBL work on the project module supported by the 3 remaining core modules.

The year 3 implementation best represents the full essence of PrBL. The projects carried out by the inaugural batch of 11 students in the project module, Integrated Project, are open-ended and unique; for example, an exercise coaching robot for seniors and a mobile phone application that assists drivers to locate their vehicles in car parks.

Integrated Learning Space

An innovative feature of the PrBL is the integrated learning space for the Engineering Product Development (EPD) option in Year 3. Lessons for the three project-supporting modules are conducted in one single laboratory location where the project is carried out. The timetabled hours for each supporting module and the project module are 3 and 11 respectively, with a combined total of twenty hours (3x3 + 11). As students have sole access to the EPD laboratory, the learning of

modules and developing of project becomes integrated; remark from a student on the EPD illustrates this, "*Students are able to learn lots of new things and immediately implement in our project. Thus, we memorize all the concepts and also have a chance to use our knowledge in our own project after learning*".

Results and Observations

The survey results for the Year 1 PrBL experience were positive. Of the 163 students who responded, 85.9% agreed or strongly agreed that project work has helped them to stimulate their creative and innovative abilities; 79.8% responded that the project work has helped them in understanding the modules and overall learning experience while 76.1% have indicated that the project was interesting and it excites them about engineering. In addition, 85.9% of the students have also said that the project experience has allowed them to connect classroom's instructions and real-world problem solving. These are all postive indicators to show that Year 1 students have found the PrBL experience useful for them and have motivated them to learn engineering. Students were open to learning through working on projects even though this was just an initial exposure for them.

The survey for Year 2 washing machine projects is consistent with results obtained for year 1. There were 129 Year 2 EE students who responded to the survey. Students indicated that they were positive about the Year 2 PrBL experience with 78.9% agreeing that this experience has helped connect classroom instructions with real-world problem solving. 82.7% of the students also felt that they have more understanding of the module which is higher by 2.9% compared to the Year 1 figure, 79.8%. The lower figure for Year 1 is possibly due to the fact that Arduino programming is not in the Year 1 syllabus and this is something "extra" that students learn in order to implement smart control of electronics; the additional learning is perceived as not directly related to the module.

(1) Real-world projects with constraints vs Creativity & Innovations

It is also noted that the Year 2 students were less positive in areas such as "the project allowing them to stimulate creative and innovative abilities" as the Year 1 had 85.6% agreement while Year 2 only have 77.3%. The results confirm some things about the PrBL implementations for Year 1 and 2 students. One key reason is that Year 1's projects are simulated and scaled-down versions of real-world projects. This means that students can be more creative and innovative when proposing solutions. However in Year 2, the projects are real-world projects which have actual constrains, and this limits the type of solutions that Year 2 students can propose.

(2) Learning in a community

One key observation from the survey was the importance students placed on the interactions between students and lecturers for both year 1 and 2 -- 87.7 % of Year 1 and 89.2 % of Year 2 students agree that it is a highlight of the PrBL experience. This underscores the vital importance of the community and social dimensions in learning. As it is well known, maintaining a positive classroom climate is a must before effective learning can take place. It is thus important too in any project-based activities, the social dimension must not be stifled; indeed, it should be built in to facilitate staff-student and student-student interactions. Future PrBL implementations may explore linking service learning to afford more opportunities for interactions at the same time help students relate engineering to society more meaningfully. This potent mix of pedagogies, PrBL and service learning, is promising in getting students to appreciate the relevance of engineering to society and at the same time allowing them to see how they can apply engineering for the benefits of society.

(3) Learning Space

The survey results showed that having a conducive workspace is important in facilitating project work. The difference in the learning space has an impact on how students perceive their learning experience.

Year 1 students had to work on their projects in regular classroom, which means the daily moving of components in boxes and equipment on trolley to the classroom and the mess created in the classroom may impacted the learning experience as the students indicated that planning was 77.3% compared to Year 2 students (83.2%). This can be due to the fact that Year 2 had better facilities in the laboratory where all project resources reside. This finding shows that the appropriate learning space can have an impact on students learning experience. For ideal PrBL implementation, proper project workspace is definitely more conducive than traditional laboratories, and hence should be a factor for consideration during the planning process.

(4) Challenging but fun learning

While both year 1 and 2 students are excited about engineering as a result of the PrBL projects, it is noted that Year 1 students seems to be more positive about the experience and had more "fun" as the overall rating for the PrBL experience was higher at 77.9% vs Year 2 students at 68.2%. This could be due to the lighter nature and variety of year 1 projects compared to the more challenging real-world project of year 2. Thus, it is indeed a challenge to design a PrBL project that is both fun and challenging that would continue to excite and motivate students while having them to learn content. It is hoped that future implementations will achieve more positive outcomes on both aspects by incorporating more interesting and diverse sensors for year 1 and adopting a

different project idea for year 2, for example, an electric vehicle.

(5) Facilitators & Facilitation

Facilitation plays a key role in deciding the outcomes of the PrBL (Arisoy & Stojcevski, 2009). A group of lecturers and technical service officers (TSOs) are involved in facilitating and supervising the project work. In the course of supervising the project work, both the lecturers and TSOs may either provide a lot of help or very little help at all; there are also the problem of facilitator doing too much for the learners. It is important for both the lecturers and TSOs who are involved to be in synchronization in carrying out the PrBL projects to yield positive learning outcomes.

Conclusions

From the Ngee Ann experience, it can be seen that the PrBL pedagogy is promising in transforming engineering education. By using projects as a driving question, students construct knowledge as they apply what they learn through study & research, discussion with facilitator and peers, self-reflection, and hands-on practical work that tests the understanding of theories. The Chinese philosopher, Xunxi, is right: "Not hearing is not as good as hearing, hearing is not as good as seeing, seeing is not as good as mentally knowing, mentally knowing is not as good as acting; true learning continues up to the point that action comes forth."

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Annex 1

Table 2. Year 1 Survey Results

Questions (4-point Likert Scale)	% of combined Agreed & Strongly Agreed
1) The C&I Week widens my interactions with my course mates and lecturers.	87.7%
2) The C&I Week helps me connect classroom's instructions and real-world problem solving.	85.9%
3) The project work helps stimulate my creative and innovative abilities.	85.9%
4) I am now better able to observe, ideate, validate, design and present project with real world applications	83.4%
5) The time allocated is sufficient for me and my teammates to complete the project.	82.8%
6) The project work helps me in understanding of the learning module and overall learning experience.	79.8%
7) The project was interesting and it excites me about engineering.	76.1%
8) The mini video project capturing the learning journey during the C&I Week haps me self-reflect my own learning.	73.6%
9) Overall, I enjoy and like the C&I Week.	77.9%
10) Overall the programme is well planned and good.	77.3%

Table 3. Year 2 Survey Results

Questions (4-point Likert Scale)	% of combined Agreed & Strongly Agreed
1) The C&I Week widens my interactions with my course mates and lecturers.	89.2%
2) The C&I Week helps me connect classroom's instructions and real-world problem solving.	78.9%
3) The project work haps stimulate my creative and innovative abilities.	77.3%
4) I am now better able to observe, ideate, validate, design and present project with real world applications	76.8%
5) The time allocated is sufficient for me and my teammates to complete the project.	77.3%
6) The project work haps me in understanding of the learning module and overall learning experience.	82.7%
7) The project was interesting and it excites me about engineering.	75.1%
8) The mini video project capturing the learning journey during the C&I Week haps me self-reflect my own learning.	78.3%
9) Overall, I enjoy and like the C&I Week.	68.2%
10) Overall the programme is well planned and good.	83.2%

HOW FUN BASED LEARNING ENGAGING STUDENT ATTENTION IN VOCATIONAL AND PROFESSIONAL EDUCATION AND TRAINING (VPET)

K.C. Wong David
Lecturer, Department of Construction, Institute of Vocational Education (Morrison Hill),
Vocational Training Council (VTC) Hong Kong.
kcdwong@vtc.edu.hk

Abstract

With the popularisation of 4G development, thousands and thousands of information flows into our life; those draw the attention of the new generation is getting more massive and tuff necessitated than before. Unlikely, most teachers find difficult to stop the student to use a mobile phone for chatting, playing games, watching an exciting topic, and collecting information while attending any class. Teachers take more critical roles to cultivate the students what they can achieve the best knowledge and technology as more specific, and as quickly as possible in a limitation of contact hours.

The Game Based Learning has been contended in many education reviews as well as in response to the needs of the times. On the other hands, more smart skills of teaching and learning are inevitable to emerge, as the time require.

With the born of the virtual environment, it comes to the attention that the digital education has gradually swatted the traditional back and white culture. The interactive technology of digital environment induces not just only the youths and the elders' communication. A new era of human beings, they are willing to spend their own time productively rather than reading and writing in which they find no interest.

The Vocational Training Council (VTC) of Hong Kong would like to investigate more pedagogies in innovation and technology for the vocational and professional education and training (VPET) in Hong Kong. The Department of Construction at IVE (Morrison Hill) under VTC has recently induced new skills of course development in conjunction with the strategy and initiatives of Smart City Blueprint in HKSAR.

This paper presents some innovative skills of teaching and learning which are designed to initiate the mode of fun-based learning in respect of the construction practice with the objectives to gain some hands-on experience and industrial environment in VPET.

In conclusion, this paper aims to figure out some methods to organise intensive learning on a fun basis for enhancing the students' interest of study in either class or elsewhere. This study motivates a way to widen the curriculum of teaching and to learn development's flexibility and reliability in exploring the development of smart city facilities, such as teacher meeting learner where they are.

Keywords: *game, based, learning, fun, virtual environment, vocational, professional, education, training.*

Introduction

This study aims to identify how we benefit of online education in the networked classes as suggested by Savage and McGoun (2015) which may assist the teachers to trigger their mythical powers of divergent thinking, spontaneity, novel behaviour and intrinsic motivation to succeed as contended by Sawyer (2007). The objective is to check whether the students had experienced the online education in elsewhere under the programmes in Vocational and Professional Educational Training (VPET) and to follow up the efficiency of flipped class with the fun based learning setup.

Following the above tasks, two modules have been chosen to pilot online pedagogy as a flipped class model. The majority of teaching plan involves gamification device to engage and to motivate the student(s) in concentration at the time of learning in the group or his own elsewhere which was studied and contended by Strawser (2017). The modules of Construction Project Management (CPM) and Building Services (BS) under the program of Higher Diploma in Surveying and Building Studies have been chosen for my study respectively.

Background

Concerning the study last year, our Head of department and Programme leaders aware that the benefits of flipped and blended class activities. The department of construction decided to launch more skills concerning the online teaching and learning in conduction with the environment of flipped or blended learning approaches as identified in the previous findings by Wong and Hui (2017).

For the findings last year, it is no doubt that the accessibility of the internet is not a problem for our students. Moreover, most students can either upload or download information without hold up. In this study, I have prepared some group works and study packs online for the CPM and BS classes.

In the beginning, there are some illustrations of how the resources abstracted from the digital world, then teaching and learning stuff would be discussed. Next is that how the Ed-tech tools are useful for the assistance of the student's self-study. Finally, there are some shares concerning the successes of the results and

feedback from my students and are better than what I expected before.

Based upon my consideration of the above situation, and the level of modules, some digital elements have been created for the students' use to analyse their performance afterwards. This pedagogy came from Strawser (2017) who studied and advised that the increase of education technology tools, the different forms of digital media had their potential to set and improve learning outcomes and pedagogical practices.

Fun Based Learning (FBL) Setup

All notes or handouts were available on Moodle. The students were informed to study before their attendance in any lesson. There were fewer lectures than the previous year. Most of the time, group works, and discussions were in the class. Allow students to learn outside the class (i.e. computer room, library or home).

All students were required to search on the internet, learn and share among themselves, study and check the referenced books, notes and handouts. On completion of each session of assigned works, every student had to express their views of work done, even little tiny. An announcement will give to the best group in class.

Besides, some quizzes were uploaded and embedded on Moodle for the students' self-study outside class. Students could discuss their queries in a specified mobile application (App) named "VTC@HK IM" with me at any time. The quizzes could be scheduled to issue them with ad hoc notice on the App during weekend or holidays, which let them perceive and arrange a time for self-study as a habit.

Setup with You-tube

In respect of YouTube, there are more than 1.9 billion logged-in users, which cover 90 countries and 80 languages being participated over the world nowadays as announced on the official blog of YouTube, (2018). Massive videos upload for various audiences.

YouTube was for a group workshop. For example, some links to video clips have been created and embedded on the Moodle, let the students watch before the class. The topics are relevant to the skills of critical path methods and the preparation of a construction Gantt chart.

The target of this set up is to assist the students to understand the logic of setting up bar chart; the essential features of the Gantt chart and the application of multi-skills on excel (i.e. formula, button command, format, and layouts design). It is surprising that all students were able to complete this task when they were asked to watch the video clip and to submit a program within the specified time (1 hour).

Three students in a group were assigned to carry out this task outside the classroom and the works done were submitted via Moodle. Many discussions and peer-to-peer shares between them throughout the whole process were observed. Students expressed that this arrangement was very impressive, and practical, indeed.

Setup with Moodle

A topic was set on the procurement of materials for a construction project. On completion of this group workshop, the students are expected to understand what the procurement documents are required from the time being to the end.

The search engine of Google was the main course; all students had to use their mobile or note-pad for this project in a limited time and then uploaded to Moodle for their presentation in front of all classmates.

Most students well completed the task. As a result, this enlightened them to recognise the function and format of the document and the logistic of the procurement process. Likely, none of them was playing games or slept in that session.

Setup with Google Map

Another topic set for the plan of site layouts. In the past, a demonstration of the case for site layouts was inadequate, due to the limitation of the two-dimension plan and lack of aerial photos for the individual construction site.

Never think of that a satellite map could be quickly picked up from Google map. Students were instructed to collect a plan for the construction site and to discuss the matters already studied from the handouts. The objective is to enhance their attention and participation in this topic. The responses were quick and keen on them. Each student of different groups had focused on the site they interested in and identified the elements, plants, facilities of their selected location.

After they had uploaded their findings, they provided their explanations of what they found. The results of their collected information were symmetrically and comprehensively in correspondence with the notes of the lecture. Most of them recognised the contents of site layout plans with evidential supports successfully and effortlessly.

Setup with Mentimeter

Speakers often use the Mentimeter as the initial part of their talk. Possibly, this could also be a recap session at the end of class. The reason is that students may respond faster to finish the lesson as soon as possible. This set up helped them to remember what they have learnt.

Setup with Quizlet

Most students were found to have weak vocabulary last academic year. Therefore, some supplementary exercises were created on Quizlet and let students study intervals. Likely, there were many students participated in those scheduled quizzes outside the classroom. This set up may be one of the reasons why these sets of students achieved the rates of higher marks. Some students were enjoyable on the Quizlet exercise. It provides five types of study mode for student choice (i.e. match, spell, learn, and wildcard).

Qualitative Assessment for Two Modules' Classes

Upon completion of the above activities of fbl, a questionnaire issued for the collection of feedback.

The results of the questionnaire survey summarise as follows:

Question 1, 2 and 3 are for the efficiency of fbl activities: 84% respondents of the students agreed that they were enhanced to recap, and to understand the lecture materials as well as vocabulary.

Question 4 and 5 are for the arrangement of fbl: 84% of them agreed the devices helped them with self-study as well as preparation for the examination.

Question 6 is for the time spent on mobile learning: at least 43% of them chose 50 / 50 of time spent on studying and personal respectively.

Question 7 is for the experience of various Ed-tech tools: 5% with Formatives, 11% with Kahoot, and 6% with Plickers.

Question 8 and 9 are for the presentation of fbl: 87 % of them agreed that the arrangement of fbl was in an exciting way and well-structured outside classroom.

Question 10 is for the creation of fbl: 85% of them confirmed they loved this.

Question 11, 12 and 13 are for the use of mobile phone in class; Average 85% of them confirmed that they preferred the group workshop with online searching which enhanced them to focus on the topics with peer to peer learning as well.

Question 14 is for the behaviour of student in class: 69% of them confirmed that they had used their mobile phone for learning in class.

Question 15 and 16 are for the behaviour of student in group discussion: 87% of them confirmed that they acquired more information online during group discussion as well as peer-to-peer learning.

Question 17 is for the creation of online group-work: 81% of them were happy with this.

Question 18 is an open type for what did they like most about the fbl: they found that it was more flexible, more comprehensive knowledge and more interactive.

Question 19 is for what kind of group discussion they liked? 10%, 28%, 15%, and 48% of the students selected topics, pictures, role plays, and videos respectively.

Question 20 is for their preference between group discussion and regular lecture: Most of them consider the pedagogy of group discussion is more beneficial than the typical class. 5% of them did not care if the arrangement was meaningful.

After the focus group meeting with students, a majority of them said that the fbl activities were used to enhance their interest in self-study, their ability on answering the questions and for them to pre-plan test and examination studies. Initially, they found hard to study the module of construction project management. Indeed, they responded that the arrangement of fbl activities let them more accessible to understand the topics and also enhanced their methodical ability when answering the questions of examination rather than notes dictation before.

Regarding the results of the examination, the examination results (Figure 1 and 2) of two modules between last year and this year shown below. The results indication is quite good. These two figures indicate that the percentage of grade A is higher than last year. It suggests that the application of fbl could help with enhancing the students' performance.

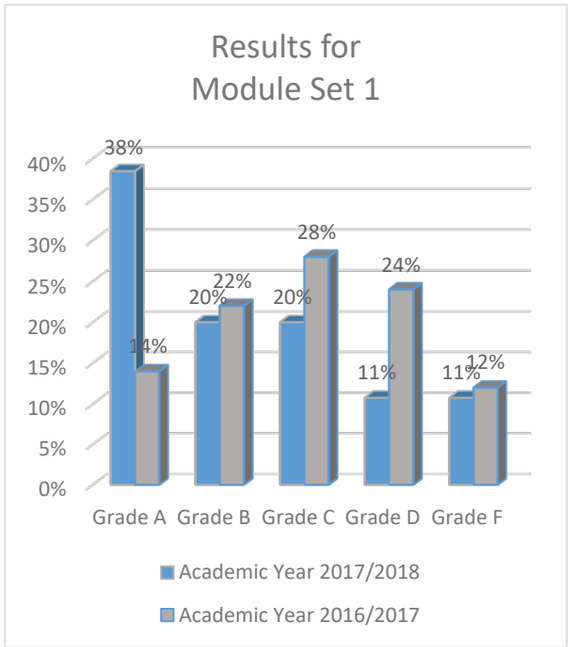

Figure 1.

Results of the Module for Construction Project Management between Academic Year 2016 and 2017

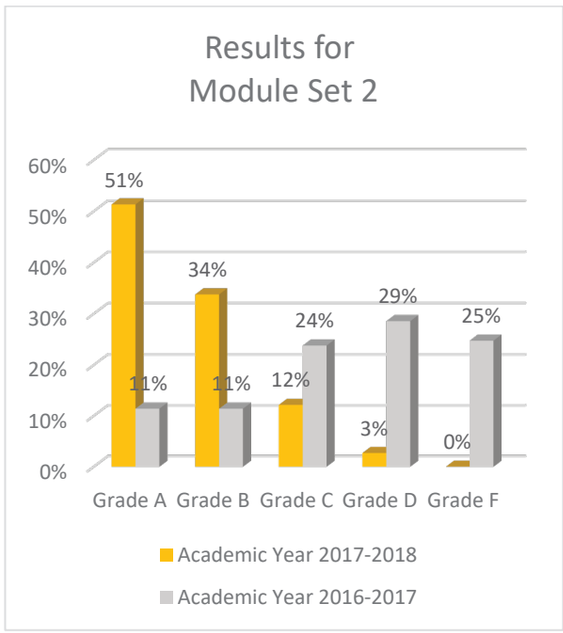

Figure 2.

Average Results of the Module for Building Services between Academic Year 2016 and 2017

Discussion

From the above survey, the following analyses are:-

The student did have the experience with online learning in the other modules in VPET.

The students confirmed that the fbl activities were helpful for their study outside class and preparation for the examination.

The students responded that making connections with peers, within the learning context, beyond the classroom. It sounds that these are the critical elements on the development of digital environments.

The students responded that they enjoyed their self-study involved the scenario of inquiry, and working. It sounds that there is room to make up the online pedagogy similar to the Quizlet device.

The students prefer to learn in the environment with online communication.

The students prefer to use the mobile phone as an essential tool for communication and learning.

The results of the examination indicate that the fbl could help to improve and engage the students' to pay attention in the session of study with more interest.

Starkey (2012) studied and confirmed that the students could understand the concept, knowledge building, and knowledge products online in the online learning activities. Allen (2014) suggested that the active classroom could have the features of visual, auditory and kinesthetic modality. It is no wonder that the digital technologies and infrastructure supports are getting more comprehensive and prosperous than before. The limitations of online learning activity become busier than before, more stakeholders to join and more choices to create.

In fact, the current surveys indicate that there are 18,394,767 numbers of the mobile subscriber and approximate 7,409,800 population recorded by Office of the Telecommunications Authority (OFTA, 2018) and Hong Kong Census and Statistics Department (HKCSD, 2017) respectively in Hong Kong Special Administrative Region.

Conclusion and Recommendation

Given the above, I believe that the mobile phones do multi-function wide these days. It replaces the recorder, drawing boards, typing machine, camera, and television. John, Traxler & Agnes Kukulska-Hulme (2016) have studied the impact of mobile phones. The change is not just only on the student and also the public behaviour. It proves that the adjustment of pedagogy to have been the connection with all kinds and levels of education as well as in VPET.

The smart learning environment studied by Liu, Wosinski and Huang (2017), there are some essential elements categorised, such as the learning resources, creative tools, teaching community, and learning community. In facts, the students could have learnt from their experience either directly or indirectly, either by the group or by themselves. The creation of such environments is going to be a new mechanism to track in VPET.

In the future, VPET could allocate more investigations for the development of learning outside the classroom in connection with the mode of human changes vastly and quickly nowadays.

Moreover, VPET could add this kind of fun based learning activities as the supplementary exercises for self-study by the students. Perhaps, the development of badge, avatars, and system would be a possible way to run as an incentive scheme bit by bit together with the scholarship awards gradually.

In consideration, it implies that gamify our class with the digital network is feasibly applied nowadays, next is to design a way of engaging the student intrinsically.

In fact, some famous companies are promoting the badges mechanics in their projects for the market attraction of more stakeholders in the long-term task which was revealed by Farber (2015). There may have some kinds of scholarship tied up.

I want to quote a famous epigram by Heywood (1546) who wrote that "Rome was not built in one day", therefore the online education should be developed step by step.

Once the artificial intelligent techniques are running matureness with the solid backup of the Nano-based computer system as the appearance which studied and measured by Picciano (2017) and the obstacles (i.e. Legal issues and privacy rights, infrastructures establishment in super-cloud and cost of initial setup) could be resolved as studied by Das (2015).

I believe that the fun class-based learning will be an essential element in the ways of pedagogy in future. A new era of digital education becomes true; any examination could also be carried out on the internet with certification upon receipt of the matureness of biometrics technology.

Acknowledgement

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I am also thankful to all the colleagues and students of our department for their support, passionate participation, and valuable suggestion. Indeed I would like to express my sincere appreciation towards ISATE2018 and expect to see more new Ed-tech development in engaging our students learning effectively in VPET.

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USING LEARNING STYLES APPROACH IN MOODLE PLATFORM TO ENHANCE TEACHING AND LEARNING DESIGN

K.S. Tsang

Hong Kong Institute of Vocational Education (IVE), Hong Kong

tsangalex@vtc.edu.hk

Abstract

The report focused on using multimedia (Moodle) platform to enhance student's motivation and individual differences. Teacher can use Moodle platform to check student's learning styles such as auditory domain, visual domain or kinaesthetic domain (VAK approach). If the teaching and learning package matched with student's learning styles, students can adopt the contents of materials easily. By Moodle platform the on-line assessment to get the instant feedback. The report is investigated the effect of knowing self-learning styles. Moreover, the report also provided how to build an effective multimedia platform by using ADDIE (Analysis, Design, Develop, Implement and Evaluation) model and Gagne's nine instructional event model in an electrical engineering module. These models can help teachers to enhance teaching and learning design by using innovative multimedia technology. This report is integrated the multimedia technology with educational theory in order to provide effective learning environment to our new generations.

Keywords: VAK styles, Moodle, ADDIE module, Gagne's instructional design, instant feedback

Introduction

Nowadays, most of my students use Hong Kong Diploma Secondary Education Examination (HKDSE) scores to study the engineering program in the vocational training institution. However, their academic backgrounds are quite differences. For example, some students have already studied physics and advanced mathematics, but some students studied history and language in secondary school. Student's learning individual differences are very large and some student's learning motivation are low due to lack of basic knowledge. Therefore, the report is pinpointed the efficiency of using learning styles approach and Gagne's instructional teaching design (Mayer, R.E., 2001), (Gagne, R. M., Briggs, L. J., & Wager, W. W. ,1992) in one technical engineering module in order to minimize student's learning individual differences and increase their motivation.

Background and Pedagogy

The report focus on two groups of students who study in the Qualification Framework (QF) level 4 of higher diploma in electrical engineering course. One module "Control and Automation System (CAS)" is selected to use the new learning styles approach and Gagne's instructional design. This module is selected to review because it is lower than benchmark marks under The Hong Kong Institution Engineers (HKIE) accreditation review. Moreover, if teachers use traditional lecturing method for teaching, most students feel boring in the single direction teaching and some of them cannot follow the teaching flow in the lesson. The CAS module is mainly to teach the LabVIEW software program technique and Programmable Logic Controller (PLC) logic program. This module consists of 5 numbers of laboratory workshops, 7 numbers of tutorial classes and 13 lecture classes. This module has total 52 contact hours. One chapter about "while loop and array program" of LabVIEW software is selected to use the new instructional design approach.

ADDIE (Analysis, Design, Develop, Implement and Evaluation) instruction system design model (顏春煌, 1996), (Richey, Klein & Tracey, 2011) is employed to review this chapter to enhance the teaching materials incorporated with the multimedia technology. For the Analysis stage, it is a process to define the learning outcome, the character of students, the needs of resources. For the Design stage, it is a process to design the teaching contents, classroom activities and assessment methods to meet the learning outcomes. For the Develop stage, it is a process to combine all teaching and learning activities based on the design blueprint. For the Implement stage, it is a process to act the teaching and learning activities in real situation. For the Evaluate stage, it is a process to evaluate the quality and effectiveness of the teaching and learning activities such as achievement of the learning outcomes, learning motivation.

Using ADDIE Methods

Analysis:
The objectives of using multi-media (google and Moodle platform) to let student to learn the LabVIEW software "While loop and array" easily. The objectives are:
Objective 1) As some students have low motivation and they don't know their level of understanding, interactive multimedia teaching materials and online formative assessment can improve their motivation and achieve "assessment for learning" by attractive new cut animations and online instant feedback to each student (Broadfoot, P. M., Daugherty, R., Gardner, J., Harlen, W., James, M., & Stobart, G. 2002).
Objective 2) as different students have different learning styles and learning speed, students can learn the online teaching materials according to their learning styles and speed. It can minimize the learning individual differences.

Design:
The learner-centered approach is preferred to use in the multimedia learning design, which are consistent with the human mind works effective (Mayer, R.E., 2001).
If the multimedia learning features can match student's learning style, it can help learner's information processing system effectively. Therefore, one group of students are required to do a learning style test in the initial stage in order to identify their learning style types. The learning styles are mainly consisted of Visual, Auditory, and Kinesthetic (VAK) learning style (Cassidy, C., & Kreitner, B. 2009). After they know their learning styles, students can use their domain style to choose learning materials (such as reading manual or watching video) to absorb new information more easy. Some VAK test (Victoria Chislett, 2005) shows as below:

1. When I operate new equipment I generally:
   a) read the instructions first
   b) listen to an explanation from someone who has used it before
   c) go ahead and have a go, I can figure it out as I use

2. When I need directions for travelling I usually:
   a) look at a map
   b) ask for spoken directions
   c) follow my nose and maybe use a compass

3. When I cook a new dish, I like to:
   a) follow a written recipe
   b) call a friend for an explanation
   c) follow my instincts, testing as I cook

4. If I am teaching someone something new, I tend to:
   a) write instructions down for them
   b) give them a verbal explanation
   c) demonstrate first and then let them have a go

5. I tend to say:
   a) watch how I do it
   b) listen to me explain
   c) you have a go

After students know their learning styles, they are required to learn "while loop" and "array" function in LabVIEW software. The layout of the VAK learning package shows as below:



Figure 1: Layout of the VAK learning package

Moreover, the multimedia design use Gagne's nine instructional events as the design foundation to design the flow of the multimedia teaching materials. Firstly, the news cut video can attract student's attention easily. It can teach students the real application of the software. If the teaching materials can hold their attention, the new knowledge can put into short-term memory & long-term memory in student's information processing system easily. It is because attention is the first and important step in the human processing system (高源令, 2010). Secondly, the teaching materials should be recalled student's prior knowledge. The new knowledge can construct based on their prior knowledge. This arrangement matches with the construction theory, which indicate the new knowledge can develop from zone of proximal development (陳世芬, 2010). Finally, online instant feedback can provide in the middle stage and final stage. One advantage of multimedia can provide instant and fast feedback to students when it compares with the traditional written feedback. If students can get the instant feedback, it can get a strong reinforcement, improve their level of understanding and achieve assessment for learning principles. The detail multimedia design used Gagne's instructional event shows as below:

Instructional event	Corresponding design	Purpose
1. Gaining attention	News cut video introduced first.	To arouse student's motivation in order to help the memory process
2. Informing learners of objectives	Simple wording and graphic to show Objectives	To let students the aim and the expectations in learning
3. Stimulating recall of prior learning	Use Moodle to check students prior knowledge	To help recalling prior learning
4. Presenting the content	Present the content systematically and different VAK learning styles can use.	To construct interrelationships of different concepts with multi-channel learning
5. Providing learning guidance	To give a examples to explain the array	To maintain learning motivation
6. Eliciting performance	To give a short quiz (MC) in Moodle to do the formative assessment	To check students' level of understanding To provide online instant feedback
7. Providing feedback	To perform the summative assessment e.g. MC test and give an instant feedback	To check students' level of understanding by instant feedback
8. Assess performance*	Provide scores of test results	To explain the difficult questions
9.Enhance retention and transfer*	To carry out a min-case study in laboratory in order to have an authentic assessment.	To carry out a min-case study in laboratory in order to have an authentic assessment.

*exercises will carry out in tutorial session and laboratory session

Table 1: Gagne's Nine Instructional Events Design

Development and Implementation:

In the VTC, formal e-learning platform is Moodle platform, so it mainly uses in this study. Firstly, students need to do the VAK in the Moodle platform, the format of the VAK is in MC with graphical presentation. It is easy for students to catch up their learning styles. The format of VAK test shows as below:

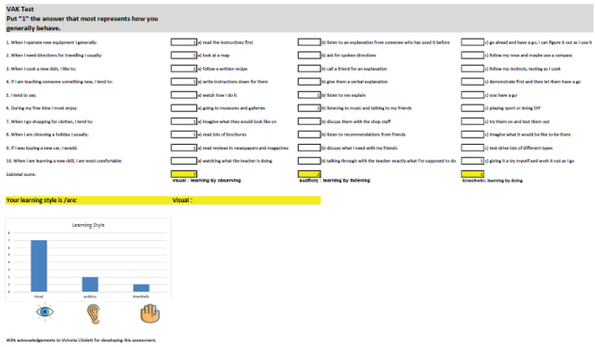

Figure 2: VAK test questionnaire

It is found that student's learning styles using visual and auditory type is 62.9% while kinesthetic styles is 37.1%. It is indicated most of the students are mainly used the visual and audit to absorb the daily information.

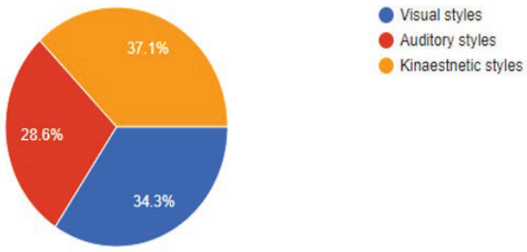

Figure 3: Student's learning styles pie chart

Secondly, student need to carry out the online formative assessment in Moodle and google questionnaire via QR code. The format of questions shows as below:

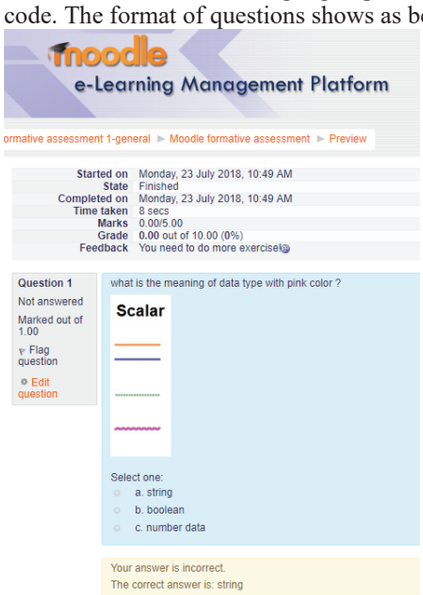

Figure 4: Sample of questions

As Moodle platform can provide student instant feedback individually, students can enhance their knowledge by Moodle correct feedback. It can help to minimize the learning individual differences.

Thirdly, after students need to learn the basic functions of LabVIEW software using Gagne's instructional design repeatedly, they carry out the formative assessment at middle stage of the course. The questions of the formative assessment are not only the bookwork questions, but also students need to analysis and apply the prior knowledge to solve a case study. The format of the case study shows as below:

Design a LabVIEW program (block diagram) to generate a random integer number between 1 to1000. Then the random integer number will be run until matches a number specified **"Number to Match"** in the front panel. The matched number is indicated in **"Current Number"** and the number of iterations is indicated in **"# of iterations"** in the front panel.
Sample results in the Front panel:

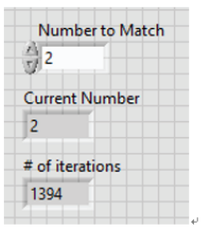

Figure 5: sample of formative assessment (case study)

Evaluation and Results:

There are several evaluation of this study. First, if students can know their learning styles, the overall performance in the formative assessment indicated that students who know their learning styles are better than the students who do not know their learning styles (Table 1). It is one solution to minimize the individual learning differences.

Questions	Students (who know learning styles) get correct answer (%)	Students (who don't know learning styles) get correct answer (%)
Q1	84%	80%
Q2	96%	87%
Q3	56%	54%
Q4	76%	75%
Q5	61%	43.5%
Overall	**75%**	**68%**

Table 1: Performance in online formative assessment

Secondly, as students go through several time of formative assessment in the multimedia platform, they need to carry out a test in the middle stage. The performance shows as below:

	Students (who have online formative assessment)	Students (who have not online formative assessment)
Sample size	31	31
(Test pass rate %)	90%	60%
Mean	67.1	42.5
t-value	5.9	
p- value	$P<0.05$	

Table 2: Performance in mid-term test

It is found that the p value of the t - test is less than 0.05. By conventional criteria, this difference is to be statistically significant. Moreover, it also indicated that formative assessment could provide students to evaluate their level of understanding. As Moodle can give instant and individual feedback to students, this function can help to construct their knowledge. If students cannot get the passing marks in the online assessment, students can do the test again. This arrangement is a kind of mastery learning and it can reduce student's individual differences.

Conclusions

Multimedia technology can enhance the traditional teaching method. It can also enhance student's motivation, provide instant feedback, match different learning styles and speed, and minimize learning individual differences. ADDIE model can use to evaluate the usage of multimedia. In different formative assessment stages, Gagne's nine instructional events principles can incorporate into the design of the multimedia materials. This arrangement can enhance the student's motivation and minimize student's learning individual differences.

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NURTURING FUTURE CYBERSECURITY PROFESSIONALS: AN EXPERIENTIAL LEARNING PEDAGOGY

D.M. Konidala*, H.G. Tan, Y.T. Ng, H.J. Ong, S.C. Tan, Y.H. Liew, and M.S. Omar

Ngee Ann Polytechnic/School of InfoComm Technology, Singapore

*Divyan_KONIDALA@np.edu.sg

Abstract

This paper documents the journey undertaken by the Diploma in Information Security & Forensics in Ngee Ann Polytechnic in adopting experiential learning as the signature pedagogy throughout the course to nurture future cybersecurity professionals.

It was noted that training students in various and seemingly discrete security concepts, tools, and systems would neither serve the ever-growing demand for skilled, passionate and motivated cybersecurity professionals, nor help in alleviating the high turnover rate and demands faced by the cybersecurity industry currently. Students needed a more "practice-based" and innovative curriculum that will immerse students into the ecosystem of cybersecurity and also nurture them to be ready as cybersecurity professionals by inculcating the essential traits needed for this industry.

These requirements led to the adoption of Experiential Learning for this course. The experiential learning model (Kolb, 1984) is a process of learning through experience and reflection on doing. Experiential learning needs to be intrinsically woven into the course's curriculum for its effectiveness. In the design of the curriculum, the experiential learning is being experienced both within a module and within a course where the different stages of experiential learning are being anchored in different modules using a variety of innovative teaching and learning approaches. These innovative teaching and learning approaches include state-of-the-art lab facilities, hands-on practical exercises, real-world case studies, open assignments; usage of industry recognized security tools, invited expert talks, industry visits, internships, study trips cum masterclasses, participation in competitions, and showcasing projects at external conferences.

The paper provides evidences of our students inherently applying Kolb's experiential learning cycle to develop the essential traits of a cybersecurity professional while pursuing their diploma.

Keywords: *Experiential learning, cybersecurity, Kolb's learning model*

Introduction

The School of InfoComm Technology (ICT) in Ngee Ann Polytechnic had offered a specialisation option in Information Security & Forensics under its Diploma in Information Technology where students studied cybersecurity related modules such as Information Security, Ethical Hacking, Malware Analysis & Antivirus Technologies, Digital Forensics, and Mobile Device Security & Forensics. However, due to increase demand in the industry for well-trained cybersecurity professionals, ICT started to offer a 3-year diploma course in Information Security & Forensics (ISF) where students are trained in a wider range of cybersecurity topics and more opportunities for students to develop the unique qualities of a cybersecurity professional.

Designing the Curriculum

To achieve this outcome, the teaching team had to determine the traits, competencies and professional attitudes of the "cybersecurity" professional to develop a programme that would meet the needs of the industry. The teaching team reviewed requirements of a cybersecurity professional with industry partners and also referenced the Skills Future Framework for Infocomm professional (SkillsFuture Framework, 2018), which is a list of professional competencies that is co-created by key stakeholders such as employers, industry associations, union and government for the Singapore workforce in a specific industry. The output was a list of traits that were identified for the cybersecurity professionals and that ISF graduates are required to have in addition to their competency in the subject knowledge. The traits are listed in Table 1.

Table 1: Traits desired in a Cyber Security Professional.

T-shaped skills	Striving for accuracy
Problem solving skills	Integrity and responsibility
Critical thinking	Perseverance
Lateral thinking	Continuous learning
Analytical thinking	Communication skills
Self-directed learning	Community service

The list of traits gave the teaching team with a "direction" as to the type of learning experience and approaches that they will require in order to develop these traits in their students. The review of literature shows that Experiential Learning was most suitable for this course as the learning process will provide the opportunities for the development of "traits" of the profession.

Experiential Learning as ISF's signature pedagogy

Experiential learning was initially proposed and discussed in the works of John Dewey (1938) followed by Kurt Lewin (1951) and Jean Piaget (1970, 1976). David A. Kolb was influenced by these works and developed the modern theory of experiential learning (1984). Experiential Learning Theory (ELT) defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb, 1984, p. 41).

The ELT model portrays two dialectically related modes of grasping experience: concrete experience (CE) and abstract conceptualization (AC) and two dialectically related modes of transforming experience: reflective observation (RO) and active experimentation (AE). According to the four-stage learning cycle depicted in Figure 1, immediate or concrete experiences are the basis for observations and reflections. These reflections are assimilated and distilled into abstract concepts from which new implications for action can be drawn. These implications are actively tested and serve as guides in creating new experiences (Kolb, Boyatzis, and Mainemelis, 2001).

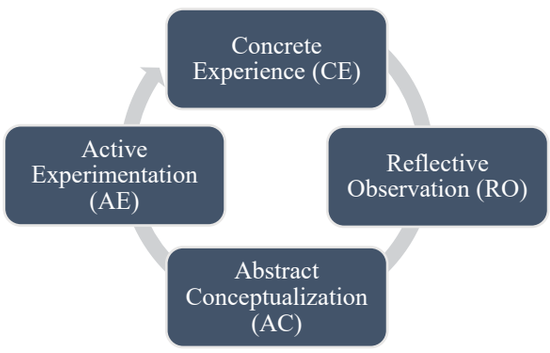

Figure 1: The Experiential Learning Cycle (Kolb, 1984).

Implementation

The curriculum for Diploma in ISF implements experiential learning both at the module level and at the course level.

At module level, students will go through the 4 stages of Kolb's experiential learning cycle in the module. Experiential learning at course level have the different stages of Kolb's cycle anchored on key modules that are linked to one another. Learning experiences from an earlier module serve as an "anchor" experience for the next stage in the cycle which is experienced in a different module.

Experiential Learning at the Module Level

Ethical Hacking (EH) is a core module taken by the students of the Diploma in ISF during their first semester in Year 3. This module offers foundational ethical hacking and penetration testing knowledge and skills. Students learn the techniques and tools malicious hackers use, but in a lawful and legitimate manner, with a goal to assess the potential impact and risk of an actual cyberattack, and to deploy necessary countermeasures.
In addition to the content knowledge that students acquire during the experience learning process, students are also able to develop professional traits that are essential for the cybersecurity professionals in the EH module. Table 2 summarizes the implementation of experiential learning stages in the EH module, along with the professional traits honed by the students at each stage.

Table 2: Implementation of Experiential Learning Stages in the EH Module

Experiential Learning Stages	Supporting T&L Approaches Implemented in the EH Module	Professional Traits Honed by the Students
CE	Hands-on lab exercises	Problem solving
RO	Document observations, and reflections while doing the lab exercises	Critical thinking Analytical thinking
AC	Open-assignment on real-world cyber-attacks	Self-directed learning Continuous learning Communication skills
AE	Pen-testing assignment on a testbed that simulates an IT infrastructure for a small and medium enterprise	Lateral thinking Analytical thinking Integrity & responsibility Perseverance Striving for accuracy

Stages 1 & 2: Concrete Experiences & Reflective Observations.

In the EH module, students gain concrete experiences and carry out reflective observations through hands-on lab exercises. Students are provided lab worksheets to learn and practice the basic hacking tools and skills using industry recognized pen-testing tools such as Kali Linux and Metasploit. During the reflective observation process, students think through how their own experience has impacted their understanding of "Hacking". These observations made during the hands-on lab exercises also allow students understand the modus operandi of hackers, which will enable them to better protect networks, systems, and applications.

Stage 3: Abstract Conceptualizations.

Students experience this stage of "abstract conceptualizations" through an open-assignment on real-world cyberattacks. This process gives students the opportunity to draw on their understanding from their hands-on experience and reflective observations done previously as a reference in their research and further study into the topic.

This open-assignment is a self-directed learning exercise whereby every student gets a chance to choose a latest system hack to research on, construct a demo and a worksheet to teach others in a step by step manner. Students need to present their findings and perform a live demo in front of their peers. They are also given a chance to better their grade by creating a demo video.

Stage 4: Active Experimentations.

In this stage, students are given access to a testbed that simulates an IT infrastructure for a small and medium enterprise. Students apply skills acquired in previous stages and carry out active experimentations via a pen-testing assignment on this testbed. This is a group assignment consisting of two to three students per team. Students brief the tutors on their findings and action plan.

Although students are provided with a brief about the project and have support from their tutors, the teams are very much left on their own to develop the proposal by themselves. This is the opportunity for students to showcase the knowledge and skills that they have acquired over the course of the module, and to demonstrate the traits that they have developed as a result of their experiential learning journey.

Effectiveness of Experiential Learning in a Module

Feedback from students have been positive, with many recognising that the process not only allowed them to have a better understanding of the topic, it also provided them with the opportunity to develop key traits such as team work, perseverance, problem solving etc. The quotes below are extracts from students' feedback on their learning experience.

"I think that the experiential *learning in penetration testing assignment has been a very meaningful learning experience as* ***teams were highly motivated*** *to research on the various vulnerabilities and exploits on their own accord* ***instead of waiting for instructions*** *from the lecturers."*

"This module had taught me the attributes of a pen-ester, and one of them is **being *able to succeed even when you are stuck at one point***, *especially during my Assignment 2, where most of my exploitations did not work initially. With the help of my friends and tutor, I was able to work another way around and finally managed to exploit into the machine.* ***It made me learn not to give up*** *even when things go south."*

"The self-directed learning in open assignment has made profound impact on my learning as it ***has nurtured me to become more self-directed*** *in my learning. Although we started of not knowing anything about ethical hacking, this assignment has allowed us to understand the various vulnerabilities that exist and the numerous ways in which we could exploit these vulnerabilities…"*

Experiential Learning at the Course Level

The curriculum for Diploma in ISF requires each student to complete 21 core, 3 disciplinary elective modules and an internship. In addition, students are also required to complete 8 interdisciplinary modules. Figure 2 depicts the core and elective modules, and their dominant association with one of the four stages of experiential learning.

It can be seen in Figure 2 that the year 1.1 (year 1 semester 1) modules emphasize more on providing concrete experiences to the students. Year 1.2 modules are best at creating opportunities for students to carryout reflective observations. Year 2.1 modules support students to derive abstract conceptualizations. Finally, year 2.2 to 3.2 modules allow students to carryout active experimentations.

Table 3 shows how the experiential learning process is anchored in the different modules within a course and the teaching and learning (T&L). approaches used in these modules to hone the traits of a cybersecurity professionals.

Table 3: Implementation of Experiential Learning Stages at the Course Level

EL Stages	Modules	Supporting T&L Approaches Implemented in the Modules	Professional Traits Honed by the Students
CE	Cryptography	Hands-on exercises Simulation tools	Problem solving Analytical thinking
RO	Vulnerabilities 101	Invited expert talks Real-world case study	Lateral thinking Communica-tion skills
AC	Information Security	Open assignment	Self-directed learning Critical thinking
AE	Digital Forensics	Use of Industry recognized tools	Integrity & responsibil-ity
	Governance & Data Protection		Striving for accuracy
	Internship	6-months Internship	T-shaped skills Continuous learning

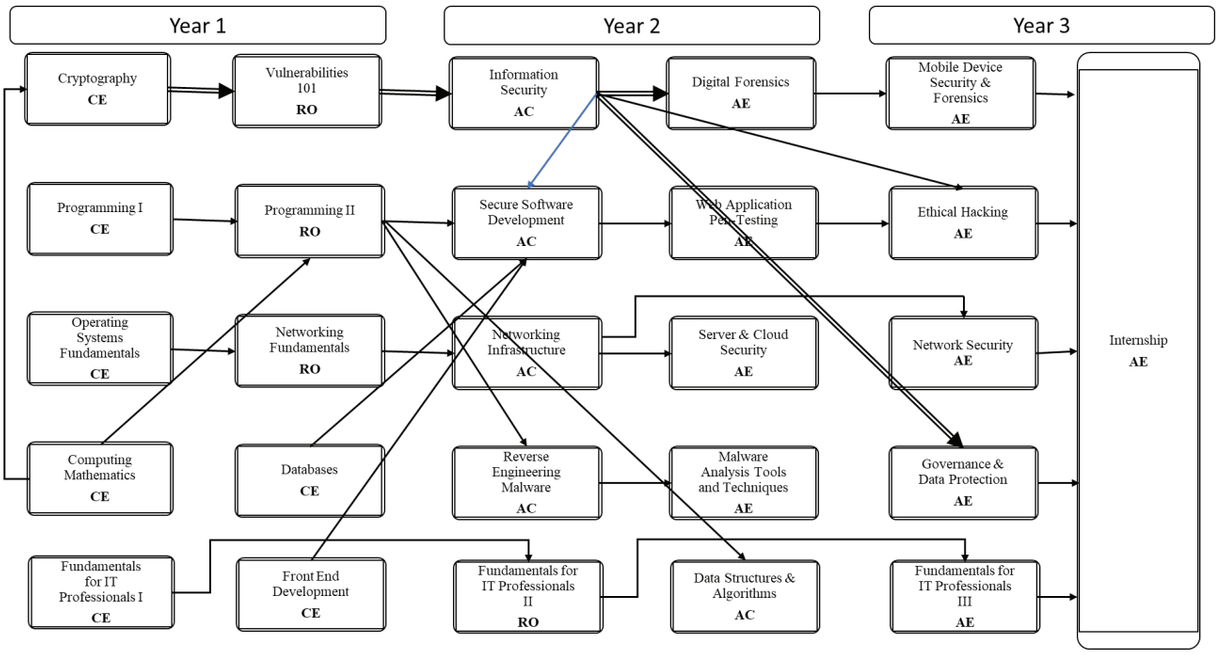

Figure 2: Experiential Learning at the Course Level

One such sequence of modules supporting each stage of the experiential learning at the course level is presented below.

Stage 1: Concrete Experiences.

Cryptography (CTG) is a core module in ISF that is taken by students in their first year, first semester. This module covers the essential concepts of cryptography, including public key infrastructure, digital certificates, digital signatures, and encryption/decryption algorithms. The fundamental concepts of cybersecurity originated from cryptography. Therefore, to grasp rest of the modules in ISF, it is essential for students to have a very good understanding of cryptography.

In this module, students gain concrete experiences by building their own cipher tools using cardboard and papers, as shown in Figure 3. A handmade cipher tool "scytale", provides students with a good introduction into the concepts of encryption, decryption, secret key, plain text, cipher text, and the transposition method of ciphering. In another exercise, students create a cipher wheel, which helps them to easily understand the concepts of symmetric encryption and shift cipher.

Another way that students are able to have a concrete experience is to leverage on technology by using simulation tools to depict the operations of some of the modern and more complex cipher and hash algorithms.



Figure 3: Concrete Experiences: CTG Module

Stage 2: Reflective Observations.

Vulnerabilities 101 (V101) is a core module offered to the students during their first year, second semester. This module provides a broad overview of the various security vulnerabilities, threats and attacks in different domains (end-user, physical, data, network, software, system). This module engages cybersecurity professionals from the industry to give lectures pertaining to real world attacks and security problems in different domains. Students are expected to reflect on the talks by the experts in the light of their own experiences in the previous module on cryptography.

In V101 module, students, based on their concrete experiences in the CTG module, get to choose a case study of a real-world cyber-attack to research into, construct an article to share with all concerned. The articles must be in the multimedia format using the Microsoft (MS) tool called the "Sway" and are posted in MS Office 365 for sharing and learning with their peers. Students are also required to present and defend their findings. This approach allows students to derive reflective observations from their peers' work.

Study Tour cum Masterclasses. The bigger security industries and research institutes are largely based in USA, Japan and Europe. There are so many areas that the students could observe and reflect from these industries and institutions. The various security industries in USA include Palo Alto, Cisco Systems, Fortinet and NXP Semiconductors.

A 2-week Information Security Study Tour to USA is targeted at Year 2 students. The Masterclass sessions are focused on the network security. The students are introduced to the NextGen firewall that performs deep inspection of traffic and blocking of attacks. Students had the opportunities to learn, observe and reflect on how to configure the NextGen firewall.

This study tour cum masterclass enabled students to observe and reflect on the academic, enterprise, culture, environment and economic aspect of US. The students visited reputable universities and prominent information security and technology companies.

Stage 3: Abstract Conceptualization.

Information Security (INS) is a core module offered to the students during their first semester in Year 2. This module provides an overview of the various domains of Information security. It aims to provide an appreciation of information security from an end-to-end perspective. This module covers security in 7 domains: data, physical, system, network, software, end-user and organization. Students will understand the various aspects of Information security and this will lead them to the more advanced modules such as Malware Analysis Tools & Techniques, Ethical Hacking and Digital Forensics.

As with the use of "Open Assignment" in Ethical Hacking, the assignment here gives students the opportunity to draw on their prior experience and new knowledge to develop new insights into the topic of their interest. The open assignment component is incorporated in to the INS module to encourage independent learning, and peer-learning. It fosters abstract conceptualization on latest issues in information security; and to let students experience learning in the "real" world. This assignment provides the students a chance to research into the problem, establish root cause and brain storm for solutions, produce a prototype for a chosen solution, carrying out testing and validation with stakeholders. A seminar cum competition is held at the end of the module for sharing and learning purpose. The deliverables of this assignment also include a poster and a report.

Stage 4: Active Experimentation.

The School of ICT has setup state-of-the-art lab facilities (one of which is depicted in Figure 4) to facilitate active experimentations for the modules in ISF. Digital Forensics (DF) is a core module taken by the students during their second semester in Year 2. This module gives an insight to the process of forensics investigation. It covers the various types of computer-related crimes, techniques of gathering electronic evidence, and recovering of deleted, damaged or encrypted data.

In this DF module students make use of the "system domain" specific abstract conceptualizations derived in the INS module to carryout active experimentations. Students use industry recognized forensic tool called the EnCase Forensic Software to perform forensic investigation. Besides the tools & techniques of investigation, students are encouraged to take on the role of forensic investigators to solve a real-world case study. They are given a simulated crime with evidence files to investigate. Through this active experimentation students understand the forensic investigation methodology and the proper handling of evidence.

Similarly, in another module "Governance & Data Protection (GDP)", students make use of the "organization domain" specific abstract conceptualizations derived in the INS module to carryout active experimentations. Students use industry recognized, Governance, Risk, and Compliance (GRC) tool, called the RSA Archer, to carryout active experimentations and be trained in how risk and compliance are properly managed in organizations.

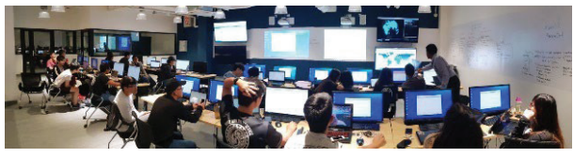

Figure 4: Active Experimentation - Cyber Security Operations Centre

Effectiveness of Experiential Learning at the Course Level

There are encouraging signs to show that the students in ISF are developing attitudes and traits that are valued by the industry e.g. community service, integrity and responsibility and communication skills.

As part of the Active Experimentation process, students in ISF organised an awareness programme on End-User Security at a Community Centre. For one week, during the evenings, selected students and their posters were displayed at the community centre together with demo sessions at specific time slots. Students have to be ensure that their posters are able to convey the message to the residents in a manner that would be relevant to them. Residents would view the students' posters and the students would be on stand-by to explain the concepts as depicted by the posters and suggest possible measures to be undertaken to protect the end-user from potential threats. Students have to take on the role of the "expert" to the community and they have to be responsible for the message and knowledge that they are sharing.

Students are also encouraged to showcase their projects at conferences and take part in cybersecurity competitions as shown in Figure 5.



Figure 5: Active Experimentation – Participation in Cybersecurity related Conferences and Competitions

Events like these not only allow students to hone their knowledge and skills on cybersecurity but also allow them to develop their competence in communicating with the community and to develop integrity and responsibility for the message that they are sharing.

Conclusion

The School of ICT has embarked on integrating experiential learning into the curriculum for Diploma in ISF both at the individual module level and at the course level. It is constantly reviewing this signature pedagogy and improving its T&L approaches to ensure that their graduates are prepared with the types of skills and knowledge that is required of their profession.

Experiential learning is not only able to allow students to acquire the necessary knowledge and skills that a competent cybersecurity professional requires but also the "traits" that are valued in the industry. Through the different stages of the Experiential learning cycle, students are constantly interacting with theory, and translating them into practice, modifying their understanding to suit issues in different context and actively proposing new ideas to meet real-world needs.

While this curriculum is still in its infancy, feedback from both students and industry partners have been positive, and the teaching team would continue to review the experiential learning process to ensure that their graduates would have the required skills of a cybersecurity professional.

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A REPORT ON OPEN COURSES IN MATHEMATICS FOR JUNIOR HIGH SCHOOL STUDENTS ASSISTED BY UPPER-CLASS STUDENTS AT NIT, KURUME COLLEGE

K. Kawashima [a], Y. Matsuda [a], M. Okita [b], M. Sakai*, [a] and T. Tanaka [c]

[a] Sciences and Mathematics, Liberal Arts, NIT, Kurume College, Kurume City, Japan
[b] Department of General Education, NIT, Ariake College, Omuta City, Japan
[c] Department of Mathematics, Faculty of Education, Gifu University, Gifu City, Japan

* sakai@kurume-nct.ac.jp

Abstract

In this paper, we discuss how mentoring younger students appeared to aid upper-level students at National Institute of Technology, Kurume College in their comprehension of and ability to explain mathematical concepts.

We have held open courses for the junior high school students at NIT, Kurume College during summer vacations since 2010. In these open courses, we gave introductions to "knot theory" and "quadratic curves" with the upper-class students serving as assistants.

We here review "knot theory" and "quadratic curve". Knot theory is a field of mathematics in which we analyze knots of strings in a topological way. One of the fundamental problems of this theory is to determine whether two knots are equivalent to one another. To put it simply, this theory concerns under which condition a knot is unknotted. In addition, it needs just an elementary computation of matrices to begin to learn this theory. A quadratic curve is in general defined to be zeros of a degree two polynomials in two variables. It is well-known that each quadratic curve is divided into either a hyperbola, a parabola, an ellipse or a circle. In the open courses, we introduce a quadratic curve by showing a section appearing in cutting a cone. Changing the angle of cutting, we can find all of four kinds mentioned above. Then we choose these two themes for the open course since the participants may be familiar with them and need little mathematical background.

A questionnaire sent out after the open courses indicated that the participants gave high evaluations. And it seemed that they liked the assistants because of their kind help. Besides, the upper-class students proceeded to study knot theory. They learned tricolorability, the number of p-colorings and the Goeritz invariant. Through this learning, they came to understand some basic mathematical notions more deeply, such as sets and propositions, congruence and matrices. More surprisingly, they obtained new results independently and gave successful research presentations.

Keywords: *Mathematics education, Open courses, Quadratic curve, Knot theory, Active learning*

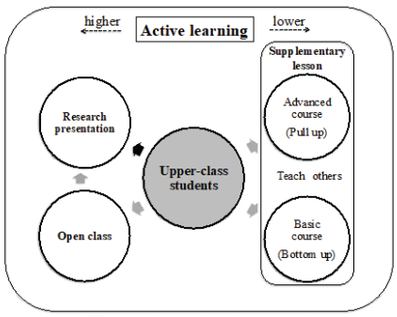
§1. Introduction

Active learning is defined in Collins (2003) as "The process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas. Requiring students to regularly assess their own level of understanding and skill at handling concepts or problems in a particular discipline. The attainment of knowledge by participating or contributing. The process keeps students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving".

The main purpose of this work is to help our stuents acquire the skills of learning by themselves, unifying knowledge and giving presentation in the class. Moreover, we had the upper-class students help us in *low-level* active learning: supplementary lessons and open classes so that they can connect this experience to their research and presentation (see Figure 1).

Knot theory is an interesting field in Topology. Beginners can understand it easily since it is not necessary to know its background well and there are various teaching materials of knots in which they can learn visually (e.g., Kawauchi & Yanagimoto, 2012; Miyaji, Sakai & Nakabo, 2013). On the other hand, knot theory is associated with various fields, such as DNA in biology and QFT in physics, which correspond to the relevant feature. Therefore, we think that knot theory is suitable for our students who study in the technological field. In particular, we gave three research themes for three upper-class students respectively: tricolorability, the number of p-colorings (Lickorish, 1997) obtained by considering congruence modulo p and Goeritz invariant which is a non-negative integer sequence obtained by the deformation of the elementary row operation of integral square matrices. They can learn mathematics

deeply because congruence and matrices are the learning contents which they understand in ordinary classes. This paper is composed of ten parts. Section 1 is the introduction, which includes the background of the investigation. In Section 2, we explain the construction of open courses. In Section 3, we review the scenes of open course with some photos. In Section 4, we introduce an open course about quadratic curves. In Section 5, we introduce examples of knots and define knot invariant. In Section 6, 7 and 8, we define some knot invariants: tricolorability, number of p-colorings and Goeritz invariant, and introduce its calculation results which the upper-class students obtained. In Section 9, we describe the result of the questionnaire obtained from the participants. Finally in Section 9, we describe the conclusion of this effort and the future challenges.



[Figure 1: Active learning]

§2. The structure of open course

We constructed the open course as follows.

(a) Learning contents
Quadratic curve and knot theory.

(b) Construction
- Participants
Junior high school students (the first to the third grade).

- Leaders
Three teachers and three teaching assistants.

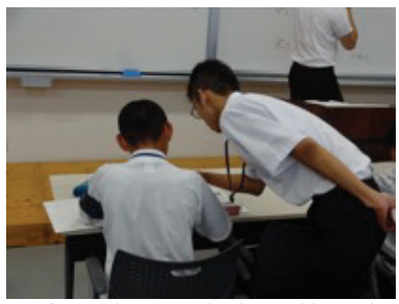
- Time
210 minutes which consists of 60 minutes for quadratic curve and 60 minutes + 90 minutes for preparation and knot theory.

§3. Some scenes of open course

In this section, we review the scenes of the open course with some photos. The teachers write some points to solve the problems on the blackboard or show slides on the screen (see Figure 2). The participants write the points on their answer sheets before solving problems. At the same time, the teaching assistants walk around the participants to answer their questions (see Figure 3). Through these activities, the teaching assistants developed their ability to teach mathematical subjects.



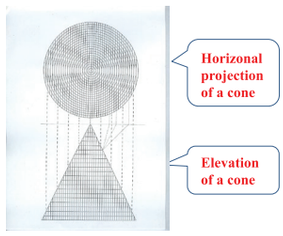
[Figure 2: Lecture]



[Figure 3: question answering by teaching assistant]

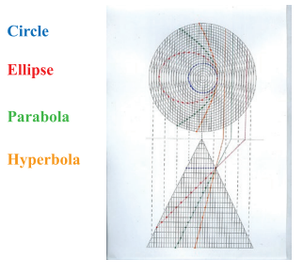
§4. Quadratic curve

A quadratic curve is in general defined to be zeros of a degree two polynomials in two variables. It is well known that each quadratic curve is divided into either a hyperbola, a parabola, an ellipse or a circle. In the open courses, we introduce a quadratic curve by showing a section appearing in cutting a cone.



[Figure 4:Chart form of a cone]

Changing the angle of cutting, we can find all the four kinds mentioned above (see Figure 5).



[Figure 5: Quadratic curve obtained from the angle of cutting]

§5. Knot and its invariant

First, we define a knot and a knot diagram, and give some examples.

Definition 5.1. A *knot* is an embedding of a circle in 3-dimensional Euclidean space R^3.

Definition 5.2. Let us consider the projection of a knot onto a plane. A small change in the direction of projection will ensure that it is one-to-one except at the double points, called crossing. The projection which is distinguished between the over-strand and the under-strand at each crossing is called a *knot diagram* (Figure 6).



[Figure 6: Knot diagram]

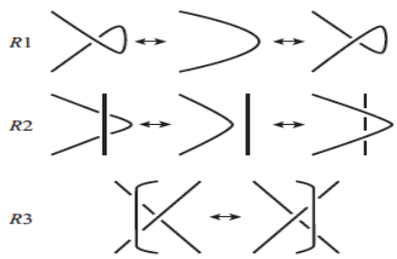
Example 5.3. Knot diagrams shown in the Figure 7 are called a trivial knot, a trefoil knot (or 3_1 knot), a figure eight knot (or 4_1 knot) and a 6_1 knot respectively.



[Figure 7: Examples of knots]

Next, we define some deformations of a knot diagram and a knot invariant, or a value which is independent of the deformations.

Definition 5.4. The following deformations R_1, R_2 and R_3 in the knot diagrams are called Reidemeister move.



[Figure 8: Reidemeister move]

If two knot diagrams can be moved by repeating Reidemeister moves finite times, they are defined to be the *same* knots. Moreover, a value which is defined for each knot and is independent of Reidemeister moves is called *knot invariant*.

We define some knot invariants in Section 3, 4 and 5 to check whether a knot can be unknotted or not, and whether two knots are same or not.

§6. Tricolorability and its calculation results

The definition of tricolorability is given as follows:

Definition 6.1. A knot is *tricolorable* if each strand of the knot diagram can be colored one of three colors, subject to the following rules:

1. At least two colors must be used in the knot diagram, and
2. At each crossing, the three incident strands are either all the same color or all different colors.

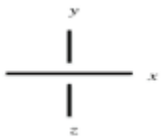
Then it is well known that the following statement holds.

Theorem 6.2. Tricolorability is independent of Reidemeister moves, i.e., it is a knot invariant.

Example 6.3. A trivial knot is not tricolorable because it has a knot diagram which does not satisfy Condition 1 in Definition 6.1.

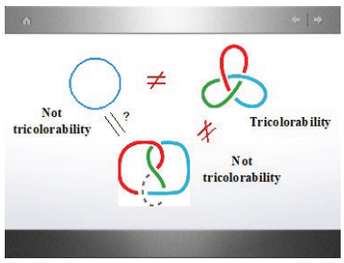
Remark 6.4. (1) The converse of Theorem 6.2 does not hold because a figure eight knot is not tricolorable.
(2) Considering the contraposition of Example 6.3, we see that a knot is not unknotted if it is tricolorable.

Remark 6.5. We may denote three colors by three integers 1, 2 and 3. If each of x, y and z denotes one of the three integers, as in Figure 9, then the condition 2 in Definition 6.1 has an alternative description as $2x \equiv y + z \ (mod\ 3)$ by using congruence modulo 3.



[Figure 9: Crossing condition]

One of the teachers explained the calculation result about three knots given in Figure 7 using a slide and promoted the understanding of tricolorability.



[Figure 10: Tricolorability of knots]

In addition, he suggested that the trefoil knot was unknotted using Remark 6.4 (2) and it was impossible to consider whether a trivial knot and a figure eight knot are the same or not using tricolorability because of Remark 6.4 (1).

§7. Number of *p*-colorings and its calculation results

Using the description in Remark 6.5, a generalization of tricolorability called *p*-colorability is given as follows:

Definition 7.1. A knot is *p-colorable* if each arc of the knot diagram can be labeled by the one of integers: 1, 2, … , p, subject to the following rules:

1. At least two integers must be used in the knot diagram, and
2. For each triple of integers $x, y, z \in \{0, 1, \cdots, p-1\}$ at a crossing as in Figure 9, they satisfy the condition: $2x \equiv y + z \ (mod\ p)$. (This condition is called *crossing condition* at the crossing.)

Next, let us define a number obtained from Definition 5.1.

Definition 7.2. We say that a knot diagram is *p-colored* if each arc of the knot diagram is labeled by one of the numbers 1, 2, ⋯, p in such a way that at each crossing the labels satisfy the condition 2 in Definition 7.1. The number of p-colored knot diagrams for a knot K is called *the number of p-colorings of K*.

Theorem 7.3. The number of p-colorings is independent of Reidemeister moves, i.e., it is a knot invariant.

Example 7.4. The number of p-colorings of a trivial knot is p.

Remark 7.5. (1) The converse of Theorem 7.3 does not hold.
(2) Considering the contraposition of Example 7.4, we see that a knot is non-trivial if the number of p-colorings is not p.

Remark 7.6. If the crossing number of a knot diagram is n, then it needs to choose (x, y, z) which satisfies the crossing condition out of np^3 ways in order to calculate the number of p-coloring.

Since the figure eight knot has four crossings, it needs to choose (x, y, z) which satisfies the crossing condition out of $4 \times 5^3 = 500$ ways in order to calculate the number of 5-coloring from remark 5.6. Therefore, one of the teachers divided the participants into 5 groups and gave a calculation sheet for each group (see Table 1).

[Table 1: Calculation of 5-colorings of a figure eight knot]

y	z	w	crossing condition at A 2y≡x+w	crossing condition at B 2w≡x+z	crossing condition at C 2z≡y+w	crossing condition at D 2x≡y+z	5-colored or not
1	1	1					
1	1	2					
1	1	3					
1	1	4					
1	1	5					
1	2	1					
1	2	2					
1	2	3					
1	2	4					
1	2	5					
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1	4	4					
1	4	5					
1	5	1					
1	5	2					
1	5	3					
1	5	4					
1	5	5					

The calculation result about three knots given in Figure 7 is as follows:

[Table 2: Number of p-colorings of knots]

Knots	Number of p-colorings	p=2	p=3	p=4	p=5
Trivial knot		2	3	4	5
Trefoil knot		2	9	4	5
Figure eight knot		2	3	4	25

Moreover he suggested the following results and these three knots as above were different.

- A trefoil knot and a figure eight knot are not unknotted by considering the number of 3-colorings and 5-colorings respectively.
- A trefoil knot and a figure eight knot are not the same by considering the number of 3-colorings.

§8. Goeritz invariant and its calculation result

Let D be a diagram of a knot K. Then D devides a plane into finitely many domains D_1, D_2, …, D_n, one of which is unbounded, say D_n. We classify these domains into two classes, black and white in such a way that no domains of the same color have edges in common. For convenience, we assume that D_n is a black domain. Now we define an index ε = +1 or -1 of a crossing point of D according to Figure 6.



[Figure 11: Index of crossing point]

Here, a shaded area indicates a black domain and the orientation of K is irrelevant. Let $\{W_1, W_2, \ldots, W_{m+1}\}$ be the set of all white domains. Using these white domains, we define an $(m+1)\times(m+1)$ integer symmetric matrix A $= (a_{ij})$, $1 \le i, j \le m+1$ as follws:

Definition 8.1.

$$a_{ij} = \begin{cases} \sum \epsilon & (\text{for } i \neq j) \\ -\sum_{j=1,\ i\neq j}^{m+1} a_{ij} & (\text{for } i = 1,\ 2,\ \cdots,\ m+1), \end{cases}$$

where the summation $\sum \varepsilon$ runs over all crossing points of D that are common to W_i and W_j. This matrix A is called Goeritz matrix of a knot K.

Let an irreducible Goeritz matrix A_1 be a minor matrix of A that results from A by removing an arbitrary row and an arbitrary column. Goeritz invariant of a knot is given by deforming the irreducible Goeritz matrix using the following transformations. Let M and N be two integral matrices.

Elementary transformations
(a) Interchange two rows (resp. two columns).

(*b*) Multiply a row (resp. a column) by −1.
(*c*) Add a row (resp. column) to another one multiplied by an integer.
(*d*) If we have $M = (1) \oplus N$ or $N = (1) \oplus M$, then change M (or N) to N (or M).

Definition 8.2. Using the above operation, any integral matrix, especially, the irreducible Goeritz matrix A_1 can be deformed into a unique diagonal integral matrix: $(k_1)\oplus(k_2)\oplus\cdots\oplus(k_d)$ which satisfies the following condition (i) and (ii). Then the non-negative integral sequence (k_1, k_2, ⋯, k_d) is called Goeritz invariant of a knot K.

(i): If $d = 1$, then $k_1 \geq 0$.
(ii): If $d \geq 2$, then $k_i \geq 0$, $k_i \neq 1$ $(1 \leq i \leq d)$ and

$k_{i+1} = mk_i$ $(1 \leq i \leq d\text{-}1$; m: integer)

Example 8.3. Since a trivial knot is described as in Figure 7, we have its two Goeritz matrices (1) and $\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$. Therefore, the Goeritz invariant of a trivial knot is (1).



[Figure 11: Trivial knot]

Theorem 8.4. The Goeritz invariant is a knot invariant.

Remark 8.5. (1) It is well known that the converse of Theorem 8.4 does not hold.
(2) Considering the contraposition of the conclusion in Example 8.3, we see that a knot is non-trivial if the Goeritz invariant is not (1).

One of the teachers suggested that these three knots as above were different considering Goeritz invariant.

[Table 3: Goeritz invariant of knots]

Knots	Goeritz matrices	Goeritz invariant
Trivial knot	$\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}$, (1)	(1)
Trefoil knot	$\begin{pmatrix} 3 & -3 \\ -3 & 3 \end{pmatrix}$, $\begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix}$	(3)
Figure eight knot	$\begin{pmatrix} 3 & -2 & -1 \\ -2 & 3 & -1 \\ -1 & -1 & 2 \end{pmatrix}$, $\begin{pmatrix} -2 & 1 & 1 \\ 1 & -3 & 2 \\ 1 & 2 & -3 \end{pmatrix}$	(5)

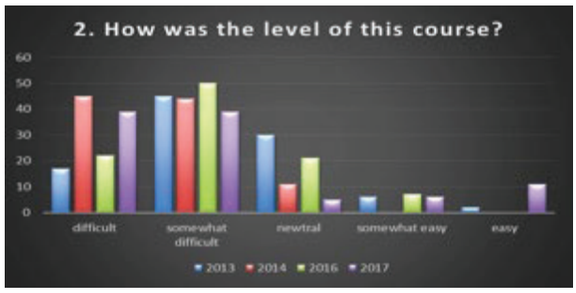
§9. Results of the questionnaire

We have carried out the questionnaire for the participants about the above themes since 2013(except 2015). The items of questions and their results are the following:

Question 1. Did you understand this course?
Question 2. How was the level of this course?
Question 3. Was this course useful for you?
Question 4. Were you satisfied with this course?

[Table 4: questionnaire for the participants]









§10. Conclusion of this effort and a future subject

We had the following comments about our teaching materials from the upper-class students.

- It was interesting that whether a knot can be unknotted or not using congruence.
- I was able to understand that various mathematical methods decided whether a knot can be unknotted or not without deforming knots by hand.
- I want to study knot theory and calculate various knots and links in the future.

Knot theory is one of the fields of current mathematics. Using teaching materials concerning knot theory, the authors tried to have students pay attention to relevance of the theory and be motivated to learn (Kawashima, Sakai & Tanaka, 2014). The trial of this

time is aimed that students notice knot theory is closely related with various contents of mathematics and understand them deeply, paying attention to cautions and relevance.

The questionnaire showed good results. As is in the comment, we think that themes which are relevant to their field such as DNA in biology were well received.

Though the original guidance plan was to help students calculate knot invariants of a trefoil knot and a figure eight knot using the number of *p*-colorings and Goeritz invariant respectively, the upper-class students have studied knot theory enthusiastically, and at last they have succeeded in calculating more complicated knot; 6_1 knot. They presented these results at a symposium held in 2015. Their presentations were brief and to the point. In addition, they all got an extremely high score on the national mathematics test, the unified National Institute of Technology examinations for the third-year students. This means that they had a good grounding in mathematics through this trial including the supplementary lessons and an open class. From the above, this trial can be regarded as a positive one.

Now we introduce the following teaching material so that we can help students' research and presentation in the future.

"*L-S category"* (Cornea, Lupton, Operea & Tanre, 2003; Miyaji & Sakai, 2013) in homotopy theory. It is an invariant for various figures and can be understood relatively easily since we can learn it visually as knot theory, and need to have little preliminary knowledge on it. Then this theme would be interesting for students. For example, the L-S category of a torus and a Klein bottle are both two. There is a *fibrewise* version of the L-S category and it is known to have a possibly different value from the ordinary L-S category. As a simple example, a torus has the value two as its ordinary L-S category, but one as its fibrewise version (Cornea, Lupton, Operea & Tanre, 2003). Using the property of the fibrewise A_∞-structure, one of the authors gives that the fibrewise L-S category of the Klein bottle has the value two (Sakai, 2010). In addition, it is known that the fibrewise L-S category is related to "topological complexity", a field of research involved in the motion planning of robot arms (Iwase & Sakai, 2010).

Acknowledgements

The authors would like to express their gratitude to the upper-class students in NIT, Kurume College for their great contributions.

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LINKING HANDS-ON EXPERIENCE IN TEACHING TECHNOLOGY

Man-Ching Yuen [*a], Shin Ying Chu [b], Wing Hong Chu [a], Hoi Shuen Cheng [a], Ho Lam Ng [a] and Siu Pang Yuen [a]

[a] Hong Kong Institute of Vocational Education (Tsing Yi),
Department of Information Technology, Hong Kong, China

[b] Universiti Kebangsaan Malaysia, Faculty of Health Sciences,
Centre of Rehabilitation and Special Needs, Kuala Lumpur, Malaysia

* Senior Member, IEEE, connieyuen@vtc.edu.hk

Abstract

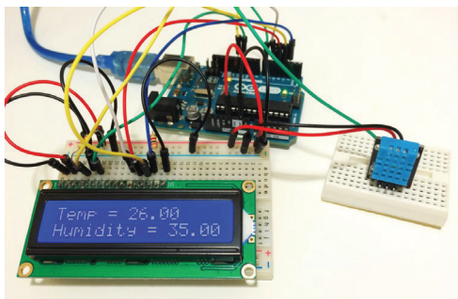
The hands-on experience that was once thought of as key to creating a well-shaped student has now disappeared from the classroom. Hands-on Learning isn't just for sewing, cooking or painting; it could be for subjects in science as well. In this paper, we present the phases of creating a hands-on experience for students in learning advanced networking technologies in their final year projects. Students were grouped (3-4 students per group) and were asked to prepare a project related to the Internet of things (IoT). IoT is the network of physical devices embedded with electronics, software, sensors, and network connectivity which enable these objects to connect and exchange data. IoT recently incorporated into our daily living that makes our life more comfortable. However, many previous works do not consider the need of people with disabilities, and the cost of building up a smart home can be very expensive. A group of students proposed a low-cost smart home especially for people with disabilities and pet owners. The smart home has four main features: (1) Effective temperature & humidity monitoring by using DHT11 temperature sensors; (2) Pet / disabled / elderly monitoring by using Arduino robot car; (3) High security by using RFID and (4) Health monitoring by using pulse sensors. This low-cost system can give users real-time reactions or important warning messages. Besides, the data collected by the system will be sent to the data server for further peruse if necessary. During the project, the teacher acts as a supervisor to guide students in forming the project, writing up proposal, implementing the project, solving problems they faced and organizing tasks. Through this, students have the opportunity to develop their skills, collaborate as a team, gain knowledge on designing and making functional products, and practice their public speaking skills. In this paper, we will introduce each part of the smart home and their functions. Besides, we will describe what problems the students faced during each stage of the project and how they solved their problems.

Keywords: Hands-on, Technology, IoT, Smart Home, Sensor, Robot car, automated system

Introduction

As technology grows exponentially in the past two decades, a number of previous works proposed many learning framework for students to learn the latest technology. Yu and Lin proposed an online learning system which first presents the theorical concepts of Mathematics, Science, and Technology (MST) to students, and then provides an online simulation to help students utilizing the concepts to design virtual products of MST, and finally requires students to design and make the real products in order to integrating concepts learned with practical problem (Yu & Lin, 2017). Rutten et al. pointed out that computer simulations can enhance traditional instruction, but it is also necessary to consider the possible impact of teacher support, the lesson scenario, and the computer simulation's place within the curriculum (Rutten, van Joolingen & van der Veen, 2012). Cruse proved that using educational video in classroom teaching is an effective way to help students to understand the teaching materials, and it is important to take into account the length of video (Cruse, 2006). In this paper, we propose to guide the students to learn practical skills by using educational video outside classroom and working on hands-on projects to link up the concepts and practical problems. We found out that educational video is a very good resource to help students to learn hands-on skills. Besides, watching video outside classroom can further motivate students' learning interest because students can watch the videos at anytime, anywhere. However, students need to have some basic theorical background, which can only be learned from classroom, in order to understand the skills taught in videos.

Table 1. Applying Design Thinking Skill in Hands-on Projects

Step 1: Empathy ● Gain insight on needs through interviewing people with different needs and pet owners, normal users, and pet owners. ● Consider in detail on how IT technology can help with the people needs.	
Step 2: Define ● Improve people's living by making use of the advanced technology. ● Offer more convenience by allowing users to remote control the device. ● Detect and update the temperature and humidity information timely with the sensor.	
Step 3: Ideate ● Explore useful functions for people with different needs such as provide navigation for the visually impaired with the robot car. ● Explore useful functions for pet owners such as allow users to remote control the robot car to walk around and exercise with their pets. ● Explore more timely reflection of temperature and humidity information for users.	
Step 4: Prototype ● System functions were coded by development tools such as Visual Studio and Arduino IDE. ● The above tools are developed by C/C++ programming language in order to instruct the sensor to perform required functions.	
Step 5: Test ● Perform module test to validate individual system component. ● Conduct user acceptance test (UAT) to justify system usability.	

Materials and Methods or pedagogy

Doing hands-on projects is a common methodology to help students to learn practical skills. Before working on the projects, students have to learn the basic technicial concepts in classroom and these knowledge can help the students to further explore themselves to develop the real products outside classroom. However, contact hours in classroom are limited. Online learning materials might be a good resource to help students to learn by themselves, and online educational videos attract the most attention from learners. It is because students can watch the videos at any time, any where.

In this case study, a group of 4 final year students from Higher Diploma in Telecommuncations and Networking worked on their final year project for 9 months. During their Year 1 study, the students have learned some basic technicial modules, such as Network Fundamentals, Introduction to Programming, Web Application Development Frameworks, Telecommunications &Networking Project and so on. After group formation, the students adopt the Design Thinking Model (Denning, 2013) in their project work as shown in Table 1.

- **Step 1 – Empathy**. Students have to brainstorm what project topics they have interest to work in. They need to think about how how IT technology can help with the people needs.

- **Step 2 – Define.** Students have to define they project topic with the consent of their supervisors.

- **Step 3 – Ideate.** Students have to write up their project proposal which includes the project scope, targeted users, project deliverables, division of tasks and project timeline.

- **Step 4 – Prototype.** Students have to develop the smart home system with sensors of various functions and the online system for data collection and analysis. In this stage, students needs to integrate what they learnt in classroom into practical real scenarios.

- **Step 5 – Test.** Students have to perform module test to validate indiviual system component. They have to carry out integrated system test to validate the system perfromance as a whole. They also need to conduct user acceptance test to justify system usability.

Results

The students successfully design and produce the IoT system within 9 months. Figure 1 shows the output of their product.

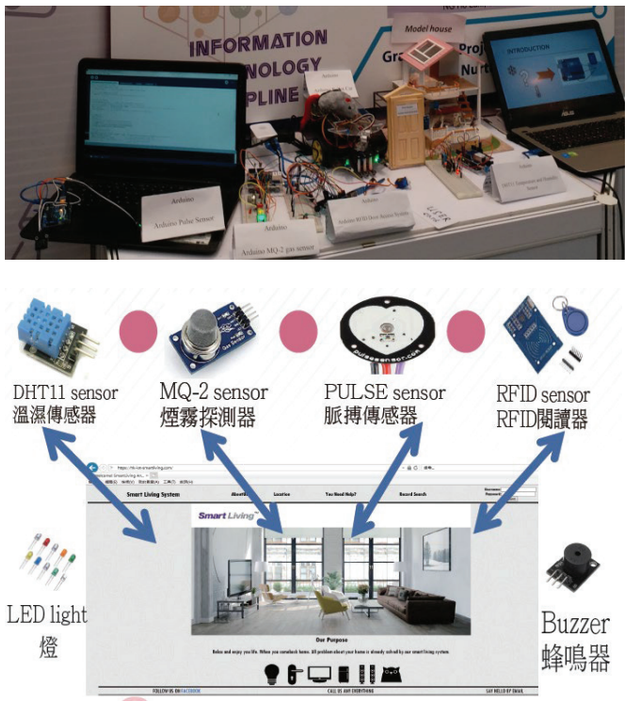


Figure 1. Students' project work on IoT system for smart living for people with different needs and pet owners.

In the project, the students create a high-effective and low-cost smart home especially for people with visual disabilities or hearing disabilities or pet owners by using Internet of Things (IoT) technology. The smart home not only use various sensors to provide real-time reactions to users in 4 main aspects including clothing, food, shelter or travelling, but also use web server to store the collected data, provide data statistics and support some data analysis. The students use DHT11 Temperature Sensor for measuring temperature and humidity, pulse sensor for health checking, smoke detector for home safety, RFID via NFC for home security and robot car for pet caring. The smart home not only make the life of people with disabilities better, but also help pet owners to take care their pets when their pets staying at home alone.

Discussion

For critical evaluation, the students reported the problems and solutions in their project:

Problem 1: Sensor does not work

- *Problem:*
  When we want to try programming on the DHT11 sensor, the sensor cannot display the detected output. We try to search on the Internet and found that when the sensor does not work, it will show us some error messages on Arduino IDE software (as shown in Figure 2).

- *Solution:*
  We had tried to contact our sales in Taobao online shop and tell them our problem on the sensor, they have sent a new DHT11 for us to replace the sensor with problems.

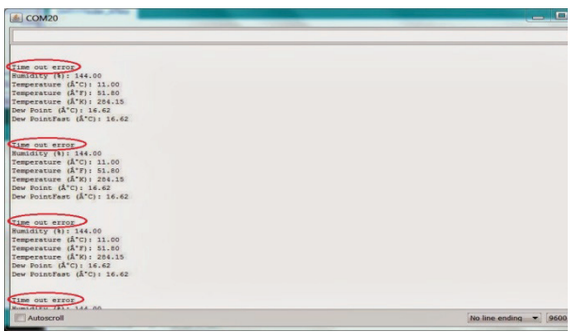


Figure 2. The screen capture of DHT11 sensor error when the sensor does not work properly.

Problem 2: Modules inside robot car are not compatible

- *Problem:*
  When I test the robot car, I find a problem I need to solve. Each sensor has its own set of commands, some commands and modules are not compatible. It will affect the functionality of Robot Car.

- *Solution:*
  Switch to use other module that has same function and also find solutions online.

Problem 3: Lack of space inside robot car

- *Problem:*
  In the later stage of our project, we want to add other sensors in order to provide more features for our target user, but we find that there is not enough space inside robot car to expand.

- *Solution:*
  After discussing with other experts on the Internet, we know that the installation of additional floor is feasible without affecting the normal operation of Robot Car.

Problem 4: Lack of experience on setting RFID security door

- *Software Problem:*
  As we were not very skilled at connecting circuits, we spent a lot of time on the wiring together in order to have a better understanding of the circuit part. Besides, the design and reality are biased. We found some errors returned when we entered the code, such as the LED lamp losing reaction. Also, it cannot detect the blue tag successfully (as shown in Figure 3).

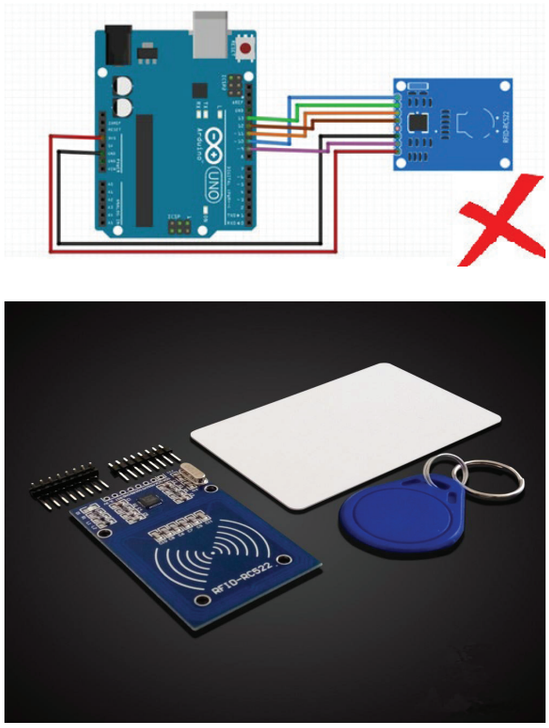


Figure 3. The scenario of connecting circuit.

- *Software Solution:*
  With these problems, we will take other ways to solve the problem. For example: ask the teacher to solve Arduino problems or view Arduino category books. On the other hand, we will find relevant information on the website and also online teaching materials (such as educational video in YouTube) to solve the current problem.

- *Hardware Problem:*
  When we use Arduino for the first time, we insert the wrong line situation. Therefore, some hardware did not respond. Also, there is damage in the mini-motherboard, which leads to the entire system not be fully functioned (as shown in Figure 4).

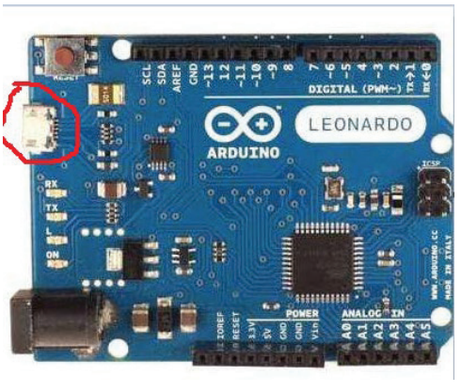


Figure 4. The scenario of connecting circuit.

- *Hardware Solution:*
  We tried to contact the seller and asked whether there are any damages to the micro-motherboard and negotiate with the seller to replace a new miniature motherboard to solve the problem. Besides, we further explore some other technical problems and the causes to the problem with the seller. ***By watching the educational videos many times, we can learn the right installation process step by step clearly. It is very convenient for us to learn because we can watch the online video at anytime, anywhere. We can choose the language that we are the most familiar with. It strongly motivates us to know more about the skills involved in the installation process. The most important thing is that the basic concept we learnt before in classroom helps us to understand the technical terms used in the videos and the supervisor's guidance helps us to do things in the right way too.***

Problem 5: Sensors not having reaction

- *Problem:*
  In the testing environment, sensors do not have immediate reaction. After 1 to 2 minutes, sensor result values have very small changes only, which cannot cause the buzzer to activate.

- *Solution:*
  After research and investigation, we find out that the cause of the problem is sensor is not sensitive enough. ***After learning from the online video about how to train the sensors, this problem has been solved.***

Conclusions

This study shows that Design Thinking Model can help out students to do hands-on project, and also online video is an effective way to help students in learning hands-on skill outside classroom. By implementing the skills in real projects, students can integrate their technical concepts into real scenario. Our future work is to study what factors affects the degree of attractiveness of an online education videos.

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ON POSITIVE EFFECTS OF DESCRIBING PROCEDURES OF DERIVING SOLUTION FOR PROBLEMS IN MATHEMATICS CLASS BY DIALOG-STYLE

Michiharu SUZUKI*

Natural Science Devision , NIT, Kisarazu College, Kisarazu, Japan

*E-Mail m-suzuki@kisarazu.ac.jp

Abstract

My purpose in this paper is to introduce you to my method to improve students' abilities to explain the other students for mathematical notions by writing the procedures for solving their problems tackled in class.

This method is based on the thought of "manabiai" advocated by Professor Nishikawa at Joetsu University of Education and is considered as one of active learning.

Especially I have been trying to introduce my students to not only knowledge of mathematics but also what students get through this class since my "manabiai" class started.

Keywords: *cooperative learning, active learning, questionnaire, mathematical education, curriculum management*

1. Introduction and Motivation

To begin with, I want to show you a typical example which one of my student in the first grade wrote as an answer for one simultaneous equation.

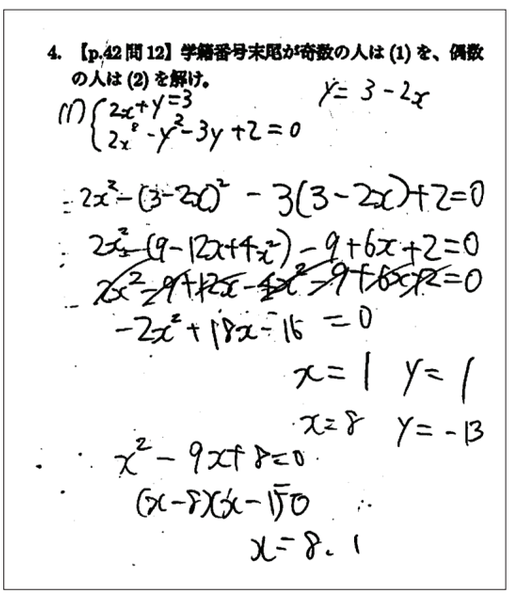


Figure 1 Typical writing for answer

We experience that a lot of students in our school write only formulae and hardly read between the formulae.

This sheet shows me that a lot of Japanese students would think we can only get an answer and the processes towards the solution are not necessary, we don't write the courteous procedure if possible. On the other hand, we, mathematics teachers, know whether they can understand the problem and the necessities for mathematical tools, skills and notions. Moreover I wish they could acquire the talent of explaining them to the other person.

In this paper I try to substantiate that my practice for the last three years is more effective than one kind of active learning, that is, "manabiai" method. Here "manabiai" method was introduced in ISATE2016. Moreover I wish some participants will be interested in my practice and "manabiai" method, and I'd like to discuss improving this method in the near future.

Although I have practiced active learning by "manabiai" method to my classes since the latter half of the 2008 academic year. I have one trouble in regards to my practice. There are only a few students that couldn't consult his/her classmates even if they couldn't solve their problems on their own. I believe all students should have communication skills as well as mathematical notions and skills after they will graduate from their school and to work at their company. In my mathematics classes there are about three fourth of 90 minutes in each class for students to solve problems in their textbook which I give them.

First of all, we, math teachers, always think that how our students obtain mathematical skills and techniques and also seize how to consider various phenomenon in nature from the mathematical view.

Though I have been looking for ways of solving these concerns, I couldn't get any solution.

By the way, in 2016 I came up with a certain thought.

That was to write down a solution as if you would explain your classmate to each other's faces by gentle and understandable ways.

I continue to do this writing down procedure almost every time in every class during one year.

2. "Manabiai" as One Method of Active Learning

I briefly explain "manabiai" to whom it is not familiar. Because I perform this practice on the basis of "manabiai", one of various methods in active learning.

"Manabiai" is thought as one method of cooperative and active learning. Professor Nishikawa at Joetsu University of Education advocated about twenty years ago and proclaims that "manabiai" is a thought consisted of three views of education: First, children have their excellent talents on their own. Second, teachers should prepare students' learning environment to promote their learning. Moreover teaching ought to entrust students. Third, school is the place where students acknowledge that their fellows are indispensable to themselves for doing their own tasks or subjects in school activities.

Professor Nishikawa often says that there aren't concrete ways in "manabiai", so we may call all the classes based on these three views "manabiai" classes. So, "manabiai" class are not limited to specific subjects. Therefore we have possibility to expand almost all subjects in all types of schools, including high school, KOSEN, or university.

But I think that there is an orthodox method as "manabiai" or we, who practice "manabiai", should keep some rules in class.

First, at the first time of all the classes in a year teachers have to illustrate why "manabiai" class will be needed for students.

Second, teachers should set up subjects or problems each time and estimate students' activities in class, that is, they get musts which teachers indicate or aim to that day.

Third, teachers give students as much freedom and time as possible to solve problems of that day. For attaining this purpose they can leave their own seats and talk with their classmates about solutions. They do not always keep their seats.

Hence the better "manabiai" works, the better this practice is.

3. How to do this practice

Honestly I confess that there are some students who give up solving problems and that due to giving freedom to students in class some students are chatting with small talks.

Although I encourage them to be able to solve some problems and get mathematical notions, I can't break their solid mind.

But my main concern is that I have these students tackle problems providing in class and contemplate them as hard as possible.

Under these circumstances, I began with doing this practice.

First of all, I will explain this practice in detail.

This practice is done for almost 10 minutes before the end of the classes.

I give all the students in class the following sheet.

Each student writes the procedure towards a solution of their selected problem on their own as if they would explain it plainly to their classmates, who doesn't know how to solve the problem. So this written form looks like scenario. Therefore I call this practice Dialog style writing.

And then each student selects one of all the problems they tackled in each class as they like.

Next they assume one "virtual" classmate who couldn't understand or solve his/her selected problem until that time.

Concerning the selected problem, they describe the procedure as if they will explain it to their virtual friend and write that scene like a script or scenario.

I want to make them write the procedure of solving the problem as if they will explain how to solve the problem to their classmate politely and graciously. So by continuing this procedure a lot of times I think they could get mathematical notions and skills deeply than they solve the problems on their own.

4. As a Curriculum Management

The Ministry of Education, Culture, Sports, Science and technology (MEXT) says that the next Course of Study, which plans to start in 2020, includes Active Learning. MEXT defines Active Learning as the following in YOUGOSHU in 2012 (the original in Japanese)

: Active Learning is not one-way teaching method like lecture, but a general form of teaching method by which learners can attend classes positively. Active Learning aims to raise the whole talents for learners to adjust, solve and tackle various kinds of problems occurring in our societies in the 21st century. (I paraphrased the original sentences.)

In various restrictions we all struggle to teach our own subjects, but main limitation is time. I think that teaching time is not assigned enough compared to their contents of each subject.

Therefore we must create some effective methods to attain our purpose of fostering engineers in our school.

As one solution, I propose to join mathematics and Japanese language together, in detail, to describe their procedure to solution by explaining their friends, who assume that they can't solve the same problem. In particular, I even think that this friend needn't to exist, that is, I allow this friend to be a virtual student. Because in our Japanese school there are some students, who aren't good at communicating their classmates. So I come up with one idea. If these students are training to explain how to solve the problem to a virtual friend, they are finally to explain to real friends.

5. My practice for the last three years in Kisarazu College, NIT

I started this practice for two classes of the first grader and the second grader in the second term in 2016, and have been practicing until now.

I usually do this practice at the last 10 minutes of each class. So my students totally write down around 50 sheets through an academic year.

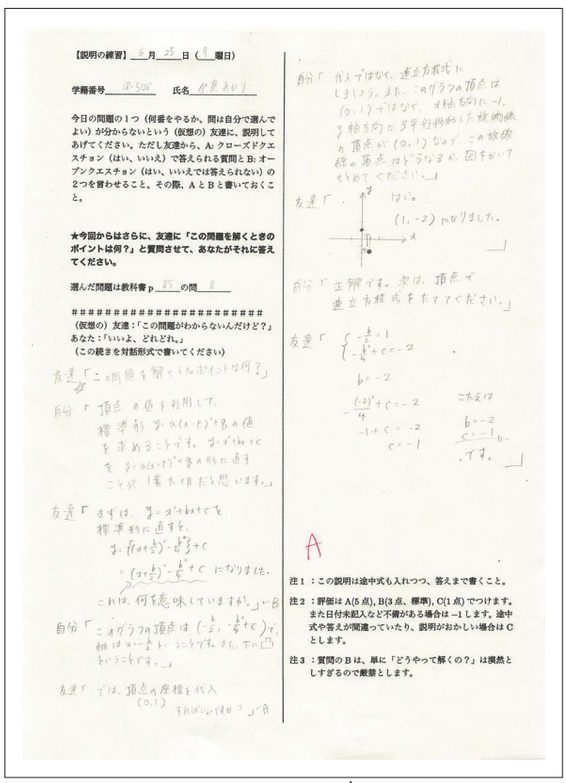
At the end of the academic year 2016 and 2017, I did questionnaires to each class.

This questionnaire contains ten items, and one of ten items is concerning this “reflection sheets”.

Here I will show you one student is developing his writing ability.

In general, the quantity of the writing at the beginning of April was little. Furthermore, the sentences were not dialog-style but monolog-style. It is only an explanation for a problem.

But the following sheet was written by one student on 25th June, 2018. I could interpret she deeply understand this problem and mathematical notions involved in this problem. For this class my students had experienced this practice around twenty times for almost two months. I am sure that this practice can enhance my students’ mathematical talents and the skills of explaining some problems they would work out to their classmates.



【説明の練習】 6 月 25 日（ 月 曜日）

学籍番号 18-508　氏名 伊東あかり

今日の問題の１つ（何番をやるか、問は自分で選んでよい）が分からないという（仮想の）友達に、説明してあげてください。ただし友達から、A: クローズドクエスチョン（はい、いいえ）で答えられる質問と B: オープンクエスチョン（はい、いいえでは答えられない）の２つを言わせること。その際、A と B と書いておくこと。

★今回からはさらに、友達に「この問題を解くときのポイントは何？」と質問させて、あなたがそれに答えてください。

選んだ問題は教科書 p 85 の問 8

##########################

（仮想の）友達：「この問題がわからないんだけど？」
あなた：「いいよ、どれどれ。」
（この続きを対話形式で書いてください）

友達「この問題を解くときのポイントは何？」

自分「頂点の値を利用して、標準形 $y=a(x-p)^2+q$ の値を求めることです。$y=x^2+bx+c$ を $y=a(x-p)^2+q$ の形に直すことが1番大切だと思います。」

友達「まずは、$y=x^2+bx+c$ を標準形に直すと、$y=\{(x+\frac{b}{2})^2-\frac{b^2}{4}\}+c$ $=(x+\frac{b}{2})^2-\frac{b^2}{4}+c$ になりました。これは、何を意味していますか。」…B

自分「このグラフの頂点は $(-\frac{b}{2}, -\frac{b^2}{4}+c)$ で、軸は $x=-\frac{b}{2}$ ということです。また、下に凸ということです。」

友達「では、頂点の座標を代入 (0,1) すればいいですか？」…A

自分「代入ではなく、連立方程式にしましょう。また、このグラフの頂点は (0,1) ではなく、x軸方向に −1、y軸方向に3平行移動した放物線の頂点が (0,1) なので、この放物線の頂点はどうなるか、図をかいてもとめてください。」

友達「はい。(1, −2) になりました。」

自分「正解です。次は、頂点で連立方程式をたててください。」

友達「$\begin{cases} -\frac{b}{2}=1 \\ -\frac{b^2}{4}+c=-2 \end{cases}$
$b=-2$
$-\frac{(-2)^2}{4}+c=-2$
$-1+c=-2$
$c=-1$
こたえは $b=-2$, $c=-1$ です。」

A

注１：この説明は途中式も入れつつ、答えまで書くこと。

注２：評価は A(5 点), B(3 点、標準), C(1 点) でつけます。また日付未記入など不備がある場合は −1 します。途中式や答えが間違っていたり、説明がおかしい場合は C とします。

注３：質問の B は、単に「どうやって解くの？」は漠然としすぎるので厳禁とします。

Figure 2 This sheet written on 25th June, 2018

And I change “manabiai” class little by little every year by taking into account students’ questionnaires’ answers.

But the frame of this practice is almost the same in last three years.

In our school a period of time in one class is 90 minutes.

The procedure of my one class is the following

1) Doing mini test (10 minutes), which is concerning about the contents they have learned until the previous time,
2) Exchanging mini test side by side and marking it by students (about 5 minutes),
3) Explaining brief outline of the content on that day (from 10 to 15minutes),
4) Students’ activity (about 60~70minutes) to solve the problems on that day,
5) Comment students’ overall activities on that day to promote students’ activity next time (about a few minutes).

6. Analysis of questionnaires (1)

In this section I introduce students' comments in questionnaires. I said this practice started in the latter term of the 2016 academic year. The 2016 and 2017 academic years were my trial ones for this practice. So I didn’t take decent questionnaires, only gathered their comments for this practice.

In 2016 my students of the third grade said the following.

1) Through this practice I could understand the problems deeply.
2) It is difficult to write the procedure of solution. So I need to understand the problem than ever.
3) By experiencing this practice I could explain real classmates.
4) I could have confidence in showing my classmates to explain our problems.
5) I acknowledged my extent of how deep I could understand our problems through this practice.

And so on.

I could congregate 40 comments in this class, and most of them are positive, although ten percent is negative. Some students, writing negative comments, said, “I don’t know why I must do this practice”.

Next my students of the first grade in 2017 said the following.

1) It is useful and effective for me to explain a virtual friend, who don’t solve a problem, how to solve it. Because this practice boost my achievement in maths.
2) At the beginning of this practice I hesitate to do it, but I think this practice will influence “manabiai”.
3) This practice is useful for the simulation as real conversation with my classmates when I consult about mathematical problems.
4) I can show the procedure of solving the problems to my classmates better than ever through this practice.
5) I can understand the contents in each class better than ever.

And so on.

I could collect 39 comments in this class, and almost all of them are positive, although about ten percent is negative. But these students, writing negative comments, din not completely deny this practice.

As above comments of my students, I confirmed this practice from the latter term in 2016 to 2017 would be useful and effective for my students.

7. Analysis of questionnaires (2)

I did the questionnaires on 4th June, 2018 to the second graders, to whom I have taught since last academic year, and on 5th June to the first graders respectively. So the second graders have been receiving this practice since last year.

My questionnaires consist of the following five questions:

1) Do you think you would get deep understanding for your problem picking up when you describe the procedures of solution by dialog-style?

YES, NO, I CAN'T DETERMINE

2) Do you think you get ability of explaining to your friends for your problem picking up when you describe the procedures of solution by dialog-style?

YES, NO, I CAN'T DETERMINE

3) Do you increase your opportunities for explaining your problem picking up when you describe the procedures of solution by dialog-style?

YES, NO, I CAN'T DETERMINE

4) What is your reason to pick up your problem for explaining the procedures to your "Virtual" friend?

5) What do you think of this practice? Let me know your opinions.

At first I get the following result in Question1.

Table 1 Question1 (people)

	YES	NO	I Can't Determine
1st graders	29	2	11
2nd graders	29	2	8

This table shows that most of both graders think that this practice is helpful for deep understanding of the mathematical contents in class.

Next concerning Question2, I get the following result.

Table 2 Question2 (people)

	YES	NO	I Can't Determine
1st graders	28	4	1
2nd graders	28	3	8

This table shows that most of both graders think that this practice is helpful for the ability of explaining the mathematical problems to their classmates.

Moreover I move on Question3. I get the following result. From this chart I judge that there are not necessarily increasing the opportunities of explaining the problems to their real classmates. I wish through this practice they can explain their problems working out in class to their classmates in confidence.

Table 3 Question3 (people)

	YES	NO	I Can't Determine
1st graders	15	20	7
2nd graders	8	23	8

With regard to Question4, I could get various views for them to choose their problem picking up among several problems. So I arranged all comments and got the following three views;

(1) I chose the problem which I could solve on my own.
(2) I chose the problem which I consulted my friends about it when I had been tackling it.
(3) I chose the problem which I thought it was the most important among problems we worked out on that class.

Table 4 Question4 (people)

	(1)	(2)	(3)
1st graders	11	13	13
2nd graders	18	8	6

With regard to Question5, I could get various opinions in relation to this practice as if they would explain the procedure of solving the problem to their "Virtual" friend.

Here I introduce some opinions.

[The first graders]

1) In case of explaining my friend, this practice is helpful for me. Moreover my friend says, "Your explanation is straightforward."
2) I select more difficult one among problems given on that class. Because I must ask this problem for my friend to understand the procedures towards the solution. And once I understand it, I explain the other explanation to my virtual friend. So I think my mathematical thought would beef up.
3) I am not good at explaining to the other people. So it takes more time to get used to this practice.
4) I think it is difficult to explain what I understand and can solve the problem to my classmates.
5) I think throughout this practice I can explain various matters in order to the other people.

[The second graders]

1) By this practice, I think I can get how to solve the problems better compared to when I wouldn't do this practice.
2) I sometimes noticed that I couldn't understand the problems essentially by explaining it to the virtual friend.

3) Throughout this practice I can explain the procedure of the problem to real classmates when he/she asks me to it.
4) I believe this practice can pay off and I can get the ability of explaining something which I have to tell.
5) Throughout this practice I acknowledge several important points on that content in class.

Above these comments my practice of describing the procedure towards the solution is worthwhile and almost all of my students are for this practice.

8. Conclusions and Remarks

As a lot of my students evaluate this practice postively, I will continue and enhance this practice more effectively in the near future.

Especially my next aims are as follows.

1) By using ICT, I search for the possibility that this practice will be able to automatic. Especially all classmates can see the other classmates' answer sheets for this practice and judge which one is best or which one is understandable for each student.
2) I want to evaluate students' reflection sheets by somewhat unified criteria.
3) I also like to research on the relationship between this practice and mid-term/term exams.
4) If it can be possible, I want to substantiate this practice would be effective concerning communication skills in their workplace after they will graduate.

In conclusion, I believe this practice will help them utilize some advice of their classmates by solving quite a few problems in school and encourage them to communicate with their colleagues after they are to work in society.

But I think it is hard to prove the above phenomena. So I want to demonstrate this practice will be effective to create their communication skills and boost their mathematical talents throughout this practice.

Furthermore, I also improve this practice from a ICT point of view.

I also think "manabiai", one of active learning methods, will be a base of this practice. Because in "manabiai" class all students help each other accomplish the subjects every time and then it is necessary to talk about the subjects each other and if some students are having trouble solving the problems the other classmates help them.

Nevertheless some Japanese students in our school can't depend on their classmates to solve the problems he/she faces difficulties, that is, they can't solve them. Therefore they must break their own barrier to settle the problems.

So I think this practice will be one method to break their communication barrier.

Finally I hope "manabiai" will be becoming more familiar not only in Japan but also in the other countries and this practice will be proven effective in the near future.

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EXAMINING THE INTERPLAY OF INDIVIDUAL LEARNER DIFFERENCES AND ACHIEVEMENT IN L2 PRONUNCIATION THROUGH META-ANALYSIS

H. Abe

Department of Creative Engineering, NIT Tsuruoka College, Tsuruoka, Japan

habe@tsuruoka-nct.ac.jp

Abstract

This paper offers a synthesis of the available studies on three areas in L2 Pronunciation Learning Strategies, that is, language-learning strategies, motivation, and the joint influence of motivational factors and learning strategies on the achievement of L2 pronunciation. By so doing, this study attempts to uncover the significant possibility of the mechanisms through which L2 learners regulate their individual learner differences, drawing upon the theoretical framework of self-regulated learning (SRL) (Oxford, 2017) recently investigated in L2 vocabulary learning by Zhang, Y., Lin, Zhang, D. & Choi (2017). SRL is defined as the notion in which "self-regulation of academic learning is a multidimensional construct, including cognitive, metacognitive, motivational, behavioral, and environmental process that learners can apply to enhance academic achievement" (DÖrnyei, 2005, p. 191). The SRL framework in L2 pronunciation might reveal the mechanisms through which learners regulate their motivation and learning strategies, hoping to find out that practitioners and researchers alike develop pedagogical intervention, so that more learners could actively get involved in the class and, in consequence, achieve higher attainment in L2 pronunciation comprehensibility.

Keywords: *individual learner differences (ILD), language learning strategy, L2 pronunciation (achievement), motivation, self-regulated learning (SRL)*

Introduction

The interrelationships of critical factors involved in L2 pronunciation development have been attracting scholarly attention in the past few years (Oxford, 2017; Pawlak 2017; Pawlak & Szyszka, 2018). Studies in L2 pronunciation to date have devoted to uncovering the effects of individual learner differences (ILD) on the L2 learning process with some investigating the role of motivation in the learning process (Nagle, 2018; Saito, Dewaele, & Hanzawa, 2017: Saito, Dewaele, Abe & In'nami, 2018) and others exploring learning strategies as a significant predicator of pronunciation performance (Baker-Smemoe & Haslam, 2013; Sardegna, Lee, & Kusey, 2017; Szyszka 2017; Veliz, 2015). In spite of considerable advances in our understanding of several factors in successful L2 pronunciation achievement, however, SLA in pronunciation in the last decade indicates that only scant attention was paid to the mediating role of ILD with the empirical evidence being scarce, patchy, and inconclusive. Thus, there is an urgent need for more studies in this field that would examine the role of ILD variables, as well as combination of the variables with respect to the efficacy of L2 pronunciation instruction.

This paper intends to overview this research gap in the literature, and offers a synthesis of the available studies on three areas in L2 pronunciation, that is, language-learning strategies, motivation, and the joint influence of motivational factors and learning strategies on the achievement of L2 pronunciation. By so doing, this study challenges the significant possibility that unveils the mechanisms through which L2 learners regulate their motivation and learning strategies, drawing upon the theoretical framework of self-regulated learning (SRL) (Oxford, 2017) recently investigated in L2 vocabulary learning by Zhang, Y., Lin, Zhang, D. & Choi (2017). SRL is defined as the notion in which "self-regulation of academic learning is a multidimensional construct, including cognitive, metacognitive, motivational, behavioral, and environmental process that learners can apply to enhance academic achievement" (Dörnyei, 2005, p. 191). The SRL framework in L2 pronunciation might reveal the mechanisms through which learners regulate their motivation and learning strategies, as Zhang et al (2017) suggests that "vocabulary learning is a proactive process that includes both a person is motivated to learn vocabulary, and an active and complex use of cognitive and metacognitive vocabulary-learning strategies" (p.68). In the following section is argued whether or not the integrated model probing the multidimensional construct is possible.

The Link between L2 Pronunciation Learning Strategies, Motivation and Achievement

Pronunciation Learning Strategies and Achievement : Pronunciation Learning Strategies (henceforth, PLS) is a term coined by Peterson (2000), whose pioneering work identified 43 tactics via self-reports in the form of diaries and interviews collected from 11 adult learners of Spanish across beginner,

intermediate, and advanced proficiency of learners. The 43 tactics were grouped into the 12 PLS, namely, *representing sounds in memory, practicing naturalistically, formally practicing with sounds, analyzing the sound system, using proximal articulations, finding out about TL pronunciation, setting goals and objectives, planning for a language task, self-evaluating, using humor to lower anxiety, asking for help, and cooperating with peers.*

Very few studies have quantitatively examined the extent to which the application of PLS in fact translates into greater achievement of L2 pronunciation. First, Eckstein (2007) aimed to investigate the correlation between PLS and spontaneous language performance, deploying the *Strategic Pronunciation Learning Scale* (SPLS). The data of 183 international students at low intermediate, intermediate and high-intermediate levels of proficiency were measured with the SPLS, and a standardized speaking *Level Achievement Test* (LAT). The analysis found that three PLS positively correlated with pronunciation performance, such as *noticing pronunciation mistakes, adjusting facial muscles while speaking and asking for help with the pronunciation of new English words*. In this line of research Berkil (2008) conducted a study in which he examined the PLS use and pronunciation attainment in the case of 40 Turkish university students representing different levels of proficiency. The quantitative analysis of the data, measured in terms of his *Strategy Inventory for Learning Pronunciation* (SILP) reading a passage and performing a free response task, revealed no significant correlation between overall PLS use and attainment, however, three of the strategies included in the SILP demonstrated statistically significant difference between participants at different proficiency levels, more specifically, the participants of moderate group showed more reliance on purposeful listening to sounds and listening to tapes television, movies or music.

In yet another attempt to look into the relationship between the frequency and duration of PLS use and pronunciation performance in semi-spontaneous speech in the case of 40 students of teacher education at a university in Chile, Véliz (2015) applied the SPLS and modified the instrument comprising 36 statements representing strategic devices and a 5-point likert-scale to scrutinize both the frequency and duration of PLS use. The attainment of pronunciation performance in semi-spontaneous speech was assessed by means of a test designed by the researcher, and evaluated by two raters. The research found no major correlation between the frequency and duration of PLS use and pronunciation performance, but yielded positive relationship in the case of the levels of pronunciation intelligibility. In a study involving 63 Polish university students majoring in English, Rokoszewska (2012) investigated the relationship between PLS use, and the perception and production of TL vowels, in which perception was assessed with three listening tasks, while production was evaluated through articulation tasks and reading minimal pairs and a continuous text. The analysis revealed a weak but significant correlation between PLS use and production of English vowels and diphthongs.

Also worth mentioning in this section is the project conducted by Szyszka (2017), who conducted a mixed-methods study among 94 trainee teachers of English as a foreign language at a Polish university, investigating the interplay between the use of PLS and different levels of language anxiety. The data were quantitatively and qualitatively collected, yielding several findings as follows: (1) compensation and memory PLS were employed more frequently by anxious trainee teachers, (2) higher input anxiety levels were connected with less frequent use of social PLS, (3) higher processing anxiety levels correlated with more frequent use of memory and compensation strategies, (4) higher output anxiety levels were accompanied by more frequent use of compensation PLS and less frequent affective strategies, and (5) anxious and non-anxious pronunciation learners differed significantly in their use of a number of pronunciation learning tactics (Pawlak & Szyszka, 2018, p. 311). Baker-Smemoe and Haslam (2013) is one of the few studies that examined in depths the effect of language learning aptitude (i.e., learners' natural ability to learn languages) and learning contexts (i.e., EFL or ESL) on the PLS use and pronunciation achievement. Participants were recruited from two different contexts, EFL participants enrolled in two intensive English language schools in Beijing, China and ESL participants from intensive lanuage institute at a major univerist in US. They were further divided into four groups of 15 to 16 participants each according to the *Pimsleur Language Aptitude Battery* (PLAB) Test, namely, EFL high aptitude, EFL low aptitude, ESL high aptitude, and ESL low aptitude, and completed pre-/post-pronunciation tests at the beginning and end of a 10-week speaking class. The Pronunciation scores in global foreign accent fluency, comprehensibility, and accuracy were compared with both overall and individual setion PLAB scores and the PLS use. Results indicated that learning context plays a limited role in strategy use However, participants' post-test pronunciation scores suggested that aptitude affects pronunciation accuracy and pronunciation strategies affct comprehensibility, indicating that strategy and aptitude impact different aspects of pronunciation.

Motivation and Achievement: While the use of PLS has some positive effect on the achievement, it seems unlikely that L2 learners demonstrate adept use of PLS unless they were motivated to learn. The longitudinal data of 26 English-speaking learners of Spanish were presented by Nagle (2018), who scrutinized L2 Spanish pronunciation development over a yearlong period and learners' motivation change over the same period. The pronunciation data were collected via a simplified picture description task five times a year spanning their second, third, and fourth semesters, and rated by 18 native speakers of Spanish regarding comprehensibility and accentedness. A quantitative motivation survey based on the L2 Motivational Self System and an open-ended questionnaire on their language learning beliefs once per semester were completed by participants. Nagle (2018) mentioned that "Learners were consistently evaluated as very comprehensible despite the presence of a moderate foreign accent (p.33).", and

suggested that although motivation decreased overtime, learners' comprehensibility and accentedness improved during the research period. Similar line of inquiry was conducted by Saito et al (2017), probing the predictive power of motivation for L2 speech learning at a university EFL classroom in Japan, where 40 first-year students attended over one academic semester. The development of L2 oral proficiency was investigated deploying pre-/ post pronunciation tests at the onset and end of a semester, and a motivation questionnaire which consists of five factors; Factor 1: Integrativeness, Factor 2: Instrumentality, Factor 3: Nativelikeness orientation, Factor 4: Lexicogrammatical orientation, and Factor 5: Comprehensibility for vague and long-term future. Although the comprehensibility of learners' speech rated by five native speakers did not reach statistical significance at a $p < .05$ level, the achievement in comprehensibility was significantly related to Factor 5 in the motivation profile, e.g. *I want to study English because better English proficiency is crucial for my future job*., and marginally to Factor 4, e.g. Appropriate and rich vocabulary. Following this, Saito et al (2018) took an exploratory approach towards investigating "the triangular relationship between L2 motivation/ emotion, use and L2 speech (p. 25)" of 108 high school EFL learners. The learners completed (1) motivation/ emotion questionnaire provided at the beginning of the research programme and (2) oral proficiency data collected at the beginning and the end of the period, rated by 5 native speakers of English. The cross-sectional and longitudinal analyses by Saito et al (2018) found the significant role of motivation towards attaining L2 comprehensible speech in the classroom. However, this line of discussion, i.e., the immediate impact of motivation on L2 attainment, was questioned by an inquiry of educational psychology (Horino & Ichikawa, 1997, p.24). According to a recent survey of language learning strategy by Rose, Briggs, Sergio, & Ivanova-Slavianskaia (2017), the role of strategy has caught scholarly attention as a mediator of motivation and scholastic achievement in several disciplines in SLA, for instance, L2 writing, L2 vocabulary and so forth. A structural model in L2 pronunciation is thus called for.

The Combined Effect on Achievement: The combined effect of ILD on attainment has been vigorously documented in Educational psychology in the last three decades, as is mentioned in Zhang et al (2017). Among a handful studies that have even cursorily investigated the structural relationship of the combined effect on L2 pronunciation achievement, Sardegna et al (2017) took an initial step in this direction, proposing a structural equation model of L2 pronunciation with an aim to scrutinize learners' self-efficacy beliefs, attitudes toward learning pronunciation skills, and choice of pronunciation learning strategies of 704 Korean adolescent EFL learners. Participants' responses to two self-reported questionnaires, i.e. *Strategies for Pronunciation Improvement* (SPI) inventory and *Learner Attitudes for Pronunciation* (LAP) inventory, were submitted to *Structural Equation Modeling* (SEM) to determine the direct and indirect relationships among the latent variables. Sardegna et al (2017) successfully demonstrated that the greater the intentional behaviour, the more likely learners selected strategies to develop their pronunciation skills. To the best of our knowledge in SLA in pronunciation, however, no studies have challenged the structural modelling analysis in L2 pronunciation. AUTHOR (in progress) presented a research proposal in this field, drawing a theoretical model of L2 vocabulary learning by Zhang et al (2017) who probed the joint impact of different motivational factors and learning strategies on the L2 vocabulary of adolescent learners of EFL in China (n=107), deploying SEM in the analysis of the data collected in terms of two questionnaires, one assessing students' motivation towards L2 vocabulary learning and the other their L2 English vocabulary learning strategies, together with a vocabulary test. According to the researcher, "The model was a good fit for the data in this study, if compared to the saturated model, with $X^2(3) = 1.722$ ($p > .05$), CFI = 1.000, and RMSEA = .000 with a 90% confidence interval of 0.000 to 0.132). Both IM ($\beta = 1.09$)1 and EM ($\beta = 0.69$, $p < .001$) loaded significantly on the latent variable of motivation, and both metacognitive ($\beta = 0.95$) and cognitive strategies ($\beta = 0.92$, $p < .001$) loaded significantly on the latent variable of vocabulary-learning strategies (Zhang, Y. et al, 2017, p. 63, 64)". They suggested that vocabulary learning strategies mediate the relationship between motivation and vocabulary knowledge, as shown in the Figure below,

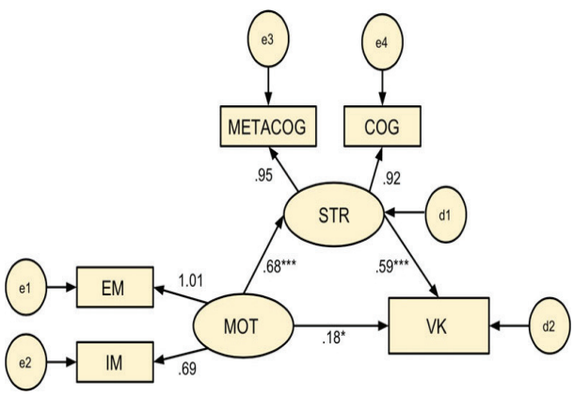

Figure. Structural model of the relationship between motivation (MOT), vocabulary-learning strategies (STR), and vocabulary knowledge (VK). (Zhang et al, 2017, p.65)

Conclusions

The mainstream research of PLS in the last decades has showcased the continuation of language learning strategies in SLA, examining to what extent the application of PLS translates into greater achievement of L2 pronunciation (Eckstein, 2007; Berkil, 2008; Rokoszewska, 2012; Véliz, 2015). The other group has probed the effect of ILD variables or conbination of variables, for instance, language learning aptitude, anxiety, and motivation on the PLS use and L2

pronunciation achievement (Baker-Smemoe & Haslam, 2013; Nagle, 2018; Szyszka, 2017). Based on the limited number of studies reviewed in this article, it is impossible to argue which one is particularly more promising than the other, however, the third group integrating SEM as conducted by Sardegna et al (2017) in L2 pronunciation and Zhang et al (2017) in L2 vocabulary could be forged in this direction. It is hoped that the findings will help practitioners and researchers alike develop pedagogical intervention, so that more learners could actively get involved in the classroom and thus achieve higher attainment in L2 pronunciation comprehensibility.

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USE OF TECHNOLOGY ENHANCED TEACHING ROOMS TO SUPPORT FLIPPED TEACHING

K.L. Henderson*, C.A. Hobbs, and D.Rh. Gwynllyw

Department of Engineering Design and Mathematics
University of the West of England, Bristol, UK

* Karen.Henderson@uwe.ac.uk

Abstract

In this paper we report on our experiences of flipping the classroom for three modules delivered to first and second year Mathematics students at the University of the West of England, Bristol. In particular we focus on how using collaborative teaching rooms have supported the flipped classroom. All of the modules described are now delivered in a Technology-Enhanced Active Learning (TEAL) space as opposed to a typical flat teaching room, as was the case previously. This space contains collaborative working pods comprising a plectrum-shaped table and a single large-screen integrated PC. Each pod can seat up to six students. The display on these PCs is flexible; options include reproducing the main podium display, displaying a different pod's output or each pod having their own individual display. Flipped-style teaching or the flipped classroom has seen a surge in interest recently. This style of teaching is a change to the traditional lecture model used in universities for hundreds of years. In the traditional model the lecturer is in charge of the class and largely dictates the material and pace at which this is delivered. Typically students are then required to work through more challenging material on their own before attending tutorials/problem classes for support. The idea behind the flipped classroom is that students' initial exposure to material takes place in their own time, so students work through material independently at their own pace before the formal class. Class time may then be used for active learning, where students are able to deepen their understanding of the material, through for example problem-solving, peer instruction and discussion. Enabling students to work with each other is an effective methodology, encouraging students to be active learners by talking through concepts in their own words to each other. We have found that using a TEAL space encourages better small group discussion and peer instruction in class.

Keywords: Flipped-style teaching, active learning, TEAL classroom, collaborative teaching room

Introduction

We report on our experiences of flipping the classroom for three modules, namely a compulsory first year Calculus and Numerical Methods module (CNM), a compulsory second year Algebra, Combinatorics and Graphs module (ACG) and an optional second year Coding Theory and its Applications module (CTA). All these modules are taken by Mathematics students at the University of the West of England (UWE Bristol). Flipped-style teaching or the flipped classroom has seen a surge in interest recently (Brame, 2013; Maciejewski, 2015). This style of teaching, pioneered by Mazur (1997), is a change to the traditional lecture model used in universities for hundreds of years. In the traditional model the lecturer is in charge of the class and largely dictates the material and pace at which this is delivered. Typically students are then required to work through more challenging material on their own before attending tutorials/problem classes for support. The idea behind the flipped classroom is that students' initial exposure to material takes place in their own time, so students work through material independently at their own pace before the formal class. Class time may then be used for active learning, where students are able to deepen their understanding of the material, through for example problem-solving, peer instruction and discussion.

In this paper we focus on how using collaborative teaching rooms have supported the flipped classroom. All of the modules described above are now being delivered in a Technology-Enhanced Active Learning (TEAL) space (MIT iCampus, 2016) as opposed to a typical flat teaching room, as was the case previously. This space contains collaborative working pods which each seat up to six students and includes a PC. Students within each pod can work independently on their PC and the lecturer can choose to project the pod's or the podium's screen to the whole class if desired. A typical TEAL room used at UWE Bristol is shown in Figure 1 with a close up of one of the collaborative working pods shown in Figure 2. CNM and CTA used TEAL rooms for the first time in 2016/17. ACG was been flipped for the first time in the 2017/18 academic year.



Figure 1: A typical TEAL room at UWE Bristol.



Figure 2: Close up of a collaborative pod in a TEAL room.

The flipped approach has been used very successfully for the CTA and CNM modules for several years, measured in terms of student engagement, attainment and satisfaction (Henderson, 2017; Henderson, Hobbs & Last, 2017). However, we found that running the classes in a traditional flat teaching room was not conducive to group working. Enabling students to work with each other is an effective methodology, encouraging students to be active learners by talking through concepts in their own words to each other. Research has found that students who work in groups perform better academically, particularly in regard to reasoning and critical thinking skills (Lord, 2001). We have found that using a TEAL space encourages better small group discussion and peer instruction in class. In addition, the technology built into each pod facilitates students to use relevant software (e.g. Maple) during class.

Methodology

Calculus and Numerical Methods (CNM) is a 30 credit compulsory first year module taken by all mathematics students at UWE Bristol. It runs year-long and the second semester has been taught using a flipped approach since the 2014/15 academic year. For this module, a highly scaffolded approach was employed using technology to create pre-class materials (Hooper, Henderson and Gwynllyw, 2014). A workbook containing gapped lecture notes was created as well as a handbook containing exercise sheets and extra reading material. Typically there were four screencasts to watch each week lasting on average 10 minutes each. A total of 35 screencasts were produced using Camtasia Studio software on a tablet PC. These were made available through SCORM packages on the University's Virtual Learning Environment (VLE). Each week, prior to attending the class, students were expected to independently do the following:

- watch screencasts and fill in the relevant gaps in their workbooks;
- take a formative e-Assessment;
- try some basic questions from the exercise sheet;
- optionally do some extra reading and/or work through a Maple file.

The formative e-Assessments were run using Dewis (2012) and further details of how e-Assessment was used to support the delivery of this module can be found in Henderson (2017). During the two hour class, TurningPoint (TP) audience response questions and group activities were used to encourage active learning. Worked solutions as well as the filled in workbook were made available via the module's VLE after the class.

Algebra, Combinatorics and Graphs (ACG) is a 30 credit compulsory second year module taken by all mathematics students at UWE Bristol. It runs year-long and the second semester has been taught using a flipped approach for the first time in the 2017/18 academic year. Prior to the start of the module students have been supplied with a booklet containing a complete set of lecture notes together with approximately three questions per weekly topic. In all a total of 60 screencasts were produced using Camtasia Studio software on a tablet PC. These included several which recapped some of the key topics covered in the pre-requisite first year module. Each week students were emailed an announcement from the University's VLE giving details of what topics were to be covered that week. Students were directed to read the relevant section of the lecture notes, watch particular screencasts (typically lasting a total of 1 hour, 15 minutes) and to try three pre-class questions which were designed to check surface learning of the material. Solutions to these questions were made available shortly before the start of the three hour class. Following a brief overview, students work through a set of more challenging in-class questions in groups and these are designed to encourage debate amongst the students and to develop deeper understanding of the topic. In addition some very challenging questions were made available but it was made clear by the lecturer that these went beyond what was required to satisfy the learning outcomes of the module. Full solutions to all of the in-class questions were made available after the class.

Coding Theory and its Applications (CTA) is a 15 credit optional module run in the first semester of students' second year of the Mathematics award at UWE. It has been taught using the flipped approach very successfully since the 2013/14 academic year. For the last three academic years, students coming into the second year have had experience of the flipped approach through taking the CNM module in their first year. The CTA module is based on a set textbook (Biggs, 2008) and students are informed in advance of signing up for this module that they need access to it.

The style of the sessions each week varies, but the main philosophy is that mathematics is best learnt through doing rather than watching others. Students are expected to undertake directed reading each week in advance of the class; this is typically a chapter of Biggs (2008), and to attempt particular exercises from this book. Some videos, recorded via a data visualiser, covering particular algorithms/problems are available. During classes, which are scheduled for 3 hours, students work together on problems designed to check their understanding of the material. This takes the form of TP questions, further exercises from Biggs (2008) as well as supplementary problems. The style of the module is active rather than passive learning. Students are informed that it is expected that they will contribute to sessions, possibly by reporting on a particular topic they have researched, or by presenting their solutions to problems to the rest of the class. After each class, the TP questions (with solutions) as well as worked solutions to exercises are posted on the module's VLE.

Results

Student feedback has been very positive to the flipped-style approach on all three modules. Students recognise that carrying out the pre-class work means that they get more out of the classes. We have found that module performance is strongly correlated to engagement and attendance (Henderson, 2017; Henderson, Hobbs & Last, 2017). In the first year of flipping CTA, feedback from the few students who failed to engage and did poorly in module indicated that they were unhappy about the lack of lectures and the requirement to engage during sessions. It is unlikely that we are able to please everyone all the time, but our goal is to change the culture so that our students recognise the benefits and move away from just being passive learners. We now emphasise the benefits of the flipped approach very clearly and set expectations at the start of each module and have received fewer comments along these lines as a result.

At the point of writing, two of the modules (CNM and CTA) have been fully delivered using the TEAL classroom for two years. ACG was flipped for the first time in 2017/18 and a TEAL room was used. Feedback from students on this aspect has been sought via the end of module evaluation (all modules) and via mid-term in-class questionnaires (CNM and ACG) as well as other aspects of the flipped-style approach. Feedback on the TEAL rooms has been positive with students remarking on how it facilities the interaction with other students.

For CNM the same mid-term in-class questionnaire has been used on three separate cohorts (2015, 2017, 2018) and the results over these three years to some of the questions are displayed in Figures 3-5. Note that the 2015 classes were in a flat teaching room whilst 2017 and 2018 were in a TEAL room. It can be seen that responses have been quite consistent across the three year groups and that working in the TEAL room has not had a significant impact on student responses. However it is clear that the majority like the flipped-style delivery, would like to experience it in their second year modules and are happy with the amount of time available to go through the example sheet questions in class. As a result of earlier student feedback on CNM an additional weekly one hour extra support session was timetabled for students to utilise if they felt that they needed more help with a particular topic. This was not heavily used but was appreciated by the students that attended.

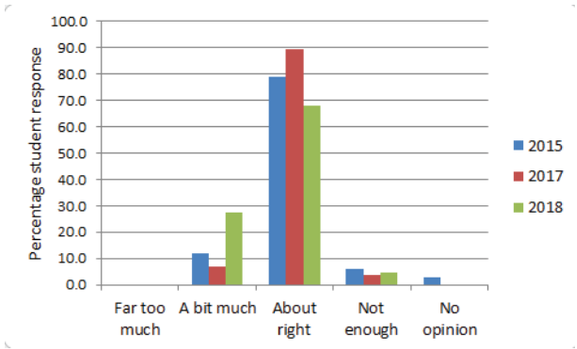

Figure 3: CNM Student responses to the question: *The time we had to go through the example sheet questions in class was.*

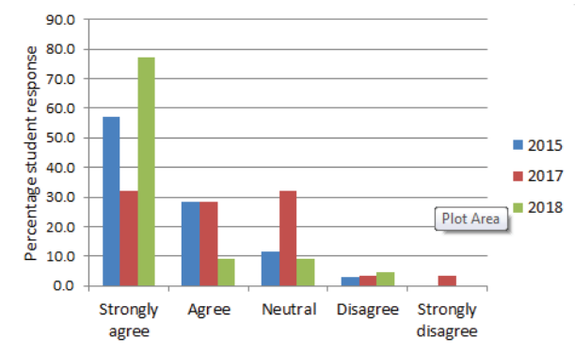

Figure 4: CNM Student responses to the question: *I liked the new style of teaching.*

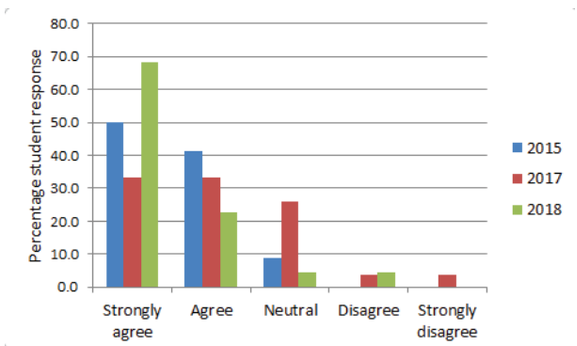

Figure 5: CNM Student responses to the question: *I would like to experience this style of teaching for my level 2 modules.*

ACG used a similar questionnaire and the results to some of the questions are displayed in Table 1. Again it can be seen that the majority of students found that doing the pre-class students helped them understand the topic, that the in-class questions gave them a deeper

understanding of the subject, that they benefitted from working as part of a group and that they preferred this style of teaching. Typically mathematics students dislike working in groups so it was very encouraging to see students working together to solve problems and recognising the benefits of doing so. The TEAL room certainly facilitated this approach. In flipping ACG for the first time, the lecturer found a noticeable increase in the quality and depth of the questions asked to them in class.

Table 1: ACG Student responses to some of the questions used in an in-class questionnaire (April 2018).

Qn 1: *I found doing the pre-class questions helped me understand the topic*				
Strongly agree	Agree	Neutral	Disagree	Strongly disagree
5	6	5	1	0
Qn 2: *The in-class questions gave me a deeper understanding of the subject*				
Strongly agree	Agree	Neutral	Disagree	Strongly disagree
9	7	1	0	0
Qn 3: *I have benefitted from working on questions as part of a group*				
Strongly agree	Agree	Neutral	Disagree	Strongly disagree
10	4	1	1	0
Qn 4: For this topic, *I prefer this style of teaching*				
Strongly agree	Agree	Neutral	Disagree	Strongly disagree
7	9	0	0	1

For all three modules we observed that students tended to sit at the same pod each week, so although group working was happening, it tended to be within the same students each week. All classes were held in a TEAL room which has a capacity of 56. This has worked better for the compulsory modules (ACG & CNM), which have higher student numbers than for CTA which is optional. For example, in the 2017/18 academic year only 20 students enrolled on this module resulting in students being quite dispersed in the room and just five of the possible eight pods were used. One way of resolving this issue would be to have a greater range of sizes of TEAL rooms available to use, which should be the case next year.

Students in CNM and ACG were specifically asked for their feedback (via the in-class questionnaire) on how they found the TEAL rooms. They unanimously preferred the TEAL room to a traditional flat teaching space. They liked working in small groups even though some did not like the flipped approach. The following is a selection of student feedback which typifies their comments:

- These rooms are so much better, more interactive, so I stay focussed for longer and can discuss with people better..
- The room we used was very useful as could work in groups using the computers for Maple.
- The room was good and it helps a lot for working in groups. It was good working with other people on questions.
- TEAL room was great – comfortable, good layout. Liked the idea of working in groups.
- Liked the group table, can discuss and share answers/methods more effectively. Less chance of getting lost/left behind.
- Room was great, however sometimes had issues with screen to computer and other way round. Otherwise really like it!

Conclusions

We have found that students recognise the benefits of being taught in TEAL rooms using a flipped approach. However TEAL rooms are also being used for classes for modules which are delivered in a more traditional way. Students have remarked that they like the layout, which also facilitates the lecturer moving around the room enabling them to more easily interact with students and view their written work. From a lecturer's perspective, the TEAL rooms are proving to be very flexible teaching spaces. Two TEAL rooms, with capacity of 24 and 48, have been incorporated into the design for the new Mathematics and Statistics space that is planned to open at UWE Bristol in September 2018 (Henderson, 2018).

Although the collaborative rooms have software installed, enabling sharing of individual PC screens to the podium/other pods, facilities do not currently exist for students to be able to easily upload hand-written workings onto their pod PC. This is something that we aim to address in the future through the use of webcams and electronic writing pads which will enable the lecturer to easily share students hand-written work between pods.

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DEVELOPMENT OF EFFECTIVE FRAMEWORK FOR SOCIAL IMPLEMENTATION PBL EDUCATION FOCUSING ON PRACTICAL AND AGILE PROTOTYPING PROCESS

S. Tarao*,[a], T. Ohtsuka[b], H. Tsutsumi[a], T. Ichinohe[b], Y. Fujiwara [c] and N. Tsuda [d]

[a] National Institute of Technology, Tokyo College/Dept. of Mechanical Engineering, JAPAN
[b] NIT, Tokyo College/Dept. of Electronic Engineering, JAPAN
[c] NIT, Ichinoseki College/Dept. of Engineering for Future Innovation, JAPAN
[d] NIT, Wakayama College/Dept. of Intelligent Mechanical Engineering, JAPAN

*tarao@tokyo-ct.ac.jp

Abstract

A promising framework for "Social Implementation Education" is proposed. The social implementation education framework is intended to provide the participating students with opportunities of facing up to real social issues and creating value in cooperation with diverse users in society through dialogue and engineering solutions. Those opportunities are expected to be enhanced PBL themes corresponding to the effective experiences for future engineers in learning competencies to make innovation happen. On the basis of specialized skills in the fields of engineering, social implementation education focuses on the strengthening of communicative competence as engineering literacy, independent-minded stance against facing real social problems, and creativity that connects science technology with new values through practical and agile prototyping. The real aim of this education framework is to give students a situation in which the students must communicate with trial users, because the realization of higher value production needs to be achieved by producers and users mutually communicating their intents and perceptions. This framework also provides very good opportunities for students to apply their engineering knowledge and sense to solve problems with no correct answer in real society. To analyze the process generated through the framework, we focus on the frequency of student-user interaction and adopt a classification of the process according to the development method type of "Agile" or "Waterfall" for estimation of the characteristics of each social implementation approach performed by students. In order to steadily and effectively overview the process of social implementation, we defined an evaluation index "Agile Index" which indicates the degree of cooperation between a students and users. After analyzing the performance of students through the index, the relationship between expert evaluation (evaluation of educational outcomes) and agile index score is checked and the applicability of the agile index is validated. In addition, as an example of promotional attempt, we introduce a mobile robot development whose platform is designed and prototyped through multi-laboratory collaboration in order to lower technical hurdles faced through robotics social implementation approach. The realized robot platform consists of two low-end in-wheel motors for the sake of simplicity of the design and assembly of the drive unit.

Keywords: *Social Implementation Education, PBL, Prototyping, Agile Index, Robot Platform*

Introduction

In today's drastic industrial structure change, there is an urgent need to improve frameworks of industrial might foundation to make science and technology innovation happen, that is, directly linked to social reformation with dynamism, by means of science and technology-driven new value-creation. With progress in industrial structure change, as a promising approach to innovation, prototyping activities cooperated with users, custom design in order to best meet user's needs and so on have received a lot of attention in recent years (e.g., Prahalad, C. K. and Ramaswamy, V., 2004; Hippel, E. V., 2006). It seems that it is more and more important for manufacturing education to recognize the trend of innovation by approaching to different needs of users with mutual collaboration between users and creators.

Against this background, since 2011 "Social Implementation Approach Based on Robot Education" preliminary project was proposed and performed (Tarao, S., Asano, K. and Sato, T., 2015). The aim of this project is to give students a situation in which the students must communicate with trial users, because the realization of service robots needs to be achieved by creators and users mutually communicating their intents and perceptions. Following the feasibility study through the preliminary "Social Implementation project", since 2012 to 2016 "Innovative Japan Project by KOSEN" (NIT, Tokyo College, 2012) had been performed in collaboration with

seven KOSEN colleges (Ichinoseki, Oyama, Tokyo, Nagano, Numazu, Wakayama, and Okinawa). The project activities were finally joined by 21 KOSEN colleges (Hakodate, Sendai, Fukushima, Gunma, Ishikawa, Suzuka, Maizuru, Kure, Anan, Ube, Kitakyushu, Sasebo, Kumamoto, and Miyakonojo in addition to the seven collaborating colleges) showing a notable increase from the seven collaborating colleges in the first project year. More recently, from 2017 the project has been newly positioned as the KOSEN 4.0 Initiative, though the management structure has been changed, the project is going well continuously.

This paper describes the outline of the education for social implementation: “Social Implementation PBL Education” as an enhanced PBL method to effectively learn the innovative design. Next, an evaluation index "Agile Index" (hereinafter referred to as "AI") indicating the degree of cooperation between a students and users is introduced in order to steadily and effectively grasp the progress of social implementation activities. Finally, we analyze the relationship between expert evaluation (evaluation of educational outcomes) and AI score and discuss the effectiveness of our approach.

Framework for Social Implementation PBL Education

Social Implementation Education has a PBL element and consists of characteristic four steps: 1) Grasping practical problems to be solved, 2) Creating new values to be provided, 3) Implementing those in the social world, and 4) Receiving feedback directly from users. It is marked by the process to develop students’ competencies to self-identify problems and get feedback directly from the real social world as compared with standard PBL.

Figure 1 shows an example of an electric wheelchair type robot development through Social Implementation Education process. The figure shows three phases reconstructed with typical stages to be especially experienced through the above mentioned four steps. The most vital point of the whole process is getting effective cooperation from the real social world as users.

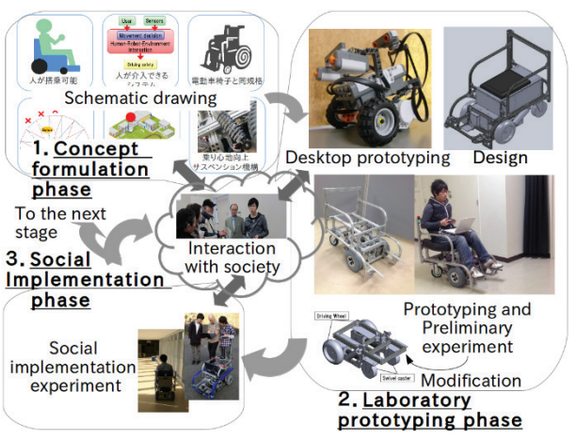

Figure 1: Three main phases of the characteristic advance of “Social Implementation PBL Education”



Figure 2: Appearance of an open experiment of an autonomous mobile robot demonstration with users

Figure 2 shows a scene of an open experiment of an autonomous mobile robot with the cooperation of users. The students obtained comments about the robot’s autonomous behaviour in a real human environment from users as effective feedback.

The autonomous mobile robot consists of a platform (See Figure 3) designed by our projects for mobile robot development in a short period of time. The hardware and software of the platform are suitable for prototyping with flexibility through a trial and error process (Tarao, S., Hayashi, T. and Ohtsuka, T., 2017).

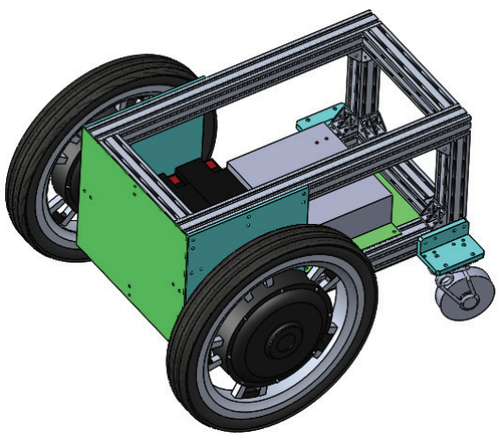

Figure 3: Appearance of the platform of autonomous mobile robot designed by our projects

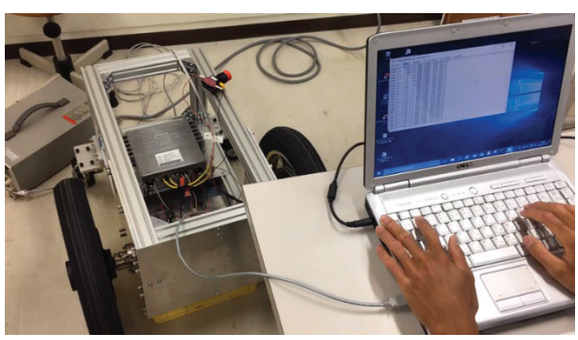

Figure 4: An example of laboratory prototyping phase using the platform of autonomous mobile robot

In addition, as an example of promotional attempt, we introduce a mobile robot development whose platform is designed and prototyped through multi-laboratory collaboration (three KOSEN colleges collaboration) in order to lower technical hurdles faced through robotics social implementation approach. Figure 4 shows a scene of experiment through a laboratory prototyping phase.

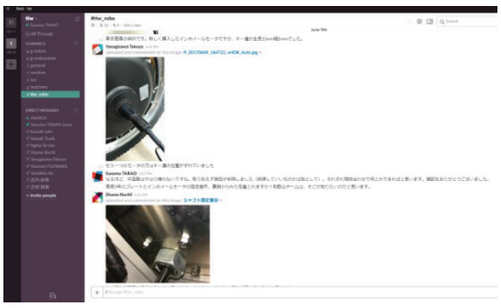

Figure 5: Discussion and sharing information utilizing SNS for collaborative development of the mobile robot

There are three robots developed in NIT, Ichinoseki College, Tokyo College and Wakayama College, respectively. The three development teams in the three colleges are connected utilizing SNS for discussion and sharing information (See Figure 5) and are prototyping the mobile robots using the common platform.



Figure 6: Mobile robot in near its default configuration, created by Ichinoseki college laboratory

As previously mentioned, the Social Implementation Education process is marked by the process to get feedback directly from the real social world, and it is very important in the conduct of the practical approaches. Quick and effective prototyping is key to ensuring the steady progress is made in the process. Therefore, an ingenuity is needed to ease time and technical constraints at the stage of prototyping. Specially in the field of mechanical engineering, a relatively large and heavy-duty mechanism may be needed to solve the problems in some situations, for such occasions, students anticipate difficulties in the prototyping as compared with different fields. As an example solution in the field of robotics (in mechanical engineering) the platform (See Figure 3) of autonomous mobile robot designed by our projects. Figure 6 shows an example of following the original approximately quite well, there are two LRFs (laser range finder) allocated diagonally to the front and back of the robot body in addition to an IMU and a GPS. Figure 7 shows an example of a guidance robot which is equipped with a handle for guide and a joy-stick-type intuitive user interface. Figure 8 shows an example of an improvement of the self-localization function by means of a LRF stabilizer which can move in synchrony with the robot's body configuration using 2DOF motion mechanism. The robot with the LRF stabilizer is repeated tested for stability improvement of autonomous running. Figure 9 shows the scene of the autonomous running experiment.

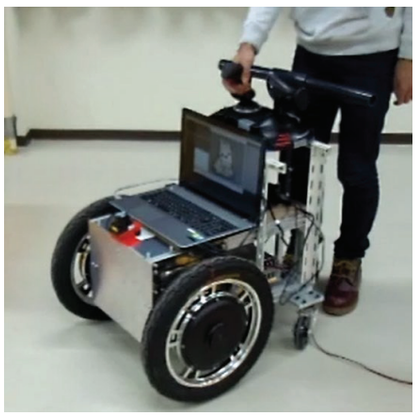

Figure 7: Example of a prototyping for robot guidance, created by Wakayama college laboratory



Figure 8: Example of a prototyping for autonomous running, created by Tokyo college laboratory



Figure 9: Appearance of an outdoor experiment of autonomous run in Tokyo college

Evaluation approach for Social Implementation PBL Education

In the Social Implementation Education program, the "Social Implementation Contest" is held as final event every March, which means that the program has also an element of competition. Each student participating team should give presentation on the result, new knowledge and achievement process obtained through the social implementation activities. Each team is judged on development concept, developed technology, performed experiment in social implementation and the quality of presentation. Fourteen teams in 2012, 30 teams in 2013, 38 teams in 2014, 48 teams in 2015, 59 teams in 2016 and 50 teams in 2017 have participated in the Social Implementation Contest before this.

In this section, an endeavour to measure and evaluate the progress and performance of each participant team in social implementation education in a subjective way and in an objective way, and to view activity status as a whole project is described.

Each student participating team is oriented to facing different problems without clear answer and is expected to solve the problems in cooperation with users in the real social world. As a reasonable approach, the strategy that participating teams create maximum value in a bounded time frame, repeat this procedure several times, and as a result, create greater overall value steadily is promising. An effective prototyping approach to be taken in the above situation has something in common with "Agile development" approach (The Agile Manifesto authors, 2001) which has received attention in recent years. This development approach has a conscious collaboration with users, through the promotion with repeating creation and evaluation in a comparatively short time interval, for much refined prototyping target in collaboration with users to accommodate changes in users' demands.

To analyze the process generated through the Social Implementation Education program, we focus on the frequency of student-user interaction and adopt a classification of the process according to the development method type of "Agile" or "Waterfall" for estimation of the characteristics of each social implementation approach performed by students.

In order to steadily and effectively overview the process of social implementation, we defined an evaluation index "Agile Index" which indicates the degree of cooperation between a students and users. Table 1 shows the definition of Agile Index (AI).

Table 1: Definition of Agile Index (AI)

Evaluation index	AI
Have the prototype used by users, be assessed by users, and refine the prototype with feedback	3
Have the prototype used by users and be assessed by users, but have not yet led to refinement	2
Contact users or experts, etc. and receive comments from them.	1
Do not contact users or experts (in the real social world)	0

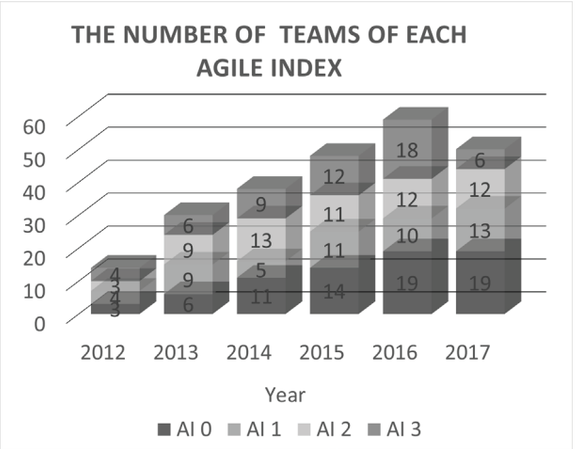

Figure 10: The numbers of student participating teams of each agile index (2012-2017)

Table 2: Evaluation by contest judge consisting of experts and intellectuals

Judging items	Aspects
Power of idea	Excellence of setting up target for social implementation, idea and concept to solve the issue
Power of specialty	Excellence of technology (hardware/software) built for social implementation
Power of action	Excellence of way of link to society, feedback from society, or experience of social implementation
Power of expression	Excellence of presentation with convincing and understanding of audience

Table 3: The correspondence relation between Pr-value and AI-value in 2016

Pr/AI	AI:3	AI:2	AI:1	AI:0
Pr:0	9	9	7	17
Pr:1	3	1	2	1
Pr:2	2	2	1	0
Pr:3	2	0	0	1
Pr:4	0	0	0	0
Pr:5	1	0	0	0
Pr:6	0	0	0	0
Pr:7	1	0	0	0
Num. of teams	18	12	10	19
Pr × AI	25	5	4	4
AI avg.	1.39	0.42	0.40	0.21

Figure 10 shows the number of participating teams and the distribution of AI-value during six years from

2012 (first year) to 2017. Though, because of the changes in the management structure, the number of participating teams slightly decreased in 2017, on the whole, the number is increasing yearly. The teams whose AI-value is three (AI:3) are successful at connecting to society and getting feedback from users, and the number of the teams have been increasing steadily over time except in 2017. On the other hand, the teams whose AI-value is zero (AI:0) which means that the teams are completely incapable of contacting users, and the percentage of the teams in every year is about 20-30 percent. It indicates that it is by no means easy to build a creative relationship oriented social implementation with society.

Next, an evaluation system by contest judge consisting of experts and intellectuals in the Social Implementation Contest is described. It is a kind of subjective evaluation whereas AI-value as previously indicated is a kind of objective evaluation. Table 2 shows the evaluation items of used by the contest judge. Those items are corresponding to the developments of "general aptitude" of the participating teams. Each team is comprehensively evaluated for the process of value creation oriented social implementation. Talented and experienced teams are received the award for each appropriate item (power of idea, power of specialty, power of action, and power of expression) in addition to the grand prize which is the most prestigious award in the contest. The contest judge scores each team out of five item for item. The award winners are selected based on the total average score. As mentioned above, the score represents a kind of developments of general aptitude.

Here we focus on the relationship between the objective evaluation and the subjective evaluation, and consider the appropriateness of those evaluations for social implementation activity. For simplification of our consideration, Pr-value for the subjective evaluation by judge is defined and the elements are determined as follows: the grand prize/the peer review prize is three points, the social implementation prize/the support company prize is two points, and other prize is one point.

Table 4: The correspondence relation between Pr-value and AI-value in 2017

Pr/AI	AI:3	AI:2	AI:1	AI:0
Pr:0	3	9	7	15
Pr:1	1	1	4	3
Pr:2	0	1	1	1
Pr:3	1	0	0	0
Pr:4	1	0	1	0
Pr:5	0	1	0	0
Pr:6	0	0	0	0
Pr:7	0	0	0	0
Num. of Teams	6	12	13	19
Pr × AI	8	8	10	5
AI avg.	1.33	0.67	0.77	0.26

Table 5: The correspondence relation between Pr-value and AI-value in six years (2012-2017)

Pr/AI	AI:3	AI:2	AI:1	AI:0
Pr:0	25	37	36	57
Pr:1	10	12	10	12
Pr:2	6	5	4	1
Pr:3	5	1	1	1
Pr:4	5	3	1	1
Pr:5	3	1	0	0
Pr:6	0	1	0	0
Pr:7	1	0	0	0
Num. of teams	55	60	52	72
Pr × AI	79	48	25	21
AI avg.	1.44	0.80	0.48	0.29

The Pr-value is integrated value dependent on every received prize for each team. One well-regarded team can receive multiple prizes except the grand prize and the social implementation prize. Table 3, 4, 5 show the relationship between the objective evaluation (by AI-value) and the subjective evaluation (by Pr-value) respectively in recent 2016, 2017, and the total during six years: from 2012 to 2017.

According to those tables, there is a tendency that the higher scoring teams for AI-value would also have higher score for Pr-value, with some exceptions. The tendency is also confirmed by the plot of the average of Pr-values on each AI-value shown in Figure 11.

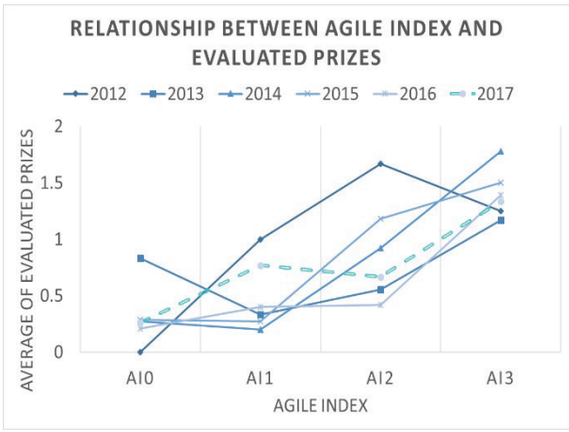

Figure 11: The relationship between the AI-value and the Pr-value of participating teams (2012-2017)

Results and Discussion

As for AI-value during six years from 2012 to 2017, the number of the AI:3 teams have been approximately increasing steadily over time. On the other hand, the percentage of the AI:0 teams in every year was about 20-30 percent. There is a room for improvement to promote

social implementation activity. Furthermore, there was a tendency that the higher scoring teams for AI-value would also have higher score for Pr-value, with some exceptions. The evaluation of social implementation process and performance using AI-value is comparatively easy, and appears to be an effective and efficient way to be applicable to a kind of "formative evaluation" discussed in the reference (Bloom, B. S., Krathwohl, D. R. and Masia, B. B., 1956), if the AI-value would be evolved to be a formative evaluation index for overcoming numerous hurdles and providing formative feedback to students from the standpoint of social implementation.

Conclusions

In this study, "Social Implementation Education" was proposed, which has a PBL element and consists of characteristic four steps:
1) Grasping practical problems to be solved,
2) Creating new values to be provided,
3) Implementing those in the social world, and
4) Receiving feedback directly from users.

It is marked by the process to develop students' competencies to self-identify problems and get feedback directly from the real social world as compared with standard PBL. The most vital point of the whole process is getting effective cooperation from the real social world as users. In the creative process, quick and effective prototyping is key to ensuring the steady progress is made in solving different problems without clear answer. As an ingenuity to ease time and technical constraints at the stage of prototyping, in the field of robotics, the platform of autonomous mobile robot was also indicated.

To analyze the creative process generated through the educational framework, we focused on the frequency of student-user interaction and defined the evaluation index "Agile Index" which indicates the degree of cooperation between a students and users. The relationship between expert evaluation and agile index score was checked and the applicability of the agile index was validated. Consequently, the number of the AI:3 teams have been approximately increasing steadily over time. On the other hand, the percentage of the AI:0 teams in every year was about 20-30 percent. The relationship between the objective evaluation by AI-value and the subjective evaluation by Pr-value, there is a tendency that the higher scoring teams for AI-value would also have higher score for Pr-value.

Based on our prior approaches, we are planning to increase the scale of the participating teams and will add the Social Implementation Education to the curriculum in the fourth grade and fifth grade of NIT, Tokyo College from the next year (2019) in sequence.

Considering the present situation, one of the future works will be directed to development of educational tools for promoting effective teaching and learning of social implementation approach in addition to seeking to further improve the evaluation approach expanding the AI-value, Pr-value and so on.

Acknowledgements

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PROGRESS OF VISUALIZATION OF LEARNING OUTCOMES WITH COMPETENCE - ANNUAL REPORT 2017

Takashi Matsumoto *, Minoru Komatsu, Koutarou Yamada,
Nariyuki Kawabata, Kengo Oota

Department of Creative Technology Engineering, National Institute of Technology,
Anan College, Anan-shi, Japan

* matumoto@anan-nct.ac.jp

Abstract

The National Institute of Technology, Anan College (NIT, Anan College) was selected for the Acceleration Program for University Education Rebuilding subsidies in 2014 by the Ministry of Education, Culture, Sports, Science and Technology. Many institutions of higher education in Japan applied for this project, and after strict evaluation, the effort of NIT, Anan College was highly evaluated. Especially, in Theme Ⅱ(Visualization of Learning Outcome), NIT, Anan College was the unique College of Technology designated. Our college promotes an environment where students can study thoroughly and unsupervised. Of great benefit for students is the evaluation of academic results by the monitoring their daily learning processes, encouraging them to make a habit of studying voluntarily, visualizing their competence as acceptable members of society and fully utilizing their own capacity for career design.

The core of the approach consists of four programs: (1) Ensure the time spent learning is accumulated in the Learning Portfolio. (2) Evaluation of creative skills. (3) Implementation of student surveys to evaluate the actual learning situation. (4) Creation of an Academic Portfolio for instructors focused on improving education and developing their skills. We describe these challenges in FY2015, FY2016 andFY2017. All students set goals in three categories consisting of career, academic study and co-curricular activities at the beginning of the fiscal year and then evaluated themselves at both the middle and end of the fiscal year. Trial evaluations of competency in about forty regular curriculums throughout the first semester of FY2017 using a newly developed rubric was conducted. The student surveys confirmed that the study hours outside the classroom increased gradually over several years. One of the reasons is the use of the Learning Management System utilized by faculty since its introduction at the college-wide level in FY2014. Our college hosts a workshop for creating Academic Portfolios as a part of faculty development and we also host a workshop with reduced hours to ensure the convenience of faculty attendance.

In this paper, the detailed achievements and results addressed up to now are described, and the future plan of competence development within the visualization of learning outcomes is reported.

Keywords: *Visualization of Learning Outcome, Management of Teaching and Learning, Career Design, Learning Portfolio, Competence, Student Survey, Academic Portfolio*

Introduction

The August, 2012 report released by the Central Council for Education, emphasized quality assurance. The keywords listed were: active learning and visualization of learning outcomes. The second Basic Plan for Promoting Education released by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) was approved in a Cabinet meeting in June, 2013. One of the basic policies is to promote university reform to increase the overall study hours of students. They have to acquire skills to continue studying by themselves throughout their career. Therefore, we ought to improve our educational methods in order to support students in achieving their goals.

In 2014, MEXT selected our educational program as the Acceleration Program for University Education Rebuilding (AP). Our program is classified in Theme Ⅱ which is aimed at visualizing learning outcomes and is characterised by focusing on competence. We were able to gain insight into the educational improvement system based on the proven worth of the activities.

Proven performance

Creating a teaching portfolio within the National Colleges of Technology has prevailed more-so than at universities and colleges. Twenty workshops have been held both on and off campus with cooperation between the Colleges of Technology so far. More than 80% of NIT, Anan College faculty members created portfolios.

NIT, Anan College has implemented the use of IR for teaching and learning since 2010. We have compiled surveys targeted at first grade students as well as student body surveys and graduation surveys, all of which share the importance and the methods of using IR in professional development workshops for faculty, and in which almost all faculty participate.

Using these means, NIT, Anan College has a fundamental commitment to improve teaching and learning. Quality assurance and teaching improvement using IR and TP at Anan College started from 2010.

Reconstructed program of visualization of learning outcomes

The overview of the reconstructed AP program at NIT, Anan College is shown in Figure 1. Our aim is to prepare educational circumstances which provide students the ability to study by themselves. Then we improve the educational management with an emphasis on the knowledge students have to visualize the learning outcomes. We think it is better to put more value on the learning process in order to achieve an attainable target for students. The cloud-based Learning Management System (LMS) is one of the solutions. It can offer e-learning, so students are able to study anywhere at any time. All students can access the LMS from anywhere that can connect to a network. Faculty can take care to maintain a connection with students through the network at anytime and anywhere.

Students have to learn practical expertise necessary in society. Recently, the competency to adapt socially and to get through life is also required. Therefore, we prepare the visualization of competence which allows students to get through their student life in our college and supports their career formation. Students acquire competence of various types throughout their student life in our college including curriculum and cocurricular activities. Since active learning-style classes have allowed students to gain competence easily, we added the promotion of active learning in class in this program from FY2017.

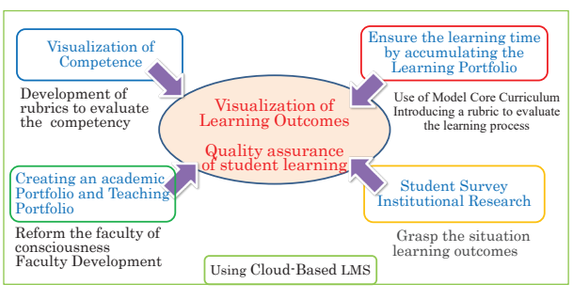


Figure 1 Overview of AP program at NIT, Anan College. There are four important approaches. We added the promotion of active learning in class in this program from FY2017.

On-going activities

Our program started from the second semester in 2014. The office for Excellence in Teaching and Learning was newly-organised to carry out our program. At first, we prepared the LMS as educational infrastructure and carried out a survey to understand the trend of competence for all current students using LMS. Actually, 97% of current students responded. Homeroom instructors returned the result report sheets to each student at a meeting and the students received the same result as a PDF file on LMS. After the students recognized their own competence, they set specific goals for achievement within the year using learning portfolios on LMS. We expect students to set goals by reflecting on themselves. Homeroom instructors have regular meetings to help them achieve success. We expect students to have a positive attitude toward achieving their goals and to make an effort toward achieving their aims. In order to realize our vision, we allow students to begin with a set of goals and to analyze their progress at the end of the fiscal year.

The use of LMS in our college has increased rapidly. We started to use LMS at a college-wide level from April, 2015. The ratio of faculty use was 76 % and the ratio of lecture use was 47% in September, 2017. The one for lectures at the end of FY2014 was less than 10 %. We laid the foundation for active learning using ICT education.

We determined six upper-level skills using the company survey regarding the competency in the Model Core Curriculum of National Institute of Technology, because it is difficult to develop, and to evaluate many skills at a time. These six skills are “communication”, “group skill”, “independence”, “sense of responsibility”, “discovering problems”, “logical thinking”. We also created a rubric for each skill and used them to evaluate student skills. In the trial evaluation, self-evaluation and mutual evaluation of students, faculty evaluation were carried out. From these results, self-evaluation of students is found to be effective as a real sustainable evaluation while avoiding an excessive burden increase.

We also revised the evaluation rubric we developed. In addition, students self-evaluated the level of competency acquired from regular lessons, cocurricular activities, and other activities using this rubric at the end of FY2017. The results and feedback were shown to each student via LMS as a radar chart shown in Fig. 2.

We studied the improvement of student competency by self-evaluation before and after the "cooperative education," which is a PBL type compulsory subject. Students cooperated in a group composed of different course students of the 4th grade and we implemented the new curriculum along with the reorganization for one department and the new course system in FY2014.

Results and Discussion

After finishing the cooperative education, we asked the students about the feeling of improving related to competences.

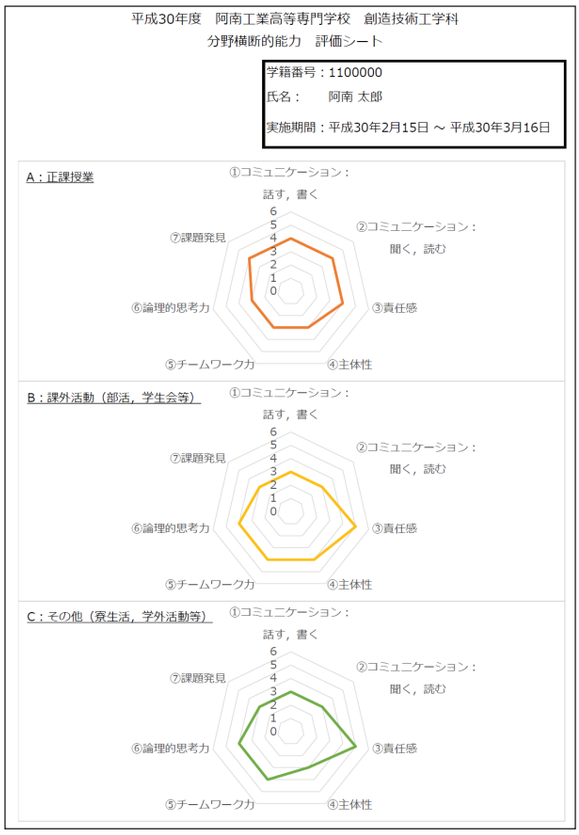
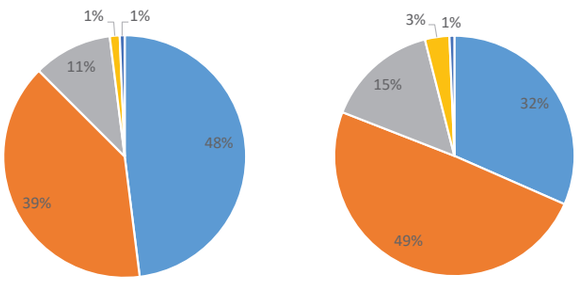


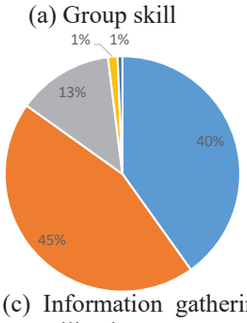
Figure 2　Sample of a radar chart of self-evaluated competency (in Japanese).

The results of each skill show that there are many students who provided an overall evaluation of a feeling of improvement.　For all skills, we estimate that more than 80% of students have evaluated "successful", and they can infer through the practical training that they were able to capture the opportunities for success using competences.

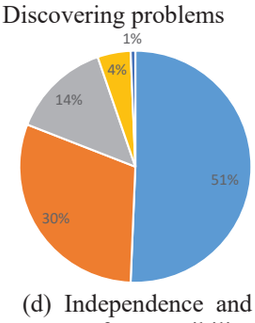


(a) Group skill

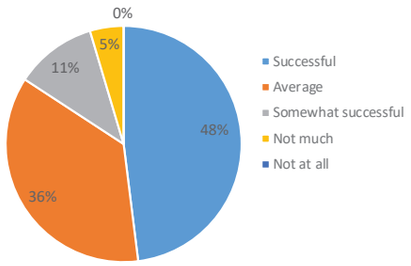
(b) Discovering problems



(c) Information gathering utilization



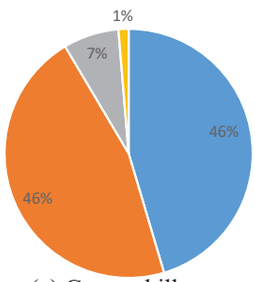
(d) Independence and sense of responsibility



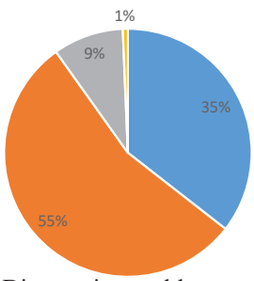
(e) Communication

Figure 3　Results of self-evaluation regarding achievement of skills.

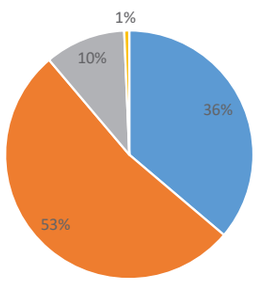
From the results of each skill, it turns out that there are many students who make an overall evaluation of feeling of improvement.　For all skills, we estimate that more than 85% of students have evaluated "improve", and they can infer through the practical training that they were able to capture the opportunities to improve using competences.



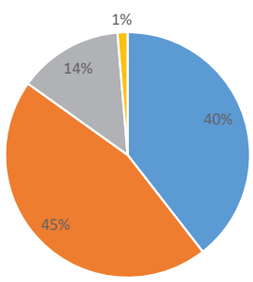
(a) Group skill



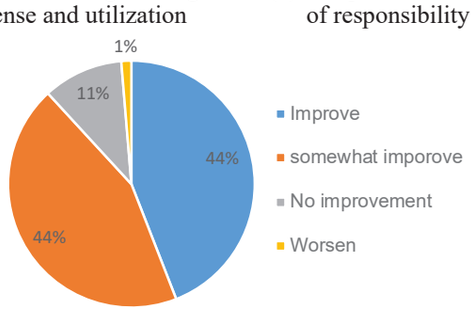
(b) Discovering problems



(c) Information gathering sense and utilization



(d) Independence and of responsibility



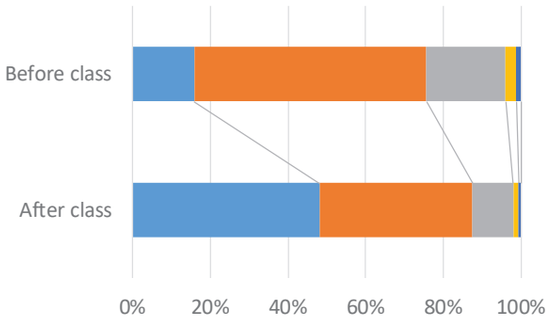
(e) Communication

Figure 4　Results of self-evaluation regarding improvement of skills.

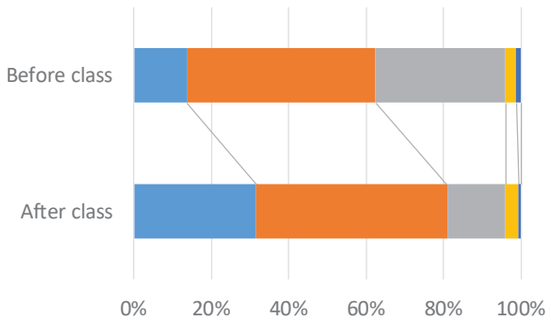
The results of self-evaluation of competences are shown before and after collaborative education.　The results of each skill show that there were many

students who selected that "They could do it completely" or "They could do it better than they thought". It can be seen that the ratio of negative evaluation decreases as an overall trend, and each cluster is shifting to an upper cluster. Although there is an individual difference in the absolute evaluation which should be considered, the results in which the feeling of improvement individually was realized for each student were obtained. On the other hand, there is little change in the proportion of students who answered "not much" or "not at all". For students who have difficulty participating in practical training, which requires advanced communication skills such as cooperative education, it became clear that it is necessary to implement some special support.

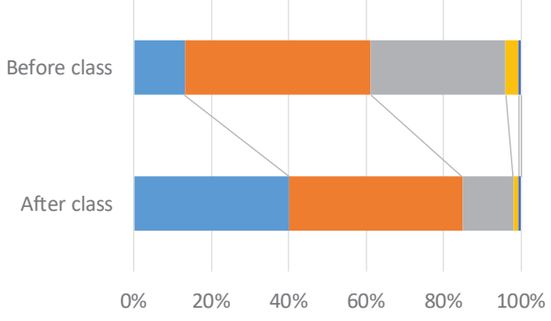
Based on the results of the student survey regarding the method of implementing cooperative education, 70% or more of the students have positive opinions concerning cooperation with other courses, and it is considered that training on a mixed team is effective.



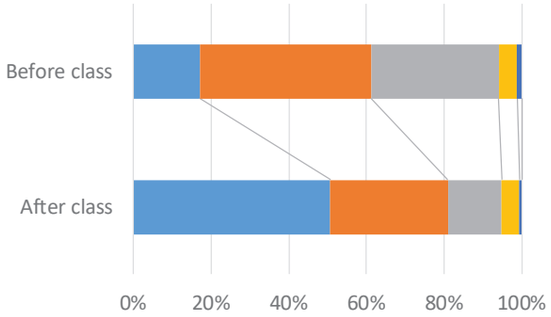
(a) Group skill



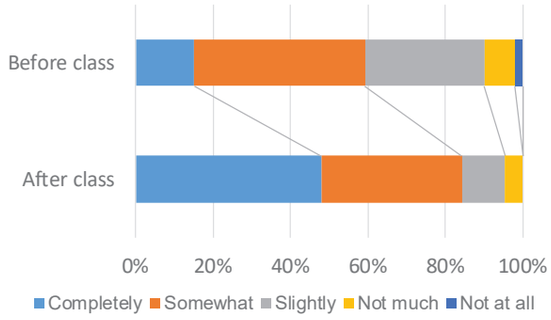
(b) Discovering problems



(c) Information gathering and utilization.



(d) Independence and sense of responsibility



(e) Communication

Figure 5 Transformation of self-evaluation regarding skills.

Conclusions

The students self-evaluated their level of competency acquired from regular lessons, cocurricular activities, and other activities using the rubric at the end of FY2017. The results and feedback were shown to each student via LMS as a radar chart. In the future, we plan to continue checking their strengths, weaknesses and improvement levels while adding additional radar charts.

Prior to the start of the project, neither faculty members nor students were conscious of competency acquisition, development and visualization, but they gradually became conscious of it through using the rubric. It can be expected that this kind of change in the atmosphere will be accelerated secondarily as an improvement of new lessons and efforts toward cocurricular activities.

Acknowledgements

This work was supported by MEXT 2014 Acceleration Program for University Education Rebuilding.

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A STUDENT-CENTRED APPROACH TO TEACHING CLASSICAL MECHANICS

Louis Ng*

* School of Engineering, Ngee Ann Polytechnic, Singapore

*Louis_NG@np.edu.sg

Abstract

Declining enrollment in technology and engineering courses is global issue as fewer students seems to be interested in learning about technology and engineering even though there is strong demand for graduates with these specialized skills. It has also been observed among Ngee Ann Polytechnic's engineering students that even though they are enrolled in the programme, many are not very keen to learn about engineering subjects. Many of the students are also unmotivated to learn, and engineering educators are finding it increasingly difficult to equip students with the necessary skills and aptitude that will be required of them in the industry. Engineering educators have to try and find suitable ways to engage students with the engineering content and to spark their interest to learn. One of the teaching and learning strategies adopted by engineering educators in the tertiary institutions is to move towards student-centered learning with game-based learning as one of the approach to enhance students' motivation and improve their learning achievement. The pedagogical intervention of game-based and cooperative learning gets the students to be curious, interested in the module content, and enhances the students' motivation.

This paper presents a study which analyses the effectiveness of infusing game-based learning and cooperative learning with an experimental group consisting of 32 students from the Mechanical Engineering course at Ngee Ann Polytechnic. The study collected evidences of students' attitudes towards the implemented pedagogical intervention.

Keywords: Engineering education, student-centred approach, cooperative learning, game-based learning.

Introduction

Since 2003, there has been a decline in interest in science and engineering amongst the young people around the world including the United States, Britain, Australia and Singapore. The decline in student enrollment in the technology and engineering courses has led to numerous challenges in engineering education in a number of countries. It has been reported by Orsak (2003) that between 1982 and 2000, 25% of its undergraduates in United States of America chose fields rather than engineering as a major. Similar trends are also observed in Malaysia and Australia. It has also been reported that more students had given up the option of reading STEM (Science, Technology, Engineering and Mathematics) subjects in the secondary and tertiary institutions (Arfudi, 2016; Panizzon *et. al*, 2014).

Despite the declining student enrollment in the technology and engineering courses in major universities around the world, occupations (e.g, Computer and Mathematical Scientists, Life Scientists and Engineers) related to science and engineering are still in high demand in line with globalization and economic competitiveness (Benson & Kirn, 2013).

Engineering as an industry has lost its "attractiveness" as the preferred choice for students as they have opted for studies in business and banking and finance courses. Despite various outreach initiatives over the years, companies have found it increasingly hard-pressed when looking for talents in the engineering field. Besides the poor salary prospects, most people think of an engineering job as boring and a job which involves getting one's hands dirty. For three consecutive years since 2012, it was reported that engineering jobs in Singapore had the most vacancies (Seow, 2015).

The lack of interest in Engineering courses among students have also been reflected in Ngee Ann Polytechnic (NP) as students enrolled in the Mechanical Engineering course are less keen to learn due to the lack of interest in the engineering. The onus is then, on educators to innovative and find different teaching and learning models to spark the interest in learning science and engineering.

Game-based and cooperative learning are teaching and learning strategies that have been used by engineering educators in the recent years. Both strategies have been known to be useful classroom interventions to enhance learning and motivation amongst the students. The use of games provides a context where game-play and content could increase skills acquisition and knowledge. Cooperative learning has also been applied to the educational context since the 1970s. It encourages a setting where students learn

from one another via discussions or debates, leading to new perspectives and innovative solutions. (Lauzon, 1992).

This paper will analyse and study the effectiveness of game-based learning and cooperative learning in a Mechanical Engineering courses. Classroom activities for 32 students were re-designed to implement game-based learning and encourage cooperative learning. The study aims to collect evidences of students' attitudes towards the implemented pedagogical intervention in the experimental class and 2 other classes (control group that adopts didactic lecture-based classes) of similar size.

Literature Review

Game-based Learning

Game based learning is an approach which builds upon the theory of constructivist learning (Li &Tsai, 2013). The constructivist philosophy is based on the assumption that 'knowledge is constructed by learners as they attempt to make sense of their experiences. Learning can only be effective when it is active, social and well-positioned. Infusing play into the learning activity can also be conducive to learning (Vygotsky, 1978). The sociocultural theory of learning and flow theory lends itself well for a successful, effective game design and learning objectives (Csikszentmihalyi, 1990; Vygotsky, 1978). The 'play' environment allows students to formulate and test hypotheses, explore their social roles, and most importantly, establish and learn the skills in the process of playing (Gee, 2005; Squire, 2005).

Game-based learning has been known to be a useful classroom intervention to improve content and skills acquisition as well as increase learning and motivation amongst the students. The learning environment created within a game setting creates opportunities for students to develop their higher-order thinking skills through resolving problems in the game-play, in a non-judgmental, enjoyable setting (Pivec *et. al*, 2003). Another benefit of game-based learning is the "repetition" which students go through as part of the game process. This "repetition" in game design can increase the opportunity for practice and to "remember" process, which is an important skill especially for technical subjects such as mathematics and sciences where it is important for students to remember certain key concepts. Also, game-based learning can motivate students through their successes in the game-play when they are able to solve problems as part of the game activities which provide students with a sense of achievement after solving the problem. Applying educational games in the classroom needs careful consideration, thorough research and focus on its contemporary learning theories (Young *et al.*, 2012). For game-based learning to take place effectively, it is not just a straightforward move by employing a game and expect students to have increased knowledge acquisition and motivation. For the outcome of the intervention to be positive, learning theories would have to be fused into the design (Wu et al.2012).

Cooperative Learning

Students form groups and learn together in Cooperative learning (Gillies, 2016; Hennessey & Dionigi, 2013). In their individual groups, students interact, discuss and exchange knowledge and students act as information providers to each other. Each member of the group contribute viewpoints and knowledge to the groups and work together to complete a task, project or an assignment (Johnson and Johnson, 1991). Cooperative learning has been reported as a pedagogy that develops critical thinking and higher order thinking. It has also been suggested that cooperative learning provides students with the opportunity to fuse together experience and knowledge from different disciplines which is an essential skill for the workplace (Johnson and Johnson, 1991).

The enthusiasm in cooperative learning first began in early 1980s where a study was done by education researchers on the effects of competitive, cooperative and individualistic goal structure on students' productivity and achievements. Johnson *et al*. (1981) conducted a study on a sample of schools in the United States and found that cooperation was more effective than having interpersonal competitions. In addition, they also noted that striving through individual efforts and cooperation together with inter-group competitions were also more effective than interpersonal competitions and individual efforts.

Research Design

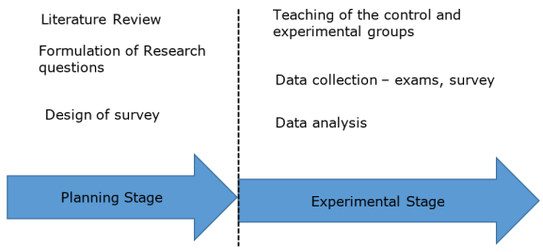

Figure 1. Schematic diagram depicting the various tasks at the planning and experimental stages

There are two stages are involved in this study. These include planning and the experimental stages as illustrated by the Figure 1.

Table 1. Summary of a typical tutorial lesson between the control group and the experimental group

Lesson Objectives	Controlled Group	Experimental Group
Demonstrate the fundamental understanding of stresses. - *Compute the stresses on a body.* Description of Hooke's Law and states the conditions for which it can be applied. - *Derivation of expression relating stress to strain. Application of Hooke's Law to solve static equilibrium force problems.*	Direct Instruction where lecturers would go through the steps to calculate the stresses and solve the static equlibrium problems in front of the class.	*Game-based learning* is infused into the tutorial lessons where students were formed into groups (roughly 2-3 per group). The game is played by posing to students questions which test key concepts of the topic. (Hooke's Law, calculation of stresses). *Cooperative Learning* - Students within their groups will discuss and attempt to solve these questions. Weaker students who had failed to grasp the concepts learn from their fellow peers. At the end of the lesson, the group which scores the highest score wins this game.

A quasi-experiment was conducted on two groups (i.e. the control - and the experimental groups) of students during the experimental stage. The students from both control and experimental groups are 2nd year Mechanical Engineering students undertaking the Strength of Materials Module. The mode of teaching to the control group was largely via traditional direct instruction, while the alternative pedagogical intervention of game-based learning and cooperative learning was employed at the tutorial sessions of the experimental group. Table 1 shows a summary of the difference in the mode of instruction between the control group and experimental group in a typical tutorial lesson. The objective of the pedagogical intervention into the curriculum is to enable students to learn and better understand the topics taught in the Strength of Materials module.

A total of 145 Mechanical Engineering students were enrolled in Strength of Materials module in April 2016. Two classes of 35 students which formed the control group were randomly chosen from the population via simple random sampling. The experimental group had 32 students of similar population from the two classes. At the end of the semester, the experimental completed an online google survey to solicit their attitudes towards the implemented new pedagogy, i.e. game-based and cooperative learning methods.

Instrument Development

An online google survey is used to measure students' attitudes towards the new teaching pedagogies. This questionnaire contains six statements. Students indicated their responses on a 6-point Likert Scale. In addition, an open ended question seeking feedback from students on how, the new teaching pedagogies can be improved. The survey was revised from a pilot study of the previous cohort. To ensure the validity of the questionnaire, a small group of 15 students from the previous cohort were tasked to go through the survey and a focus group discussion was set up to gather feedback. Bearing in mind that the questionnaire would have to be understood by the students and comprehensive enough to collect relevant information, needed to address the goals and purpose of this study, the questionnaire was revised for this study.

Results and Discussion

The results consolidated of the survey were positive with the majority of the students agreeing that the pedagogical intervention has aided in understanding the module.

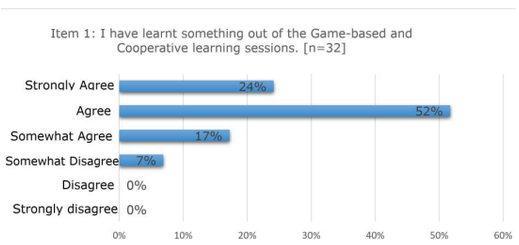

Figure 2. Percentage of students who felt that they have learnt the module with the introduction of the pedagogical intervention.

From Figure 2, it can be seen that the majority of the students felt that the game-based learning and cooperative learning instructions have its learning value, with 24% of the students strongly agreeing to the statement and slightly more than half of the sample (52%) agreeing that they had learnt topics in the module through the conduct of these sessions.

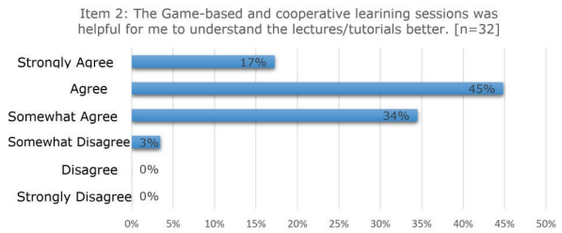

Figure 3. Percentage of students who felt that the pedagogical intervention was helpful in the understanding of the module.

In Item 2 (Figure 3) of the questionnaire, students were asked if the game-based learning and cooperative learning sessions had benefited them in their lectures and tutorials. The percentage of students which agree that these sessions had helped them understand the module better was 96% (namely 17% strongly agree, 45% agree and 34% somewhat agree).

All in all, 97% of the students felt that the game base and cooperative learning sessions had offered them, a positive and good learning experience (namely, 17% strongly agree, 48% agree and 31% somewhat agree). Only 3% (1 student) somewhat disagrees with this statement.

As said, games engage people. This, with elements of cooperative learning, aid to make a significant positive impact in students learning. The survey results in this study have shown that students felt that they have learnt and better understood the topics in the module with the introduction of game based and cooperative learning. These educational games contributed as a motivating element and made learning enjoyable for students. The students have also showed more enthusiasm in learning as compared to the traditional direct instruction approach.

Conclusion

The results generated from this study suggests that students had felt that the new pedagogical intervention of game-based and cooperative learning was useful and that it has enabled them to deepen their knowledge in the module. The students have also indicated that they have enjoyed the learning experience with this new pedagogical intervention. Game-based learning, with cooperative learning has provided the students a learning structure which engaged them in a non-judgmental, competitive yet fun manner. These findings are consistent with the studies of Henry (1997) and Sward et al. (2008) where students found motivation and enthusiasm to what they learn via game based learning.

With the findings of the study, future work would entail the investigation of the impact of game-based learning and cooperative learning along with the students' learning achievement such as problem-solving, conceptual knowledge and critical-thinking skills. These results would aid in the design of active learning approaches to enhance students' learning in various modules.

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The author would like to thank Dr Lye Che Yee, University of Adelaide (Australia), for her patience, invaluable suggestions and guidance in this project.

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BUILDING INFORMATION MODELLING EDUCATION IN HONG KONG

T. C. Lo*, W. H. Lo and C. Wong

Department of Construction, Hong Kong Institute of Vocational Education, Hong Kong

*tclo@vtc.edu.hk

Abstract

BIM Technology introduced to Hong Kong Architecture, Engineering and Construction (AEC) Industry for more than 12 years, and it added to the curricula of higher diploma programmes of Hong Kong Institute of Vocational Education (IVE) for nearly a decade. At the same time, the BIM technology continuously updated and extended to a much broader scope. With the introducing of BIM mandate to almost all government public works projects, there are profound changes in the competencies demand. All the above development imposed new challenges for the teaching and learning approaches to the subject.

This paper presents the current situation of Building Information Modelling (BIM) Education in IVE of Vocational Training Council (VTC), Hong Kong.

Keywords: *Building Information Modelling (BIM), Education, Architecture, Engineering, Construction, Hong Kong*

Introduction

In September 2016, the Buildings Department of the HKSAR Government issued the "Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers (ADV-34)" which expressly encourages authorized persons (AP), registered structural engineers (RSE) and registered geotechnical engineers (RGE) to consider adopting BIM in building projects under the Buildings Ordinance.

In January 2017, The Chief Executive of the Hong Kong Special Administrative Region (HKSAR) in the Policy Address asserted that the HKSAR Government would actively seek to require consultants and contractors to use Building Information Modelling (BIM) technology to undertaking design of major government capital works projects from 2018 onwards. The Chief Executive also urged all eligible consultants to prepare for facilitating a smooth implementation of this initiative. The message reiterated in the Policy Address in October 2017. The adoption of Building Information Modelling in Capital Works Project has been rolled out in January 2018 as scheduled.

Development of BIM in Hong Kong

BIM Technology introduced to Hong Kong Architecture, Engineering and Construction (AEC) Industry for more than 12 years, and it added to the curricula of higher diploma programmes of Hong Kong Institute of Vocational Education (IVE) for nearly a decade. At the same time, the BIM technology continuously updated and extended to a much broader scope. With the introducing of BIM mandate to almost all government public works projects, there are profound changes in the competencies demand. All the above development imposed new challenges for the teaching and learning approaches to the subject.

Literature review

Building Information Modelling (BIM) is not simply a new technology. It is not just software, hardware or a few personnel that can easily be master and become a functional business area. BIM becomes another essential business function that is crucial for every Architectural, Engineering and Civil Engineering (AEC) companies. Many AEC companies that need to introduce BIM to their business function may start by transforming the existing function department or re-training their staff to adopt BIM for their business needs. Unlike other well established AEC professional, technologists or technicians who have corresponding undergraduate courses or Higher Diplomas and Associate Degrees.

Regarding professionalism, BIM still does not have a universal recognised professional. There is no clear definition for the scope of work and job duties of the BIM personnel. Barison and Santos (2010a) identified several types of BIM job positions:

- BIM Modeller
- BIM Analyst
- BIM Application Developer or BIM Software Developer
- Modelling Specialist
- BIM Facilitator
- BIM Consultant
- BIM Researcher
- BIM Manager

BIM Manager which usually in a leading role of a team of BIM initiative of the company can further classify into:

- Project Model Manager, Modelling Manager or Model Manager
- BIM Manager at Design Firms or Chief BIM officer
- BIM Manager at General Construction and subcontractor Firms

Degree-awarding higher education institutions considered as the source of AEC professional. Employers of AEC companies expect that construction related program graduates will already have a working knowledge of BIM. There is no a BIM specific undergraduate course or Higher Diplomas BIM exists. It is even not compulsory elements for most AEC related course offered by these institutions.

Maghiar, Jain and Sullivan (2013) revealed one possible barrier that limited the availability of BIM education in the various program. Although BIM already noted as essential elements by the industry, BIM is still not formally acknowledged as the accreditation criteria of any AEC courses. Students also lack the incentive to take additional courses for BIM education that is not part of their program curricula, as far as they are not necessary to graduate.

However, with the rapid adoption of BIM over the past few years, BIM becomes the essential skill for graduates to remain competitive in the job market. Maghiar, Jain and Sullivan (2013) suggested the following important skill needed:

- Ability to apply and work with new technology;
- Basic modelling and manipulation skills;
- Ability to model detailed conditions in 3D;
- Ability to assemble and review a clash detection model;
- Ability to create 4D models using a schedule and then derives a total project estimate.

Maghiar, Jain and Sullivan (2013) concluded that "The leading instruction of this class with a few industry experts explored several areas of BIM integration and after careful considerations have determined that implementation throughout the curriculum is the most advantageous way to achieve both academic and industry". They also opine that "the next generations of construction professionals are not the BIM experts, but they are capable of applying their BIM knowledge to their daily job tasks." Wu and Issa (2013) study affirmed that BIM-oriented career development was still new to most academic AEC programs. Nowadays companies preferred to hire seasoned professionals instead of fresh college graduates for BIM staffing.

Barison and Santos (2010b) studied the approach to introduce BIM to the curriculum of Architecture and Engineering courses and conclude that the simple addition of a new BIM course may not fully unleash the potential of BIM. An integrative approach by spreading the BIM subject into separate courses and with attempts to collaborate with each other would need. Indeed, there was a similar framework developed by The Higher Education Academy and BAF (BIM Academic Forum) in the UK. The report "Embedding Building Information Modelling (BIM) within the taught curriculum" (2013) outlined a "BIM Learning Outcomes Framework". The framework covers three levels of need: strategic, management and technical.

One of the key difference highlighted by Barison and Santos (2010c) is that unlike other traditional subjects, "Collaboration" is an essential component for BIM curriculum activities. It is clear that the learning experience is still rather new and the pedagogy applied is not yet been consolidated.

Provision of BIM Modules in IVE

Table 1. List of Building Information Modelling Module offered by IVE.

Higher Diploma (HD) Programme	Building Information Modelling (BIM) Module title	Curriculum Hours
HD in Architectural Studies	Computer 3-D Visualization and BIM	39
HD in Architectural Technology and Design (*Elective Module)	BIM A	39
	BIM B	39
	BIM for Building Services Engineering*	39
	BIM for Construction Management*	39
HD in Building Studies	BIM for Building Works	39
HD in Civil Engineering	Structural Detailing and BIM	39
HD in Environmental Engineering	BIM for Environmental Applications	26
HD in Surveying	BIM and CAD	52
HD in Building Services Engineering	BIM in Building Services Design	39
HD in Real Estate and Property Management	Intelligent Building Systems & BM	39
Enrichment Modules (Offer to all IVE HD students)	Introduction to Building Information Modelling	26
	Parametric Modelling for Building Design	26
	Building Information Modelling with ArchiCAD	26

The above table lists the latest provision of BIM in IVE.

In the early stage of introducing BIM to the IVE curriculum, BIM Modules only introduced to very limited Higher Diploma Programmes of the Department of Construction. With the experience gained in delivery BIM modules and through observation of the industry development, feedback from various industry stakeholders, we finally notice that the provision of BIM modules to particular Higher Diploma cannot fit the sustainable development of BIM which focuses a lot in collaboration as mentioned in previous paragraphs.

In recent years, with the popularity of BIM, more IVE Higher Diploma programmes started to introduce BIM module into the curriculum. Currently, we have 8 Higher Diploma with one or more than one BIM modules as core or elective modules of the curriculum.

Challenges in BIM Education

Unlike hand-drafting or Computer Aided Drafting, BIM technology is a tool that can be capable of allowing one to develop a complete set of drawings including plans, elevations, Sections, schedules, 3D views, animation. The requirement of hardware is relatively higher than that of other software. Additionally BIM software tends to upgrade annually; one of the major BIM software introduced a practice that BIM files created by newer version are not backwards compatible with the older version. We cannot stick to an older version for a prolonged period as the newer version will always have new functions and improved functionality.

With the continuous development and the maturity of using BIM technology, the scope of BIM has extended rapidly. From the number of software available to the technology adopted. Examples include the use of virtual reality (VR) in visualisation, Terrestrial laser scanning of the construction site, existing building or internal environment. The popularity of unmanned aerial vehicle (UAV) and photogrammetry in surveying. All these latest development which introduced rapidly as the norm of BIM operations added new demand from Employer and various stakeholders, yet all these new technologies require a considerable amount of resources for adapting to the curriculum.

Conclusions

The paper reviewed the latest development of BIM in Hong Kong. It also reviews the challenge of incorporating BIM into the curriculum and reported the latest status of BIM provision in IVE

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CONVERGENT COLLABORATIVE LEARNING (CCL) MODEL FOR ENHANCED STUDENTS LEARNING IN BIOMEDICAL ENGINEERING COURSE

Kannathal NATARAJAN *

Ngee Ann Polytechnic, School of Engineering, Singapore

*Kannathal_NATARAJAN@np.edu.sg

Abstract

Group project-based learning is commonly used within engineering curriculum to simulate what is expected in the real-world of engineering work – working in teams to collaborate and apply their knowledge and skills to solve real engineering problems. However, many engineering educators face multiple challenges in using group projects effectively. Some of the issues observed include team members not equally contributing fairly and equally to the work, poor student motivation due to less individual accountability, and the worry of uneven acquisition of the expected skills, knowledge, and know-how by team members. In this paper, a systematic approach called the 'Convergent Collaborative Learning (CCL) model' is proposed to help educators address the challenges of implementing group projects and, at the same time, build students' interest and confidence in their own ability to learn and solve engineering problems.

The CCL model is developed by adopting collaborative learning approach but in a more structured manner to promote students' cognitive thinking. In this model, the problem solving process involves four stages. The first stage is the Idea Generation (IG) stage where the students brainstorm and collect different ideas from the group. The second stage is Idea Organization (IO) that involves comparing, analyzing and categorizing different ideas. The third stage is Idea Convergence (IC) that necessitates higher levels of cognitive processing to synthesize the organized ideas and converge to generate solutions. The last stage is the Final Design (FD) where the students integrate and complete the design. The process can be reiterated for more complex project design. In this way, this model provides opportunity for the students to engage more in deep learning.

A pilot study of the proposed model was carried out with 83 diploma level students of the Biomedical Engineering course at Ngee Ann Polytechnic. Analysis of the results indicated that the CCL model enhances the students' learning experience and fosters the development of technical and non-technical competencies in all team members. This approach also helped to alleviate the issues of free-riding and accountability of individual contribution by team members. In conclusion, this study demonstrated the potential of this model for use at any higher education courses to nurture students for future career and challenges in the rapidly growing economy.

Keywords: *convergent collaborative learning, group projects, critical thinking, cognitive thinking, biomedical engineering*

Introduction

In this decade, engineering education institutions are faced with many challenges with the decline in students' intake and interest in engineering as key factors. Currently, students encounter difficulties in applying the knowledge and skills learnt in the classroom to industry. At the same time, many companies require that employees be skilled in teamwork and communication, so as to improve productivity. In an effort to close the gap between industry needs and academia for engineering students, Daniels et al. (2010) proposed using open-ended group projects. Open-ended group projects intend to bridge the gap by mimicking real-world scenarios and enabling the students to acquire relevant skills in addition to content knowledge. It paves a way to integrate, teach and assess non-technical competencies as well, along with technical competencies.

Group projects are not something new and have been used by educators for many decades. Many university and college level courses employ group projects to simulate real-world industry experiences in solving problems and managing resources and teams (Gamson, 1994). Group projects intend to create a simulated industry-working environment for students. As much as said, many researchers have assessed the advantages of group projects in classrooms. The main advantage was found to be fostering 'deep learning' and reducing 'surface learning' in students (Entwistle and Waterson, 1988). Group work pushes students to be active learners

by enabling them to construct and synthesize their own knowledge (Ruel et al, 2003). Group projects also provided students with experiential learning opportunities and promoted their problem-solving and decision-making capabilities (McGraw and Tidwell 2001). Watkins (2004) had indicated that many students appreciated the holistic learning experience obtained by doing group projects.

Though there are many advantages for implementing group projects in classrooms, they posed significant challenges for teachers and students in achieving desired learning outcomes. As much as researchers agreed on the benefits of real-world scenario-based group projects for engineering students, they have also highlighted the various concerns and implementation issues that hinder the efficacy of using group projects for learning. According to the analysis by Davies (2009), for the students at tertiary level, group work promoted deep and active learning, construction of knowledge and higher-order thinking skills. It provides a pathway for students to discuss and assimilate new ideas in a social context, fostering social skills. Group project work also enables students to develop transferable skills and on-job learning attitude that meet the demands of the industry for flexible workers.

On the other hand, there are also some key concerns with the use of group project for learning. One of them is self-motivation. It can result in poor group work experience for students, when they are in groups with unmotivated students who only want to "free ride" or "social loaf" (Morgan, 2002). Another study (Isaac & Tormey, 2015) revealed that students' perceptions of learning in groups change during the course of the project and reported more positive group experiences with increased lecturer guidance and intervention. The students were also concerned about time as they found it difficult to meet with group members to discuss their project or meet up with their lecturers. These challenges adds pressure to their learning experience and negatively impact students' learning when working in group projects.

To address these issues of group projects, various collaborative learning pedagogies were proposed in the literature. The study by Persico et al. (2009) suggested that more structured activities during collaborative learning results in better learning outcomes and experiences. But researchers like Dillenbourg (2002) have cautioned that over-guiding of students by instructors during collaboration activities tend to cause loss of flexibility and failed to nurture students' creativity and abilities to handle unforeseen circumstances. Hence it is important to strike a balance and nurture creativity in students even with structured activities. With this objective, we have proposed a new enhanced collaborative learning model referred to as the Convergent Collaborative Learning (CCL) model to facilitate group projects for engineering courses in higher educational institutions. The proposed CCL model provides a structured approach for collaboration that allows learners to develop both technical skills and 21st century competencies. A pilot study of the CCL model was carried out with students in a biomedical engineering course with the aim to evaluate the effectiveness of the proposed CCL model in facilitating group projects and its impact on learners.

Methodology

The CCL model is underpinned by the social constructivist learning theory developed by Vygotsky (1978). According to Vygotsky, social interaction aids to build complex knowledge structures. In collaborative learning, knowledge is constructed by learners through their experiential activities and with their interactions with teachers and peers. Usually constructivist classrooms are implemented using active teaching pedagogies to create an arena that promotes discussions and reflections by learners to develop in-depth understanding.

The CCL model is developed with the objective to utilize the beneficial aspects of structured collaborative learning and in the meantime improve their cognitive processes to enable them to construct knowledge and develop an intelligent convergence of their ideas with knowledge and skills. The proposed CCL model is derived from the Harasim's Online Collaboration Model (OCL) that encourages students to work in teams to seek conceptual knowledge in order to solve real-world problems (Harasim, 2012). The conceptual map of the proposed model is shown in Figure 1.

The CCL model is a schema for educators to mimic real-world scenarios and situations encountered when working on projects, in class and bring the desired conceptual change in learners to seek and construct knowledge. This learning model incorporates four phases of idea and product development as given in Figure 1.

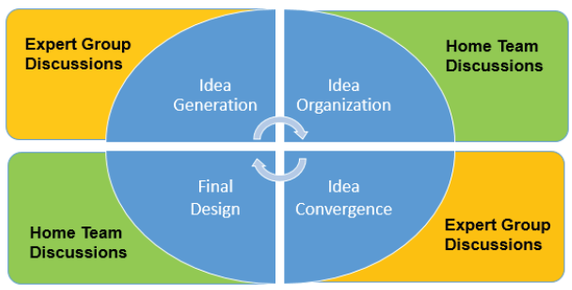
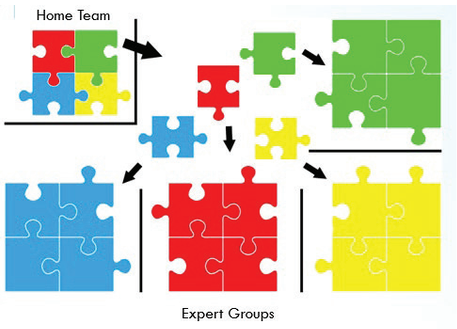


Figure 1. Convergent Collaborative Learning (CCL) Model

The first stage - Idea Generation (IG) - brainstorm and collect different ideas; The second stage - Idea Organization (IO) - compare, analyze and categorize different ideas; The third stage - Idea Convergence (IC) - synthesize the organized ideas and converge to generate solutions; The last stage - Final Design (FD) - integrate

and complete the design; The 4-stage process in Figure 1 can be reiterated for further enhancement and more complex project design. This model provides the opportunity for the students to engage in deep learning.

This conceptual model has to be integrated with an appropriate implementation model to ensure that learners achieve desired learning outcomes. The implementation model is derived from the cooperative learning approach for implementing group projects by Felder and Brent (2001). In this approach, students embark on structured learning tasks that satisfy five criteria: positive interdependence, individual accountability, real-time interaction, inter-personal skills and self-assessment skills. To achieve this, an implementation model resembling a Jigsaw pattern as shown in Figure 2 is used. Two types of groups are formed – One is a home team and the other is an expert group. Home teams are formed with members who have diversified knowledge and specialties to work on the specific projects. Each member of the home team is responsible for a specific part of the project and require specialized knowledge and skills. Expert groups are formed with members from different home teams but assigned in the same specialized area. In this method, students benefit by taking ownership of one expertise area in the project, collaborating with expert groups and exhibiting professionalism in team work. Students are accountable for completion of their part in home team and also collaborate with team members to ultimately complete the project.



[Image Courtesy: http://teachingadolescents.weebly.com/jigsaw.html]

Figure 2. Implementation model of CCL using Jigsaw structure

Lecturers or facilitators play a crucial role in linking the conceptual and the implementation model. In the first IG stage of the CCL model, instructors provide resources and encourage the students to generate ideas in their assigned expertise area along with their expert group members. In the second IO stage, students return to their home teams and share the ideas generated during different expert group discussions. They compare, analyze and categorize the different ideas from various expert groups and discuss the pros and cons of each of the ideas generated. At third IC stage, students are involved in discussions with expert group members to identify viable solutions and the ways to overcome the issues identified during home team discussions. At this stage, students are stretched to develop the ability of customizing generic ideas to make it suitable for the home team project. In the last FD stage, students construct the final design or product by integrating the different expertise ideas of respective team members. Depending on the complexity of the project, the process can be reiterated and on every iteration the student may seek knowledge at a much deeper level to arrive at feasible solutions.

Implementation and Data Collection

A pilot study of the proposed CCL model was carried out with 83 students of the Year 2, Biomedical Engineering course taking Healthcare Information Technology (HCAIT) module. The group projects in this module are formulated such that they mimic the real-life scenario in this module domain. The formation of project groups was the most crucial element of this model, thus careful and strategic selection of the group members is important in order to achieve the desired learning objectives.

Home teams were formed with a fixed number of four members per group. The students chose their home team members, but with lecturer's supervision to ensure that the members of the team possessed diversified capabilities. Each group was assigned a different scenario of the real-life problem. The scenarios were chosen such that they were of same complexity and are similar in terms of the expert knowledge requirements. Once home teams are selected and expert groups are formed, their tasks will be assigned. Lecturers provide resources and initiate the start of the project work. They will also monitor the progress of both home teams and expert groups and will provide guidance and interventions where necessary.

Evaluation which is vital to validate this pilot study was carried out at two stages – first when the project is about 75% complete and second at the end of the project. All 83 students participated in this evaluation process and provided feedback about their learning experiences in the project. The first survey, 'Group Dynamics: Group and Me' was aimed to gauge the group dynamics during the project (Table 1). The questions for this survey were chosen with reference to the guidelines given by Swaray (2012) on the evaluation of effectiveness of the group projects. The seven questions on this survey focused on three areas: motivation (Q1 & Q2), team work (Q3, Q4 & Q5) and higher order thinking skills (Q6 & Q7).

The second survey (Table 2) was to evaluate the overall learning experience. The questionnaire for the second survey was developed using Ngee Ann Polytechnic's Module Experience Survey (MES) guidelines to evaluate six specific areas: skills and knowledge, thinking, teaching and learning, feedback, materials and activities. The seventh question was to evaluate the overall experience. Each survey question is rated using 5 point Likert scale (SD-*Strongly Disagree, D-Disagree, N-Neutral, A- Agree, and SA- Strongly Agree*).

Table 1. Group dynamics: Group and Me (Student survey questions)

Question	Description
Q1	Inspiring and motivating than the other group assignments I have experienced before.
Q2	More effectively encouraged me to work with my classmates. Enabled me to work closely with my classmates with whom I usually do not interact with so much
Q3	Enabled group members to observe and monitor each other's understanding of the project
Q4	Experienced very little or no problems in the team due to group members laziness or lack of participation
Q5	We are able to complement each other's strengths and weakness in completing the project.
Q6	Helped me to think out-of-box by generating ideas, critiquing each other ideas and identify the feasible solution to achieve the final goal.
Q7	I am able to synthesize and simulate the real world application through this project which I will not be able to do so if I do the project alone.

Table 2. Overall learning experience for Group project (Student survey questions)

Question	Description
Q1 Skills and Knowledge	The group project helped me to develop useful skills and knowledge in this module.
Q2 Thinking	The discussions with expert groups and home groups helped to understand and execute the project better and achieve the desired learning outcome.
Q3 T&L	The teaching and learning approach helped to stretch my thinking skills to complete and enhance the project.
Q4 Feedback	I received useful feedback for the activities and discussions.
Q5 Materials	The materials and resources provided are good and aided me to understand the content better.
Q6 Activities	The project activities helped to improve my collaboration and communication skills.
Q7 Overall	Overall, I enjoyed this approach of doing projects and it enhanced my learning experience.

Results and Discussion

The results of the survey "Group dynamics: Group and Me" are given in Figure 3. In general, the results of the survey substantiate the rationale of using the proposed CCL model for group projects, such as promoting deep learning, increasing student motivation and reducing free riding.

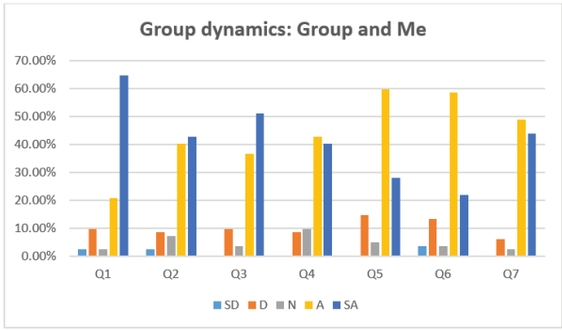


Figure 3. Results of the survey, Group dynamics: Group and Me.

Results revealed that 91% (Q7) of students were able to synthesize and simulate the real-world applications using this learning approach. 81% (Q2) of students agreed that this method encouraged them to work effectively with their classmates and also enabled them to work in a more efficient manner with new teammates who were not part of their daily interactions. Furthermore, 86% (Q3) of the students indicated that they learned by observing and monitoring other team members' work. 86% (Q5) of students also reported that they were able to identify each other's strengths and weaknesses and this helped them to complement each other's work to successfully complete the project. This indicates that students were able to do a self-evaluation as well as a peer evaluation of their contributions to the group project.

The CCL model has helped them to connect to the project and assisted in identifying plausible errors in their designs. This is an indication of the development of reflective and reasoning skills which the students might not acquire during traditional classroom teaching. These results assures that the CCL model catered opportunities for students to acquire and apply domain knowledge, and develop communication and collaboration skills by working in groups to solve real-world problems. The findings also ascertain that structured activities led to meaningful collaboration and nurtured students' cognitive abilities.

The expert group discussions paved the way for learners to seek knowledge and bring desired conceptual change to build new knowledge and deepen existing knowledge. The work in the home team enabled learners to critically analyse and apply the knowledge to real-world applications. Due to the nature of structured processes in the design of CCL model, various issues with group work such as free-riding and lack of domain

competencies were minimized. Indirectly, these processes seem to have induced trust and commitment among team members which led to better team cohesion and group dynamics.

After the completion of delivery and assessments of the project, students were asked to do the next survey on the overall learning experience of this group project. Results of this survey, given in Figure 4 were very promising regarding the positive effects of the group project implemented using the CCL model. Consistent with the results of the first survey, more than 80% (Q7) of the students were optimistic about their learning experience obtained by doing this group project using the CCL model. 86% (Q1) of students have specified that the group project helped them to develop useful skills and knowledge in this module. Indirectly, the group project enabled students to learn in and out-of-class environment, enhance leadership skills and to work inclusively with all team members. The results obtained were consistent with the findings from prior research on group work, that group work encourages active learning and enhances communication and collaboration skills.

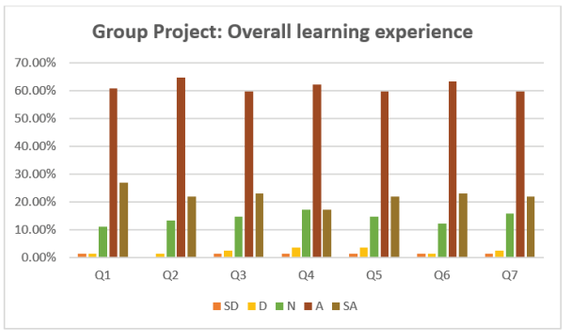


Figure 4. Results of the survey, Group Project: Overall learning experience.

85% (Q6) of students agreed that the activities enabled them to improve their collaboration and communication skills and 81% (Q3) of the students concurred that teaching and learning approaches stretched their thinking skills. They indicated that they might not able to get the same learning experience if traditional teaching and learning methods were used. The CCL model facilitated all students to achieve the desired domain knowledge, as well as the required 21st century skills such as collaboration and communication. It is important to note that only less than 5% of the students differed on the positive experiences and 15% remained neutral in their views about this learning model.

It is evident from the results that the strategies employed in the CCL model encouraged self-directed learning and nurtured independent reasoning as well. Specifically, the CCL model cultivated wide range of skills that can be applied to real-world work environments in the future. This would enable students to be more work ready upon graduation.

Conclusion

Results from this study confirms the CCL model as a viable teaching and learning approach for facilitating student group projects. This approach tends to develop the cognitive abilities of learners by scaffolding and converging different phases of knowledge construction. It also enables effective team work and aids to ensure that desired learning outcomes are achieved by all students undertaking group projects. Though activities are structured in this model, the implementation process aids to foster deep and critical thinking in students, while at the same time promoting the necessary soft skills such as decision-making, collaborating and communicating in the real-world. With further enhancement, this CCL model can be used for facilitating group projects in multitude of engineering courses.

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DEVELOPING COMPETENCIES THROUGH CO+WORK AND TOBITATE PROJECTS

T. Hiraishi[a,*], J. C. Herbert[b], Y. Kajimura[c], and S. Fujiwara[d]
[a]NIT, Akashi College/Architecture, Professor, Akashi, Japan
[b]NIT, Akashi College/General Studies, Professor, Akashi, Japan
[c]NIT, Akashi College/Electrical Engineering, Professor, Akashi, Japan
[d]NIT, Akashi College/Mechanical Engineering, Professor, Akashi, Japan

*E-Mail: hiraishi@akashi.ac.jp

Abstract

The Co+work course, which started in 2016, aimed to cultivate competencies in autonomy, cooperation, and creativity through the interaction of students from the different fields and classifications as they tackled a shared project. The name "Co+work" is derived from the thought of having a need to create something by cooperating in practice. We have chosen to use "co-" for communication, consensus, commitment, cooperation, and collaboration. Similar exercises have been implemented in many universities and NIT colleges, but ours is unique in that the students consider and decide their own topics to tackle rather than the teachers deciding and proposing what projects to do for them.

Another program that builds competencies is the "Tobitate! (Leap for Tomorrow) Study Abroad Initiative." Tobitate is a scholarship program provided by Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT) that aims to help eager and capable Japanese youth to take their first steps toward studying abroad. In NIT-Akashi College, seven students in 2015, twelve students in 2016, two students in 2017 and five students in 2018 received Tobitate scholarships and studied in schools, did voluntary work in NGOs, or worked in companies for one month.

This paper describes how students developed their competencies through Co+work and Tobitate and analyses their results on the Progress Reports on Generic Skills (PROG) Test. The PROG Test consists of 33 specific characteristics, 9 subcategories, and 3 main categories in competency. The change in competencies and the relationship between the students' grades and experience are analysed. The PROG Test was conducted on 26th January 2016 before Co+work was implemented, then on 17th January 2017 and on 18th January 2018.

As a result of these projects, the social effect of seniority, the temporary decline in competence due to difficult experiences and the subsequent growth, and the growth difference seen in certain types of competencies became clear. As Co+work has been carried out for two years and Tobitate for three years, the competencies of NIT-Akashi College (NITAC) students have become significantly noteworthy in comparison to that at other NIT colleges and Japanese universities.

Keywords: PBL, grades, PROG, Co+work, Tobitate, competency, experiment, seniority

Introduction

This paper is a continuation of a report on a three-year project. In order to bring the readers up to date on how the project started and where it is going, much of the Introduction along with a portion of the Methods section, and Tables 1 and 2 have been re-printed from last year's publication (Hiraishi, et al., 2017).

We are facing rapid social changes due to the recent circumstances in which globalization generates more people who have a wider and more diverse sense of values and in which advancements in ICT has made it easier to acquire information. This urges people to refresh and renew their own abilities constantly along with these social changes. Thus, an ability to keep learning actively has become much more significant now than ever before. We are also facing complicated problems that involve multidisciplinary issues which require an ability to cooperate with professionals from other fields to tackle these complexities. Rieckmann (2012) mentioned that universities may play very different roles in the future and could more or less be able to cope with global change and the complexity and uncertainty linked to these changes. Furthermore, the necessity of regular subjects for the purpose of nurturing generic skills in Japanese undergraduate education are advocated by Yoshihara (2007).

Unfortunately, in Japan, due to the declining birth rate and a growing tendency to have "play alone" single-child families, today's youth have fewer opportunities to interact in groups. At the same time, passive education rather than active learning has remained mainstream in Japan. These circumstances make it difficult to cultivate competencies in collaboration, autonomy, and creativity.

In order to solve these problems, NITAC introduced Co+work to develop autonomy, collaboration, and problem-solving skills through challenging team experiments for creating goods or services that would make life happier for people. Hiraishi, et al. (2017) reported the educational effects of the first year of Co+work at ISATE 2017, which included the following insights:

1) In the past, in Kosen education there was no obvious competency growth.
2) Competencies of 3rd year and 4th year students obviously grew by the implementation of Co+work.

3) Competencies in problem-solving improved through Co+work because students set their own themes.
4) It is important to develop good relationships through team building in the inital stage.
5) The setting of themes that everyone can participate in is important for maintaining motivation to complete activities.

Methods

The National Institute of Technology, Akashi College (NITAC) introduced Co+work to develop autonomy, collaboration, and problem-solving skills through experiments for creating goods or services that would make life happier in spring 2016. Table 1 shows the schedule of the Co+work course, which took place in 90-minute sessions once per week.

Table 1 The schedule of 'Co+work'

Week	Overview
1st	Guidance and team making in the gym
2nd	Ice breakers and brainstorming activities with teammates in the gym
3rd – 7th	Theme setting by each team
8th – 13th	Project progression by each team
14th	Intermediate Presentations Four teams present their projects in one room. Seven minutes for presentations and 8 minutes for questions and comments.
15th	Reflection by each team
16th	Intermediate Guidance
17th – 28th	Project progression by each team
29th	Final Presentations Poster session in the gym
30th	Reflection by each team

Reprinted (Hiraishi, et al., 2017).

Table 2 shows the competency structure used for the Progress Reports on Generic Skills Test (PROG Test) in the PROG Hakusho Project (2016). The PROG test was conducted on 26th January 2016 before Co+work was implemented and on 17th January 2017 and on 10th January 2018 after Co+work was completed. The students of the 2nd year, 3rd year, and 4th year were examined through their PROG test results. In accordance with the PROG Hakusho Project (2016), the test consists of the following three types of computer adaptive questions:

1) *The bilateral selection format* which presents two ambiguous answer choices positioned side-by-side with hidden values and which forces the quick selection of one's first impression of the answer which they can relate to more closely.
2) *The scenario assumption format (short sentence)* which proposes answers that are generally considered to be positive for conflicting situations that anyone may be experiencing and asks how often the subjects have reacted in a certain way.
3) *The scenario assumption format (long sentence)* which proposes answers that are generally

Table 2 Competency Structure of PROG

	Main Categories	Subcategories	Specific Characteristics
Competency	Collaboration	Affinity	Friendliness
			Consideration of others
			Interpersonal interest, sympathy, acceptance
			Understanding, awareness, and tolerance of diversity
			Fostering of personal relationships
			Trust building
		Cooperation	Understanding of roles and collaborative behavior
			Information sharing
			Mutual support
			Consultation, guidance and motivation of others
		Leadership	Dialogue engagement
			Opinion sharing
			Constructive and creative discussion
			Adjustments of opinion, negotiation and persuasion
	Autonomy	Emotional control	Self-awareness
			Stress tolerance
			Stress management
		Creating confidence	Understanding of identity
			Self-efficacy and optimism
			Self-transformation by new viewpoints and opportunities
		Sustaining action	Proactive behavior
			Accomplishment
			Making good behavior habitual
	Problem solving	Finding problems	Information collection
			Understanding the essence of the problem
			Cause pursuit
		Planning a solution	Goal setting
			Scenario creation
			Plan evaluation
			Risk analysis
		Implementing the plan	Action taking
			Modification and adjustment
			Verification and improvement

considered to be positive in response to conflicting situations that can occur in work places and forces the selection of what actions to take in light of the subject's experience.

Table 3 shows the number of Tobitate scholarship students and their destinations each year. The total number, 26, is the second largest nationwide in the Tobitate Scholarship program for high school students. The specific characteristics and growth of the Tobitate scholarship students are clarified by the PROG test.

Table 3 Tobitate Scholarship of NITAC

	Number of students	Destinations
2018	5	Estonia, Garman, Philippines, USA (2)
2017	2	Italy, Indonesia
2016	12	Australia, Belarus, Costa-Rica, Garman, Nepal, New-Zealand, Philippines, Senegal, Spain, Taiwan, USA (2)
2015	7	Australia, Brazil, UK, Sri Lanka (2), Vietnam,

Results and Discussion

There were no obvious differences in competency scores between other NIT colleges and among 2nd, 3rd, and 4th year students in 2016 before introducing Co+work as shown in Figure 1. The numbers of participants from other NIT colleges contributing to the data were 1,539 second year students, 1,243 third year students, and 2,114 of fourth year students. The competency of 3rd year and 4th year students increased, however the competency of the 2nd year students increased only a small amount after a year of lessons in 2017. Again, in 2018, the competency of 2nd year students was low. The change in competency between 1st and 2nd year of the same students could not be compared, as the PROG test was deemed too difficult for 1st year students, hence they did not take it. In a comparison between competencies of 2nd year students in 2017 and 2018, the autonomy and problem-solving skills of students in 2018 were found to be much lower, as shown in Figure 2. One reason for this is considered to be that 2nd year students had difficulty committing to the project because of the large competency differences between the 2nd year students and 3rd and 4th year students who had prior experience with Co+work. However, the same students who became 3rd year students in 2018 had significant increases in competency scores in their second year of the project. By mixing different classes of students, those with seniority generally felt a sense of responsibility for taking on leadership roles. In addition, since it can be thought that the younger students can see their own growth model, this observation was necessary for the effect of the mixed grade-levels to be realized.

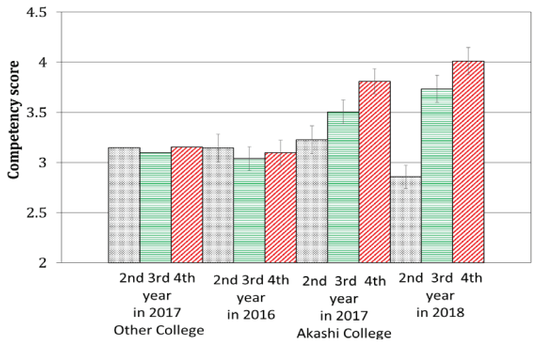

Figure 1 Competency at NITAC and Other College
(Averages shown with standard errors indicated.)

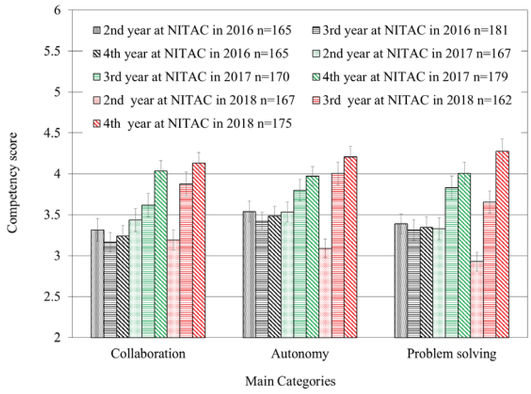

Figure 2 Main Categories Competency NITAC
(Averages shown with standard errors indicated.)

Figure 3 shows student improvement from 2nd year in 2016 to 3rd year in 2017 to 4th year in 2018 to demonstrate how the same student`s competency levels evolved from before to after Co+work implementation. Six specific characteristics have clearly seen growth from 2016 to 2017 and 14 specific characteristics have clearly seen growth from 2017 to 2018. The characteristics "Proactive," "Accomplishment," and "Making good behavior habitual;" however, have not seen an improvement. These competencies are difficult to develop in such a short time, as Co+work is generally limited to 90 contact minutes per week.

Examining the changes from 2nd year in 2016 to 3rd year in 2017 in Figure 3, we can conclude that only nine competencies have improved. Obvious growth is mainly seen in five specific characteristics under "Problem-solving." On the other hand, the changes from 2nd year in 2017 to 3rd year in 2018 in Figure 4, reveal fifteen specific characteristics under "Collaboration and Autonomy" that have improved significantly. The 3rd year students' full year of experience with Co+work is believed to have led to this positive difference.

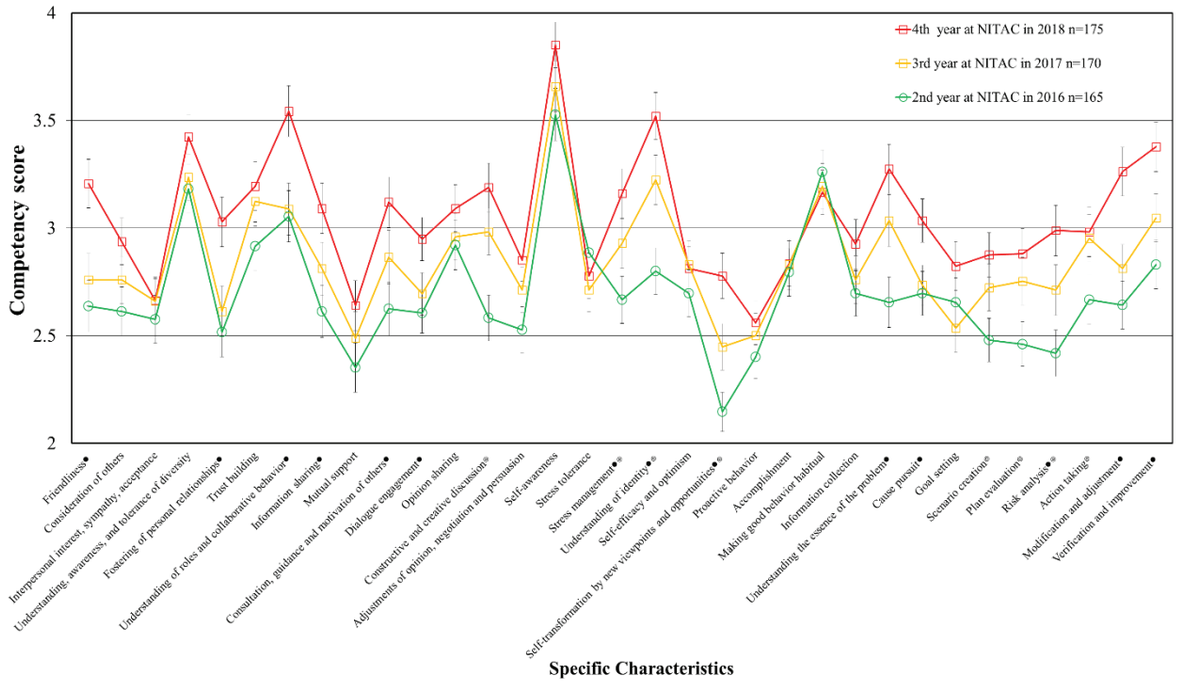

Figure 3 Specific competencies of students from 2nd year in 2016 to 3rd year in 2017 to 4th year in 2018
(Averages shown with standard errors indicated. Specific characteristics marked with "●" showed clear improvements in 3rd year to 4th year, and those marked with "◎" showed clear improvements in 2nd year to 3rd year.)

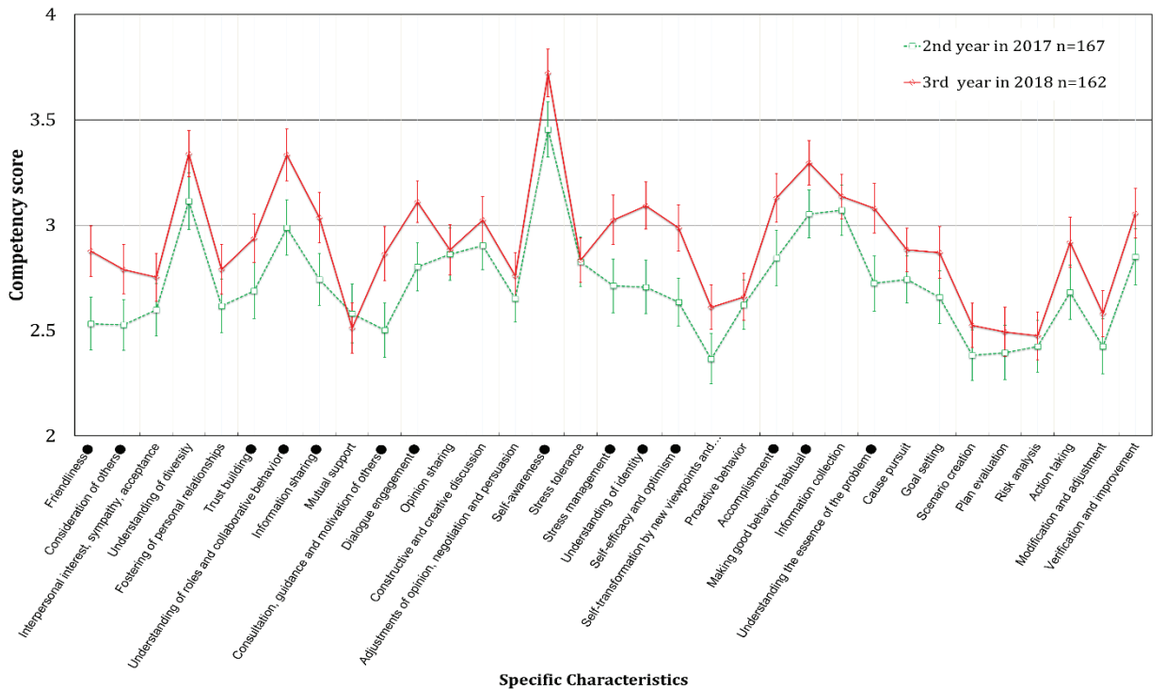

Figure 4 Specific competencies of students from 2nd year in 2017 to 3rd year in 2018
(Averages shown with standard errors indicated. Specific characteristics marked with "●" showed clear improvements)

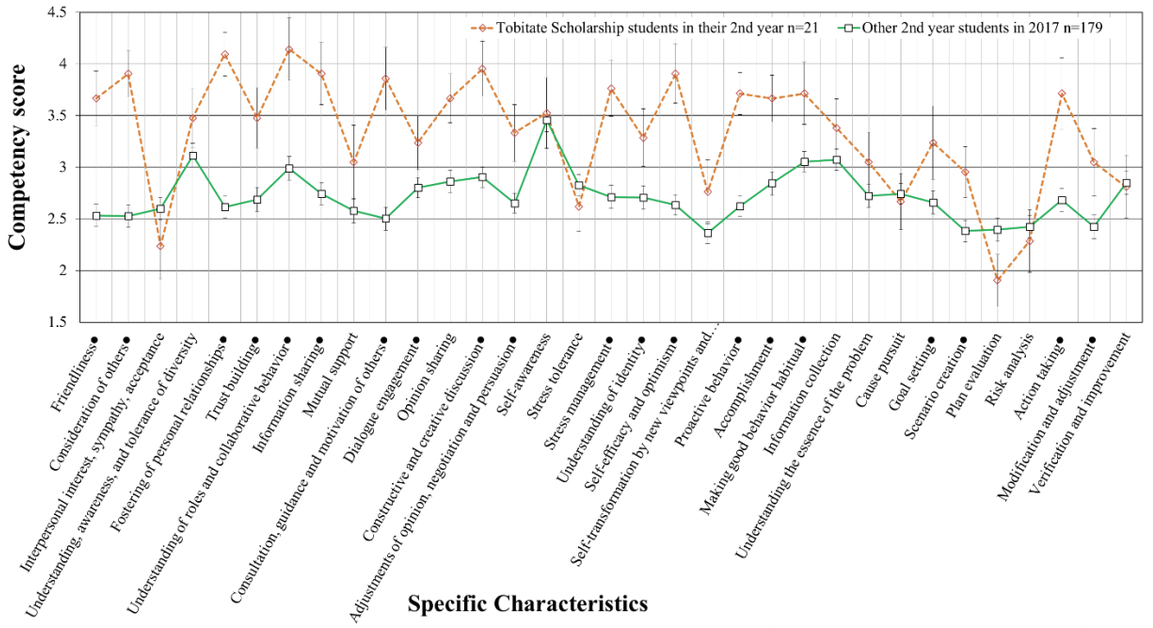

Figure 5 Specific competencies of Tobitate Scholarship students in 2nd year and all students in 2nd year in 2017 (Averages shown with standard errors indicated. Specific characteristics marked with "●" showed clear differences**)**

Figure 5 compares specific characteristics of Tobitate scholarship students to all 2nd year students in 2017. Tobitate scholarship students saw significantly high scores in most of the competency categories, except "stress tolerance," "cause pursuit," "plan evaluation," "risk analysis," and "interpersonal interest, sympathy, and acceptance." It can be said that Tobitate scholarship students are typically those who have comprehensively high competency and are strongly independent but are not deep thinkers.

Figure 6 shows the competency scores from Tobitate scholarship students and other students with respect to each grade. The competency scores of the Tobitate scholarship students are obviously higher than that of the other students. However, the competency scores of the Tobitate scholarship students slightly decreased from 5.2 in the 2nd year to 5.1 in their 3rd year, and the standard error increased as well. Then, their scores shot up again in their fourth year. This shows the tendency for Tobitate scholarship students to slightly lose their confidence during or just after their tough work they have done alone and overseas followed by the realization in the following year that they have learned and grown from the experience.

Looking at subsequent growth from 2nd year to 4th year of the Tobitate Scholarship students in Figure 7, the Tobitate Scholarship students developed "Cause pursuit," "Plan evaluation," and "Risk analysis." However, "Interpersonal interest, sympathy, and acceptance" and "Stress tolerance" were not changed. And, "Making good behavior habitual" was significantly decreased. It was assumed that the students realized their abilities were not enough for the project whilst abroad. They then recognized that effort was necessary, but their daily actions did not demonstrate the level of effort necessary to reach their personal goals.

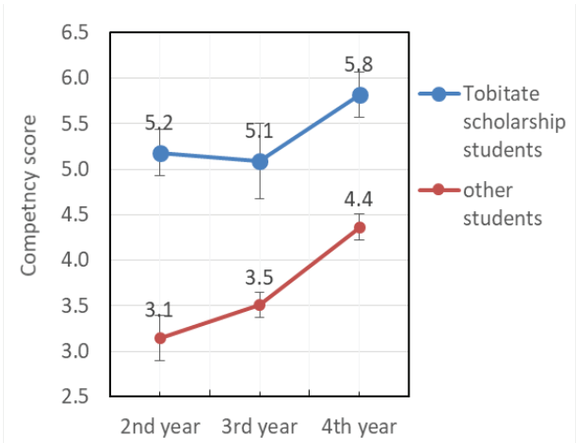

Figure 6 Tobitate Scholarship students and other students

Conclusions and implications

The following conclusions can be made from PROG test results with respect to the continued implementation of Co+work for 2 years and the competencies of Tobitate scholarship students:

1) Competencies were almost the same between other NIT Colleges and NIT, Akashi College before the implimentation of Co+work
2) Competencies of 3rd year and 4th year students obviously grew by the implimentation of Co+work
3) Competency scores of 2nd year students did not grow significantly during the first time they experienced Co+work; however, they did grow in

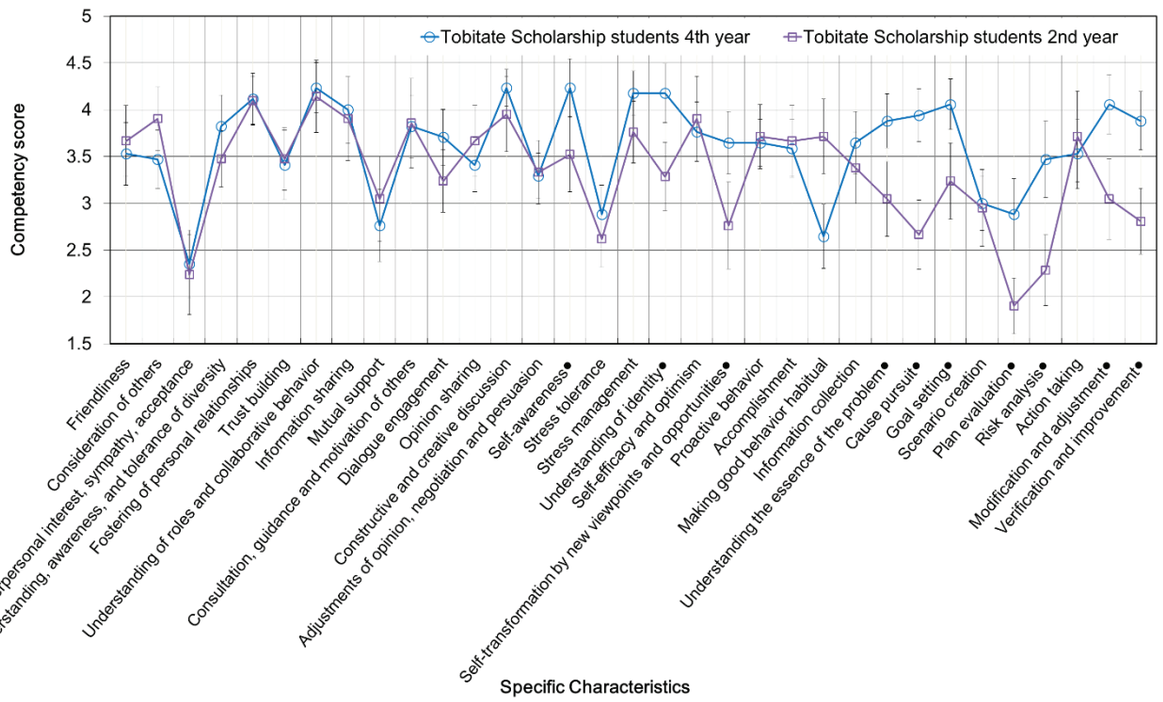

Figure 7 Specific competencies of Tobitate Scholarship students from 2nd year to 4th year
(Averages shown with standard errors indicated. Specific characteristics marked with "●" showed clear improvements)

the next year when, as 3rd year students, they already had a full year of Co+work experience.

4) The chain of seniority within the Co+work project teams affected the results of competency growth.
5) The competencies of Tobitate Scholarship students were higher than other students.
6) One of the subcategories, "Sustaining action," which includes, "Proactive behavior," "Accomplishment," and "Making good behavior habitual" should be the next target for developing our students competencies.

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PROGRAMME SPECIFIC COMMUNITY ENGAGEMENT TO ENHANCE VOCATIONAL EDUCATION – WAY OF SUCCESS

W.W.S. WU[a]; F. P.S. MOK[b]

[a] Department of Applied Science,
Hong Kong Institute of Vocational Education (Kwai Chung), Hong Kong
[b] Department of Applied Science,
Hong Kong Institute of Vocational Education (Chai Wan), Hong Kong

[a] wollo@vtc.edu.hk; [b]florencemok@vtc.eud.hk

Abstract

Vocational education and training are designed to equip students with the professional skills and knowledge of the trade, as well as relevant soft skills to prepare them for a future career. Hong Kong is facing an ageing population, manpower supply for skilled personnel in healthcare and rehabilitation industries are in severe shortage. However, some youngsters are hesitated to engage in these industries even after they have received relevant training. It possibly is because of the stereotypical image of rehabilitation and elderly service industries that youngsters perceive. They often perceive such a career would be of relatively low salary, and they are uncertain about the career advancement prospects. Indeed, some youngsters also perceive a negative image upon elderly and presume them as annoying and clumsy. Hence, the workforce of the rehabilitation and geriatric fields is always in shortage. On the other hand, these youngsters are believed to be a key member in the rehabilitation and healthcare-related industries. They should take up the responsibilities soon.

To facilitate the supply of manpower and improve the quality in these related fields, it is crucial to promote the attitudes and perceptions of the youngsters. Regular programme specific community engagement (Regular-PSCE) could be a solution. PSCE not only promotes youngsters' understanding of target populations but also strengthens their relationships with the served populations. Therefore, it boosts their level of commitment, participation and understanding towards various populations. Of note, such close interactions with different populations during the community engagements should be accompanied by timely feedbacks, coaching and supervision from experienced workers. This assures the youngsters to gain practical experiences and become competent in these fields. In this sense, it strengthens the learning experience of the youngsters as well as to promote professional development through good quality of contact experiences. Most importantly, once they involve in the workforce after graduation, such valuable experiences can reinforce them with considerable quality services for various target populations.

Keywords: *Programme Specific; Community Engagement; Regular; Volunteer; Success; Vocational Training*

Introduction

The ageing population becomes a challenge to Hong Kong that the manpower supply for skilled personnel in healthcare and rehabilitation industries are in severe shortage. However, some youngsters are hesitated to engage in these industries even they have received relevant training. It could be related to the stereotypical image relating to the rehabilitation and elderly service industries that youngsters perceived. They perceive the job nature of such career as not appealing as they would be engaged in dirty tasks and heavy labour when taking care of the elders. They are also uncertain about the career prospects with the relatively low salary offered by the current market. Indeed, some youngsters also perceive a negative image upon elderly and presume them as annoying and clumsy. (Mok, Wu, Poon & Chan, 2015) Therefore, it is critical to arouse the youngsters' interests to continue to engage in the rehabilitation and healthcare-related industries after they have received relevant training to ensure a steady supply of workforce in these fields and to improve the service quality in order to cope with the social demand of the ageing population.

Ageing Population in Hong Kong

The ageing population has evoked considerable attention across the globe and in Hong Kong. Due to the medical advancement, the average life expectancy of men and women in Hong Kong is found to be 81.3 and 87.3 years respectively in 2017, while it is estimated to be 87 for men and 93.1 for women in 2066 (Census and Statistics Department, 2017). It is also projected that the number of elderly aged 65 and above would increase from 17% in 2018 to 33.7% million in 2066 (Census and Statistics Department, 2017). Such demographic

change towards an ageing population would impose an enormous demand on rehabilitation and elderly services in Hong Kong.

Insufficient Manpower Supply in the Rehabilitation and Geriatric Industries

Despite the huge service demand, it is noted that there are 10% – 34% vacancies for professional workers in the elderly care and rehabilitation service sectors. The shortage of manpower situation is most prominent for occupational therapists and physiotherapists in elderly care. (The Hong Kong Council of Social Services, 2014) It has been reported that one of the reasons for the shortage of frontline workers in the elderly care service industry is because youngsters are less willing to enter the field due to the relatively low salary, poor career prospects and other stereotypes of the field (Kwok, Wong & Yang, 2014). In particular, such stereotypes may influence the perceptions, attitudes, and behaviours of youngsters towards older people. (Mok *et al.*, 2015) Although earlier studies have suggested possible ways to reduce prejudice in younger generation by examining the reciprocal relationships between perceptions, attitudes and contacts with the elderly (Knox, Gekoski, & Johnson, 1986; Okoye & Obikeze, 2005), these methods might have different effects when put into local context among Chinese population in Hong Kong.

Phenomena of Secondary School Education in Hong Kong

Nowadays, youngsters and teachers in Hong Kong are facing a lot of stress to cope with the standard curriculum in secondary school. The core curriculum (i.e. Chinese, English, Mathematics, and General Education) and the standard electives often focus on generic skills and theoretical knowledge rather than critical analysis and practical skills in tackling day-to-day issues. Despite the generic nature of the standard curriculum, the academic results the students attained in the Hong Kong Diploma of Secondary Education (HKDSE) remain as the major admission criteria for most of the degree and sub-degree programmes to consider by the tertiary education institutes in Hong Kong. It is therefore common for youngsters in Hong Kong, especially for those senior secondary school students, to attend extra tutorial classes, either being offered by the school and/or private tutors, during non-school hours in order to better prepare for the HKDSE examination. Although youngsters might have opportunities to participate in some extra-curricular activities and/or other learning experience (OLE) activities during their secondary school study to enhance their understanding of elderly (e.g. visit to elderly home), these short-term extra-curricular activities have little linkage to their secondary school curriculum, and oftentimes these activities do not account for their academic result. Therefore, youngsters and perhaps their parents might prefer to put more focus on other academic and merit-related activities.

Vocational Education and Training Programme

Vocational education and training (VET) is designed to equip students with the professional knowledge and skills of a specific trade, as well as relevant soft skills to prepare them for a future career. VET programme differs from the traditional or convention classroom training is that VET has trade specific context as the learning focus. VET equips the students with the specific knowledge and skillsets that are required by the employers and the society. It means that the training context and the assessments of the VET programme have to be industry-specific. In other words, VET programme emphasises what the students can do, not just what they know (Moodie, 2002). The success of the VET programmes relies on the strong interlinkage of different stakeholders and the close collaboration with each other ***(Figure 1)***. For instance, if students are engaged in rehabilitation and geriatric related VET programmes, the students should be equipped with specific knowledge and skills that enable them to fulfil the job requirements in the rehabilitation and geriatric industry upon graduation. To make this successful, not only the VET curriculum needs to embed different theoretical classes (e.g. theory of rehabilitation, common geriatric pathologies) to equip students with the trade-specific knowledge at school. The students also need to undergo solid practical training (e.g. rehabilitation exercise techniques, caring techniques for elderly) and to gain industrial exposure in the rehabilitation and geriatric settings (e.g. hospital or elderly home) to ensure that they process the required skills to work in these settings. Hence, such VET programme bridges the gap for youngsters to transit from school training to become a work-ready employee of the related industries upon graduation as they have been trained with the industry context. In turn, employers from the industries could recruit skilled workers that are well-trained to fit for purpose.

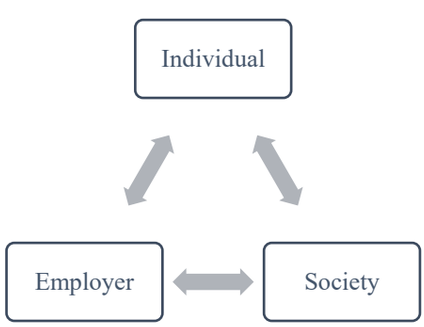

Figure 1. Benefits of VET

Programme Specific Community Engagement for VET

Despite the design of the VET programme curriculum is trade specific and task-oriented, it is important that the education programme also cultivate youngsters' passion for learning such that they value the learning opportunities and actively engage in activities throughout their study. Owing to the stereotypical images that youngsters project on elders, it is particularly important for those VET programmes relating to elderly service industry have to find ways to nurture the students to have positive attitudes and perceptions towards the elders. Programme specific community engagement (PSCE) could be a solution. PSCE means arranging students to engage in specific volunteer services in the community that are related to their VET programme curriculum. Volunteering defines as a person who freely offers to take part in an activity or to provide unpaid help or assistance to others. If rehabilitation and geriatric related VET programme could incorporate relevant volunteer activities for students to engage in the community, this would enhance the student's hands-on exposure and understanding on the various needs of the elders in reality. In fact, a recent study by Mok *et al.* found that PSCE was effective to nurture youngsters' positive attitude towards the VET programme and related industry. (Mok *et al.,* 2015) Mok *et al.* compared the final year students who studied in a 2-Year Higher Diploma in Rehabilitation Services programme at a local tertiary institute, who had engaged in PSCE with frequent associations with elderly (PSCE group) in regular basis to those who did not (non-PSCE group), found that students from PSCE group had significantly better perceptions towards the elderly than those from non-PSCE group. PSCE group had a more favourable attitude towards the elderly and paid more attention to the physical and psychosocial needs of the elderly. More importantly, the PSCE group also had a greater appreciation for their pursued education and the rehabilitation field, and they were more assertive in entering the rehabilitation field after graduation. (Mok *et al*., 2015)

The essential elements that contribute to the success of PSCE in enriching the VET programme stem from letting the students volunteer to seize different opportunities to gain relevant contact experiences from the industry, such that students could apply what they have learnt in a real work setting under the supervision of VET programme teachers. Apart from applying their vocational skills, students also have the opportunities to interact with clients and co-workers to train up their soft skills as well as interpersonal skills. Such experiences to interact with real clients would be more relevant than having the students to be trained in a confined or simulated environment with standard scenarios. It is particularly important for those VET programmes that are targeting the health services industry. For example, students who studied in Higher Diploma in Rehabilitation Services are to engage in the PSCE programme which targets to pay home visits to the elderly. Upon arrival to the elderly client's home, it is noted that the client is living alone in a non-lift landing flat on the third floor, and he is also dependent on meals-on-wheel support service for his everyday meals. Moreover, the client also complains that he is suffering from multiple medical conditions of stroke with left hemiplegia, and right knee pain. In this case, students not only need to analyse the client's physical and mental conditions critically, but also need to assess the elder's home environment in order to propose appropriate measures to fit for the client's needs. Students also have to adjust their plan according to the client's instant feedback. Notably, in comparing the value of PSCE over those ordinary volunteer activities to visit the elderly's home that are arranged by non-VET programme related organisations, another crucial element that contributes to the success of PSCE is the quality of supervision provided by the VET programme teachers. In the example above, the VET programme teachers could provide quality supervision on the spot. They could relate the client's multiple medical conditions to what has been taught in the VET programme (e.g. to coach the students in assessing if the client's right knee pain could be related to the overuse in stairs climbing to his non-lift landing flat; or could it be related to the compensating movement resulting from his left hemiplegia). VET programme teacher could provide the programme specific and timely feedback to coach their students on how to apply their knowledge and skills practically at the client's home. Such hands-on practical experience under quality supervision would consolidate students' knowledge and practical skills far more effective than other forms of training at school or in a simulated environment. Apart from these advantages, a study by Mok *et al*. also found that students who participated in the PSCE reflected that their confidence increased through the process. They also had a better understanding of the elderly populations as well as strengthened their relationships with their grandparents. (Mok *et al.*, 2015)

Conclusion

VET serves to equip trainees with trade-specific knowledge and skills to prepare them to enter the relevant industry. It helps to alleviate the manpower shortage of different industries. Implementation of PSCE in VET programme could bring many positive changes to youngsters' attitude and perceptions towards their chosen education and future career. This is particularly important for VET programmes that targeting the elderly, rehabilitation and health services sectors in order to cope with the ever-increasing manpower demand owing to the ageing society.

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THE EFFECT OF CHEMISTRY CARD GAME ON STUDENTS' LEARNING MOTIVATION AND ACADEMIC ACHIEVEMENT

Y.N. Ng*, C.W. Phoon and R.S. Liew

School of Chemical & Life Sciences, Nanyang Polytechnic, Singapore

*annie_ng@nyp.edu.sg

Abstract

A chemistry card game was designed to encourage students of different learning abilities to communicate, cooperate and collaborate in the classroom. Through this project, we hope to address the question on whether the card game is effective in enhancing students' learning motivation and academic achievement. All the four classes of students (*N*=86) from Chemical Technology program participated in this study. During the tutorial lesson, class 1 and class 2 completed the pen-and-paper worksheet, followed by playing the game. Class 3 and class 4 played the game before doing the worksheet. Pre- and post-tests, as well as a set of questionnaire were administered to capture students' learning experience on the game and worksheet. It was found that students improved their test score by 41% and 45% when they only did tutorial using pen-and-paper worksheet and game respectively. However, the combination of worksheet and game significantly improved the test score by an average of 74%. This indicates that although the worksheet and game are effective to improve students' academic result by their own, it would be best if both approaches were used together to further improve the students' learning. Based on the survey results, all students believed that both the worksheet and game helped them learn the topic better. However, only 68% of them enjoyed doing the worksheet. 29% of them even felt that it was a boring activity. On the other hand, all the students (100%) perceived that the card game was an interesting way to learn, and they enjoyed playing the game as they could interact and bond with their classmates. In conclusion, the Chemistry card game provides an affective learning environment for students to learn. This research outcome is encouraging for educators in the institutes of higher learning (IHLs) to design and adopt the in-class educational group games more frequently and enthusiastically. The components of excitement and entertainment while playing the game in a group appeal the new millennial learners. This study helps to garner more support from schools' management and parents on the implementation of the in-class educational group games to increase students' motivation and academic achievement.

Keywords: *Education Research, Educational Group Games, Learning Motivation, Chemistry, First-Year Students*

Introduction

Traditional learning method where students learn through listening and interpreting the content delivered by the teacher passively is still prevalent in many higher education institutes as it is a convenient way to teach and introduce the basic concepts (Van Eynde & Spencer, 1988; Smith & Valentine, 2012). However, students are not engaged in the passive-learning classroom. Although several active learning activities such as team-based learning, problem-based learning, small group discussion and presentation had been attempted, they are only able to engage a small group of students who are vocal and highly intellectual. Majority of the students find the activities boring, challenging and daunting. Hence, there is a need to make the lessons more lively and less pressurized, yet can still achieve the students' learning outcome and enhance their academic achievement.

Educational group game (EGG) may provide a good solution. In fact, psychologists have long acknowledged the importance of play in physical, social, emotional and cognitive development and learning. Piaget (1962) described that play is a way for children to unify experiences, knowledge and understanding. Vygotsky (1967) proposed that when a learner is playing with an adult or a more capable peer, he or she is likely to succeed at things that are beyond his or her current ability. Bruner *et al.* (1976) found that play reduces stress, and believed that it enables children to focus and established their own learning experience goals, thus enhancing learning attainment.

Although majority of Singapore school teachers believe that games can lead to better student learning outcomes, they rarely incorporated games in teaching. The main obstacles include not only the time and effort spent in the game development and game delivery, but also the school support and parents' reactions towards the game-based learning (Koh *et al*., 2012). Therefore, the aims of this research are: (1) to design an educational group game that has fun, motivating and cognitive elements, to encourage students of different learning abilities to communicate, cooperate or collaborate when they play the game; (2) to find out whether the game can help enhance students' learning motivation and academic

achievement. Successful implementation of that in-class educational group game in the local context may change the school and parents' perception of game-based learning, and inspires more teachers to adopt and use games more frequently in the classrooms.

Materials and Methods

Card Design & Game Activity

The game cards were designed to be played in groups of 4-5 students. Each group was given one set of 40 cards. Each card includes four information of an organic molecule, which are the total number of carbons, structure, name, and the functional group that the chemical molecule has. However, every card has its own missing information (Figure 1). Students have to work together to furnish the card details during the tutorial lesson. After that, they used the cards to play game.

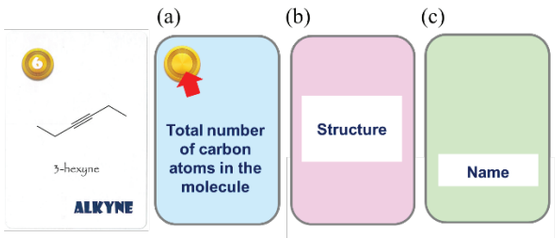

Figure 1. An example of a game card which has a missing information of: (a) the total number of carbons in the molecule, (b) structure, (c) name of the molecule.

The 40 different cards were also classified into four suits based on the functional groups and priority system in the chemistry nomenclature (Figure 2). This is similar to the poker cards, which also have four suits, namely diamond, club, heart and spade. However, in this chemistry game set, each suit only consists of 10 cards, with molecules consisting of total carbon number that ranges from 3-12.



Functional Group	Total Carbon No.	IUPAC Name
Alkyl Halide, Ether	3	methoxyethane
	4	2-methoxypropane
	5	2-ethoxypropane
	6	2-iodo-2-methylpentane
	7	1-fluoroheptane
	8	2-ethoxyhexane
	9	6-bromo-3-chloro-2-fluoro-3,4-dimethylheptane
	10	5-bromo-2-iodo-4,5-dimethyloctane
	11	2-bromo-1-chloro-3-ethyl-2,3,5-trimethylhexane
	12	3-ethyl-1,1,1-trifluoro-2,2,5,5-tetramethylhexane

Figure 2. (Left) Four suits of chemistry cards based on functional group and nomenclature priority. (Right) The "diamond" suit that consists of 10 cards with different number of carbon atoms in the molecules.

The game mechanic is similar to that of the *Big-Two* game, which is popular and already known to most of the students. Starting player is the one that holds smallest ranking card. One card is played at one time. The next player can either play out the higher-ranking card or say "pass". If a player plays out a card, and all other players say "pass", then the player can restart the round by playing out a card that is at low rank. The game ends when a player runs out of cards. It was suggested that a successful educational group game should have a simple game mechanic that merges the game and pedagogical elements to create a fun and engaging learning experience (Triboni & Weber, 2018). Indeed, adopting an existing and famous game mechanic had cut down the time used to explain the game. Students could easily pick-up and play the game in the shortest time.

Research Design

All first year students (N=86) from Chemical Technology program had given consent and participated in this study. Quasi-experiment was employed as there are four pre-existing tutorial classes. Figure 3 provides an overview of the research design.

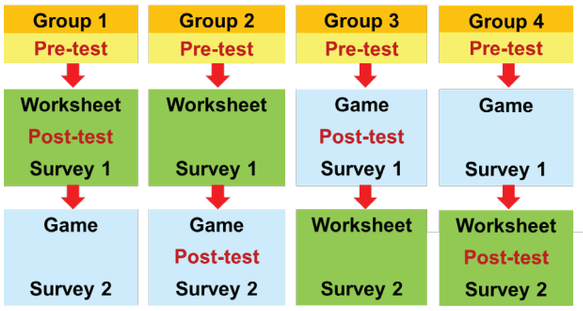

Figure 3. The research design to study the effectiveness of the card game.

During the two-hour tutorial lesson, all students did the pre-test, went through the traditional pen-and-paper worksheet, played the game activity, attempted the post-test and completed questionnaires. This was to ensure fairness across the four groups so that no student would be on disadvantage in terms of missing out the content of the lesson. However, the sequence of the content delivery was different. Through this research design, we can understand: (1) from group 1 data - the effectiveness of pen-and-paper worksheet, (2) from group 3 data - the effectiveness of the game, and (3) from groups 2 and 4 data - whether the combination of the two activities can better enhance students' academic achievement.

In addition, surveys were conducted at the end of each activity to understand student perceptions on both the worksheet and game. The questionnaires were adapted from a validated instrument, known as the Intrinsic Motivational Inventory (IMI). It is a multi-dimensional measurement device created by Ryan and Deci (2000) to assess the participants' subjective experience related to a target activity.

Results and Discussion

Students' academic achievement was measured by comparing the pre- and post-test scores. Table 1 shows the mean scores and standard deviations (SD) of the test results for all the four groups of students. The pre-test scores are in the marginal range from 4.4 marks to 6.4 marks (average = 5.4 marks, grade D), implying that students' prior knowledge after the mass lecture and before the tutorial is just in grudging acceptance. The

post-test scores range from 6.9 marks to 9.3 marks (average = 8.4 marks, grade A), showing that the activity(ies) has/have enhanced the students' understanding of the lecture topic.

Table 1. The mean scores and standard deviations (SD) of the test results in the four groups of students. The base mark of the tests is 10 marks.

		Grp 1	Grp 2	Grp 3	Grp 4
Pre-test	Mean:	4.9	4.4	5.8	6.4
	SD:	1.8	1.3	2.1	1.7
Post-test	Mean:	6.9	8.9	8.4	9.3
	SD:	1.8	1.5	1.8	1.2

Figure 4 shows the test score results in chart form. Students' test scores improved by 2.0 marks (41%) and 2.6 marks (45%) when they do worksheet and game respectively. This implies that the game activity is as effective as the pen-and-paper worksheet in improving students' learning. The combination of worksheet and game is even better. As reflected in groups 2 and 4 data, the post-test mean scores were pulled up to about 9 out of 10 marks. This result echoes with the finding by two meta-analyses of the effectiveness of educational computer games done by Sitzman (2011) and Wouters *et al*. (2013). Both of the meta-analyses concluded that educational game is more effective when they are supplemented with other instructional method(s) rather than when it is used alone.

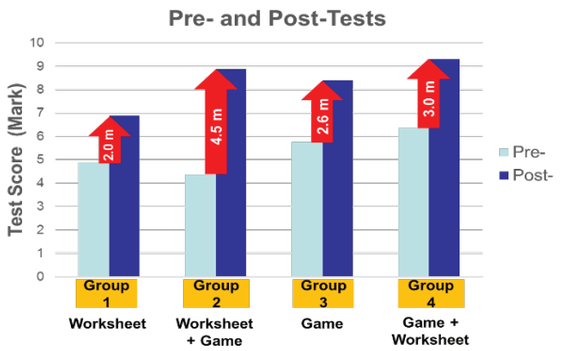

Figure 4. The pre- and post-test mean scores for all four groups of students in the chart form.

Next, students' motivations and attributes towards the worksheet and game were measured and the scores were summarized in table 2. It was found that there was a significant increment in students' interest towards the game (M=23.86, SD=2.97) than the worksheet (M=20.10, SD=4.07). Detailed analysis shows that only 68% of the students enjoyed doing the worksheet. 29% of them even felt that it was a boring activity. On the other hand, all the students (100%) perceived that the card game was an interesting way to learn. Indeed, it was observed that the classroom mood from groups 1 and 2 changed drastically from apathy to excitement when they completed the tutorial worksheet and began doing the game activity. All the four classes became lively and there were a lot more laughter during the game session. Students actively participated by talking enthusiastically about the chemistry cards that they were holding.

Table 2. The mean scores and standard deviations (SD) of students' motivations and attributes towards the worksheet and game activities.
$^{\Delta}$ The base mark of the interest variable is 28. The rest of the motivation and attribute variables have a base mark of 20.
* Variable that shows significant difference between worksheet and game based on the independent sample T-test with $p < 0.01$.

	Worksheet		Game	
	Mean	**SD**	**Mean**	**SD**
Motivation				
Interest$^{\Delta}$*	20.10	4.07	23.86 ▲	2.97
Direct Performance*	13.33	2.23	12.32 ▼	2.19
Indirect Performance	13.48	2.93	12.55	2.76
Attributes				
Value	15.60	2.21	16.02	2.56
Perceived Choice*	13.83	3.25	15.53 ▲	2.62
Perceived Competency	14.04	2.07	14.29	2.26
Effort	13.24	1.88	12.57	2.04
Pressure	9.63	2.57	9.00	2.43
Relatedness	-	-	16.42	2.39

In addition, there was a significant reduction in the direct performance-salient incentive towards the game. This means that students did not think that the game could help them improve in their grade. However, the pre- and post-test has shown that the game is effective in improving the students' grade by 45%. This shows that the game has enabled students to master the skill and knowledge subconsciously, and without realising it as an actual learning process. Such outcome is desirable and especially pleasant to educators as game can potentially help to overcome the students' trepidation of learning difficult topics.

There was an insignificant drop in the indirect performance-salient incentive towards the game as compared to that of worksheet (p=0.035). Further analysis has shown that students wanted to do the worksheet and play the game well intrinsically and not because they wanted to gain recognition by teacher or among the peers. It was also noted that during the game activity, academically good students were teaching the weak ones voluntarily, and the weak students became more engaged to furnish the card details to play the game. As such, the card game has indeed encouraged students of different learning abilities to communicate, cooperate or collaborate. It is good to have these soft skills to be cultivated during the lessons as they are essential for students' holistic development and have great impact on their future job performance (Zhang & Venkatesh, 2013).

There was no significant difference in most of the students' attributes towards the two activities (worksheet

and game). Generally, students felt that both doing the worksheet and playing the game have helped them better understand the lecture topic (Value Attribute). They believed that they were quite competent when doing the activities, and were satisfied with their performance (Perceived Competent Attribute). They did not put in much effort in completing the activities (Effort Attribute), and did not feel tense/pressured/anxious when doing the activities (Pressure Attribute). However, there was a significant increment in the attribute on perceived choice towards the game. Students did not feel like they were forced to play the game. This implies that game provides a more preferable learning mode for students, as compared to that of the pen-and-paper worksheet.

Next is the attribute on relatedness, which assesses students' perception of personal connection with their peers when doing the activity. No data was collected for the worksheet as majority of the students did the worksheet individually, although they were encouraged to discuss the tutorial worksheet among themselves. On the other hand, there was a positive response that students felt connected and close with their group-mates when they furnished the game cards and played the game together (M=16.42 with the base mark of 20, SD=2.39). This result was further supported by the open-ended questions in the survey form. Many students have given the feedback that they enjoyed the game activity as it helped them to train their thinking, improved the communication skill and promoted teamwork.

Conclusions

A simple and low-cost Chemistry card game was developed and tested in four classes of first year diploma students from Chemical Technology program. Study shows that the game provides an affective learning environment for students to learn in a playful and interactive way. The components of excitement and entertainment while playing the game appeal the new millennial learners. The effectiveness of the game as a complementary mechanism to maximize students' learning was also demonstrated in this study. Such result is encouraging for educators in the institutes of higher learning to design and adopt in-class educational group games more frequently and enthusiastically. In addition, the findings also provide concrete evidence to show to the school management and parents that in-class educational group game does motivate students to learn and improve the their academic result. Hence, more support can be sought and more resources may be allocated to develop more interesting in-class educational group games in the future.

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THE DEVELOPMENT OF 21ST CENTURY COMPETENCES BASED ON THE IMPLEMENTATION OF ACTIVE LEARNING IN THE TEACHING OF EXPERIMENTAL SCIENCES

J.A. Sanchez-Marquez*, [a], A. Hudnall*, [b]

[a] University of Guanajuato, Salamanca High School, Salamanca, City, Mexico
[b] Streetsboro High School, Streetsboro City, Ohio, United States
*,[a]ja.sanchez@ugto.mx , samj02@hotmail.com , *,[b]ahudnall@kent.edu

Abstract

In the modern society, students must acquire skills that are very different from the skills required 20 years ago. Nowadays, students should show skills that can be classified in three groups: foundational literates (scientific, technological, financial, cultural and civic literacy), competencies (critical thinking, problem-solving, creativity, collaboration and communication) and character qualities (curiosity, initiative, adaptability, leadership, cultural and social awareness). It is necessary that the role of teachers be oriented to the design of processes that promote the construction of knowledge to develop the 21st century skills. These skills should be an integral part of lesson planning and assessment in the teaching-learning process. In this sense, teachers need to combine didactic strategies and technological tools to achieve the development of 21st century skills. In this project, we studied the combination the didactic strategies such as Problem based Learning (PBL)-active learning with technological tools (applets and simulators). The objective of the project was associated with the design, analysis and construction of a spaghetti bridge (open ended issue). The type of knowledge expected was conceptual, procedural and application. It is important to point that through the development of projects, students developed skills associated with access information, evaluate sources, align solution with task, cite all sources accurately, assume shared responsibility, apply strategies, take a variety of roles, tolerate different viewpoints, listen actively, express ideas, learn from mistakes, know personal creative process, draw conclusions, reflect on learning, ask clarifying questions and maintain positive values. The use of free tools such as simulators and tools that support the collaborative activities and feedback process (Google Docs) represents a great opportunity to incorporate the development of 21st century skills in our classroom. It is for this reason that we must promote the integration and intensive use of these tools.

Keywords:
Active-learning, Problem based learning, Learning-tools, Learning-Environment, Teaching-strategies

Introduction

The development of the skills necessary for life in the Knowledge Society has become a priority for the educational systems of the world. The learning expectations, during this century, are associated with competences such as: creativity, innovation, critical thinking, communication, collaboration, digital and information literacy and social and personal responsibility [1]. These skills and competences are usually called 21st century skills and competencies in order to indicate that they are more related to the needs of emerging models of economic and social development than those of the last century at the service of the industrial mode of production. In this regard, the member countries of the *Organization for Economic Cooperation and Development* have developed joint efforts and projects to achieve these competencies. The general objectives of these projects are, on the one hand, to conceptualize and analyse from a comparative perspective the effects of new digital technologies on the cognitive development of young people as well as on their values, lifestyles and educational expectations and, on the other hand, examine the responses to the emergence of this phenomenon in terms of educational policy and practice.

For many young people, schools are the only place where skills are developed. Therefore, governments should work to identify and correctly conceptualize the set of skills and competencies required according to the educational standards that each student must be able to achieve by the end of compulsory education. For this, educational authorities should be aware that in order to be successful in this process, a double effort must be made: encourage the participation of economic and social institutions from private companies to higher education institutions. However, this whole process runs the risk of being irrelevant to schools unless this set of skills and abilities becomes the frame of reference for teachers and educational institutions [2].

Active learning is one of the teaching-learning methods that has increased its popularity in educational institutions in recent years. The path that the conventional learning process takes is invested in working under the foundations of active learning. While traditionally the information is first exposed and then its application is sought in the resolution of a problem, in the

case of active learning: first the problem is presented, then the learning needs are identified, and the necessary information is sought and finally it is returned to the problem. In the journey that the students live from the original approach of the problem to its solution, they work collaboratively in small groups, sharing in that learning experience the possibility of practicing and developing skills, of observing and reflecting on attitudes and values that in the conventional expository method could hardly be put into action. The experience of work in the small group oriented to the solution of the problem is one of the distinguishing characteristics of active learning. In these group activities the students take responsibilities and actions that are basic in their formative process. Active learning is a method that is feasible to be used by teachers in most disciplines, as a form of work that can be used in a part of their course, combined with other teaching techniques and defining learning objectives that you want to cover.

In this project we propose the integration of didactic and technological tools that allow the development of useful skills for life in our students. In order to achieve this objective, it is necessary that the role of the teacher is oriented to the design of processes that promote the construction of knowledge and the development of these skills in a joint manner.

Materials and Methods or pedagogy

The modern world demands that young people be able to collaborate, plan, think critically, make decisions, solve problems, be creative, show social responsibility and be able to handle technological tools that are not normally included in the curricula of educational institutions. In addition, students must be able to work in diverse groups in such a way that they can succeed in a globalized world and in a digital economy. To develop these skills, it is necessary that the role of the teacher is oriented to the design of processes that promote the construction of knowledge and the development of these skills together. To fulfil this objective, the combination of technological tools with strategies and didactic models is proposed. For the correct integration of these tools it is necessary that before working with the students in the sessions in the classroom, we design problems that allow covering the contents and competences of the subject. Also, it is essential that the work rules and roles of each class member be established in advance and must be shared and approved in advance by the entire group. During the planning of our subject it is important that we identify the most suitable moments to apply the problems, calculating the necessary time that the students must invest in the search of the solution to the problem.

It is important to remember that active learning is based on different theoretical currents on human learning, within which the constructivist theory has a particular presence. According to this position, the active learning is based on three basic principles:

• The understanding of a real situation arises from the interactions with the environment.

• Cognitive conflict when facing each new situation stimulates learning.

• Knowledge is developed through the recognition and acceptance of social processes and the evaluation of different individual interpretations of the same phenomenon.

Active learning includes the development of critical thinking in the same teaching - learning process, does not incorporate it as something additional, but is part of the same process of interaction to learn. We must remember that active learning seeks that the student understands and deepens adequately in the response to problems by addressing aspects of philosophical, sociological, psychological, historical, practical, etc. The structure and process of solving the problem are always open, which motivates conscious learning and systematic group work in a collaborative learning experience. In active learning students work collaboratively in teams while the teacher promotes the discussion in the working session with the group. The teacher does not become the authority of the course, but rather acts as a facilitator of the search for information. It is important to note that the objective is not focused on solving the problem. In this methodology, the problem serves as a trigger for students to cover the learning objectives of the course. Throughout the group work process, students should acquire responsibility and confidence in the work done in the group, developing the ability to give and receive criticism aimed at improving their performance and the group work process. Within the experience of active learning, students integrate their own methodology for the acquisition of knowledge and learn about their own learning process. Knowledge is introduced directly in relation to the problem and not in an isolated or fragmented way. In active learning, students can observe their progress in the development of knowledge and skills, becoming aware of their own development [3].

Once we have prepared the sessions, the next step is to lead to develop the activities in the classroom. The work session with the students involves the following sequence of steps:

Step 1. Presentation of the problem

In this stage the problem is presented in digital or printed form. At this stage it is appropriate to provide written questions to students related to the problem.

Step 2. Identify learning needs

Through collaborative work, each group will identify key points of the problem and learning needs that will lead the group to solve the problem. At this stage, hypotheses are formulated, and the recognition of the information required to verify the hypotheses is produced. It is necessary that students generate a list of topics to be studied in a group. In this stage, technological tools such as simulators, Google tools or digital search engines that allow students to solve previously identified learning needs can be integrated.

Step 3. Information learning

During this stage it is appropriate for the teacher to evaluate the progress at regular time intervals. If necessary, the teacher can interrupt the work to correct misunderstood concepts or to bring the teams to the same rhythm.

Step 4. Solution of the Problem and identification of new problems.

At this stage the teacher must connect the topics studied with the learning objectives in front of the group. Also, it is important that the professor allocate some time at the end of the session so that the whole group can present, analyze and discuss the designed solutions in order to find points of agreement or define new future problems. All stages of solving the problem are recorded in a shared document of Googletools that allows the teacher to constantly assess the process of knowledge construction and, above all, makes it possible for the teacher to make continuous feedback of the work done by the team. The support through digital tools facilitates the monitoring of the search process of solutions allowing the solution times of the problem to be covered by all the equipment.

After carrying out the activities in the classroom it is necessary that students establish their own learning plans. These plans can be focused on identifying the topics to be studied, clearly identifying the learning objectives to be covered and establishing a list of tasks for the next session. Also, students can identify functions and tasks clearly indicating their support needs in areas where they consider teacher participation important. The information required to understand the problem opens thematic of study to students, they can work independently or in small groups identifying and using all available resources for the study of these issues, it is obviously important that they share the knowledge acquired with the rest of the group.

Results and Discussion

For the incorporation of this methodology it is necessary to divide the activities designed into three stages: Before-Class Activities, During-Class Activities and After-Class Activities.

a) Before-Class Activities.

These activities should be focused on encouraging the student to acquire, review or verify the previous knowledge he has regarding the problem or case study. Basically, the activities designed at this stage should represent a first exposure to the topic under study. It is important to emphasize the relevance and the purpose of the subject and to propose the applications of the acquired knowledge. The taxonomic levels developed in this stage are essentially the first two: Remember and Understand.

b) During-Class Activities.

During the analysis of the case study it is necessary to guarantee a learning environment that encourages an increase in the motivation to learn and a deep learning of the subject under study. In addition, the role of the teacher during this stage should be focused on providing support, both individualized and collective to the students. Finally, during this stage it is important for the teacher to guide the research of the case study by encouraging a constructive discussion of the topic. The taxonomic levels at this stage are associated with Application, Analysis and Evaluation.

c) After-Class Activities.

The activities designed at this stage should be focused on building and reinforcing self-confidence, online discussion, challenging questions or projects derived from the study and case analysis. The taxonomic levels at this stage are Evaluate and Create (Figure 1).

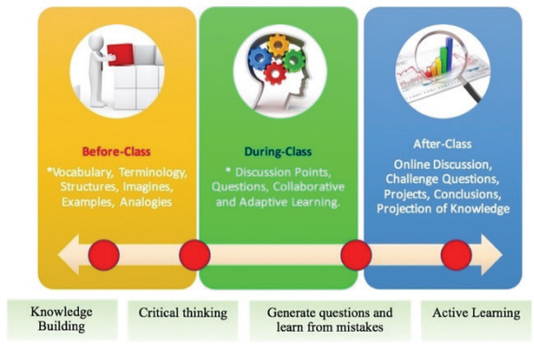

Figure 1. Learning Environment.

During this project different simulations were developed using a simulator of internal forces and mechanical efforts. This simulator is based on a 2D environment where it is possible to design mechanical structures that allow us to generate, test and analyze different designs. Throughout the development of this project, students had to cover different stages of solving the problem which are defined below:

Stage 1. Outcomes & Assignment

The goal of this project was related with the design and construction of a spaghetti Bridge. The kinds of knowledge associated with this activity were conceptual, procedural and application. During this stage, students had to make their own design using their creativity. The scenario proposed for this stage implied that a company has hired the services of your consulting firm to design and build a bridge as part of the infrastructure works of a new industrial zone. The model of the bridge must be constructed using only spaghetti and glue. In this way the problem arises was of the type *Open-Ended Issue.*

Stages 2. Norms for Collaborative Learning

Before the realization of the project the group defined the norms for collaboration. These norms included the following aspects:

a) Assume shared responsibility.
b) Respect different viewpoints.
c) Take a variety of roles.
d) Recognize know personal creative process.
e) Maintain positive values
f) Embrace diversity and respect everyone.

Stage 3. Research

This stage implies the access, organization and assessment of information. Besides, during this stage the students developed the following activities about the project:

a) Model of the Bridge, Figure 2.

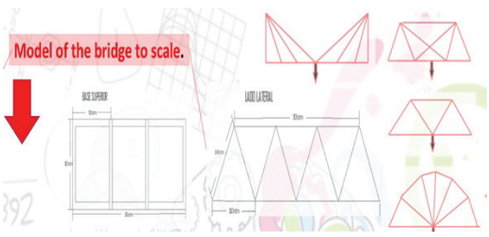

Figure 2. Design developed using the simulator.

b) Determination of the load applied on the bridge and determination of the distributed areas, Figure 3.

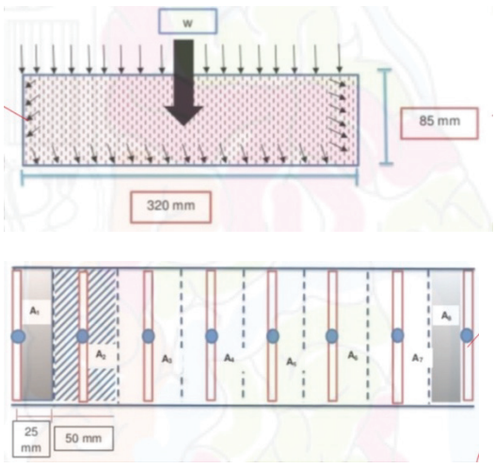

Figure 3. Analysis fs the mechanical structure.

c) Calculation of the distributed loads in the supports and determination of the internal forces applied in each element of the armor, Figure 4.

d) Determination of the elements with the lowest load and the greatest load support, Figure 5.

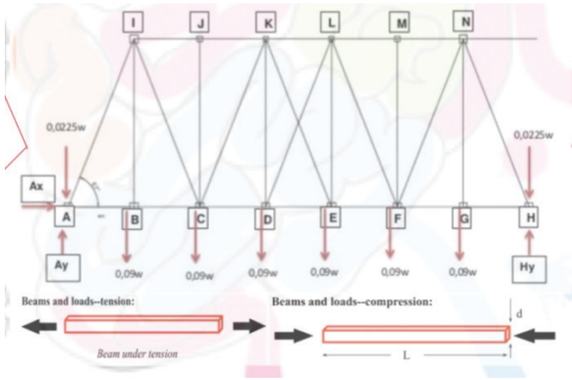

Figure 4. Calculation of external and internal forces.

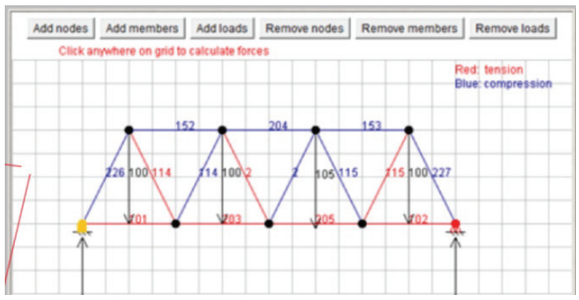

Figure 5. Calculation of the lowest and the greatest load.

e) Analysis of the forces in the armor and experiments, Figure 6.

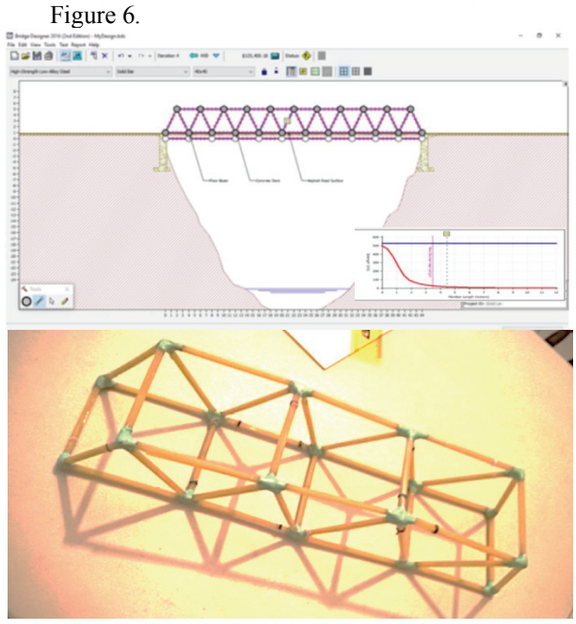

Figure 6. Analysis of the forces in the armor.

Stage 4. Presentation

At the end of the project the students were able to:

a) Express ideas and use multiple forms of media.
b) Evaluate evidence, justify arguments and draw conclusions.

Stage 5. Assessment

The student learned to evaluate their own work from their mistakes in order to improve the results in the future.

Conclusions

The development of this project allows to improve the performance of students in the area of natural sciences, specifically in the study of physics and mechanics. Once the methodology was introduced into learning activities, students began to improve their skills associated with critical thinking, thereby improving their ability to solve problems. Problem solving skills are one of the basic skills that students must have throughout their lives, they should be used frequently when they leave school. A better performance in the problem-solving process will indirectly impact other areas of knowledge because in solving problems, students have the possibility to think carefully and critically, to test, investigate, argue, recognize their own creative processes and value and appreciate the diversity of opinions and ways of thinking. In addition, this project made it possible to investigate in detail the mechanism through which answers to "why" or "how" questions are posed.

It is important to point that the combination of technological and didactic tools allows students to develop skills to access, organize and use information, assume shared responsibility, maintain an open mind and tolerant to different points of view, work efficiently as a team, listen actively, recognize their own processes creative, generate ideas, evaluate evidence, justify their arguments, establish conclusions, show respect among them and appreciate the richness of diversity. The development of these skills increases the motivation to learn in students and contributes to the achievement of meaningful and useful learning for life.

Finally, it is important to emphasize that through active learning students assume the responsibility of their learning, work efficiently in groups, share roles and stimulate learning skills and self-directed study; which improves their ability to obtain, analyze and organize information independently. In addition, through solving real problems, students increase their levels of understanding, allowing them to use their knowledge and skills to face any obstacle throughout their life.

Acknowledgements

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EFFECT OF PREPARATION WORK FOR MANUFACTURING PROJECT ON INTERNATIONAL EXCHANGE ACTIVITIES

T. Kato*,a and Y. Shimada a

a Dept. of Control and Information Systems Engineering, National Institute of Technology, Kumamoto College, Japan

* t.kato@kumamoto-nct.ac.jp

Abstract

Development of global human resources is important mission for National Institute of Technology, because a lot of engineers are working not only domestically but overseas. Although our college holds international exchange activities, there are the room to develop new exchange activities for younger students. This paper describes a new activity for our Year-2 students. When the target students are not used to exchange activities, organizer should be careful to prepare topics for the students. Therefore, common topics are provided by some cooperative works that included in the exchange activity. Especially, technical English communication is not easy for younger students, because they study technical English words not so much yet. Since the presentation about the mechanism of every project is given by students instead of teachers, the students have to prepare the English slides and also make the prototype before the presentation. The preparation gives students opportunity to study technical English words and to practice English presentation. The manufacturing project includes four themes such as "Electric music box", "Electric guitar", "LED electric bulletin board", and "Small claw crane". The questionnaire result about international exchange activities shows 51% students feel "Very fun" or "Slightly fun" before the activity. On the other hand, 90% students chose the above feeling after the activity, and the breakdown of the percentage was 44% of "Very fun" and 46% of "Slightly fun". Since the 72% of students that worked on the preparation were included in the number of percentage which answered "Very fun", the preparation work contributed to improve the satisfaction of the students that participated in the international exchange activity. Furthermore, 70% students were interested in electric manufacturing before the manufacturing project, but more than 90% students were interested in them after the project. This result shows that interest in engineering improves by not only passive lessons but also active teaching for other people.

Keywords: *International exchange activity, Manufacturing project, Preparation work, Presentation, Cooperative work, Electric kit*

Introduction

Development of global human resources is important mission for National Institute of Technology, because a lot of engineers are working not only domestically but overseas. Kamahara, Eugene, and Daimon (2016) reports the effect of short-term study abroad program for their undergraduate students. Yamazaki, Matsumura, Hasegawa, Inoue, and Murakami (2016) developed CEFR-based (Common European Framework of Reference) Can-do list to evaluate the capacity of engineering student English communication skills.

Although our college holds international exchange activities, there are the room to develop new exchange activities for younger students. This paper describes a new activity for our Year-2 students. When the target students are not used to exchange activities, organizer should be careful to prepare topics for the students. Therefore, common topics are provided by some cooperative works that included in the exchange activity. Especially, technical English communication is not easy for younger students, because they study technical English words not so much yet. Since the presentation about the mechanism of every project is given by students instead of teachers, the students have to prepare the English slides and also make the prototype before the presentation. The preparation gives students opportunity to study technical English words and to practice English presentation. The manufacturing project includes four themes such as "Electric music box", "Electric guitar", "LED electric bulletin board", and "Small claw crane".

Schedule and Preparation Works

The exchange program includes three days from ice breaking and four projects to farewell party. The table of this schedule is shown in `Table 1`. The preparation work term is assigned 2 weeks before starting the exchange program. Students make prototypes of the things for each project and create presentation slides. They can understand the structure deeply through the making prototype process, so that they can tell technical know-how to other country students with their assurance. Students can study technical English words through creating presentation slides and also they experience speaking English through the practice of the presentation. Important point is that they are ready to accept other

country students with just a little confidence instead of anxiety that they don't know what happens.

Table 1 Exchange Program Schedule

Date	Contents
Preparation works (2 weeks)	Making prototype Creating presentation slides
1st day	Ice breaking, Team building Project 1: Electric music box Project 2: Electric guitar
2nd day	Project 3: LED electric bulletin board Project 4: Small craw crane
3rd day	Presentation, Farewell party

Project 1: Electric Music Box

The electric music box is shown in Figure 1. It consists of a piezoelectric speaker, a melody IC, and a battery box. The melody IC looks like a transistor but it includes a song and it can drive piezoelectric speaker. Students study some technical skills such as, soldering electric parts on a universal board, a simple electric circuit, and driving a piezoelectric speaker, through this project.

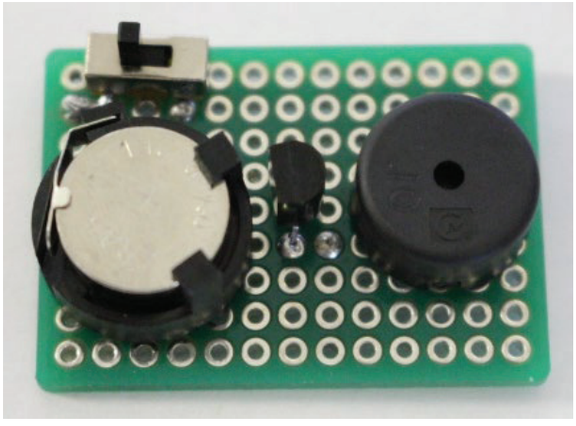

Figure 1 Electric music box

Project 2: Electric Guitar

Electric guitar is shown in Figure 2. It consists of a speaker, strings, a piezoelectric element, an amplifier circuit with operational amplifier IC, and a battery box. Students study some technical skills such as, soldering electric parts, amplifier circuit with operational amplifier IC, using piezoelectric elements as vibration sensors, hardware design for good sounds.



Figure 2 Electric guitar

Project 3: LED Electric Bulletin Board

LED electric bulletin board is shown in Figure 3. It consists of an 8 * 8 LED matrix panel, a micro-computer (ATMega 168-P), and 4 push switches. Students study some technical skills such as, soldering IC, and controlling LED panel by push switches.

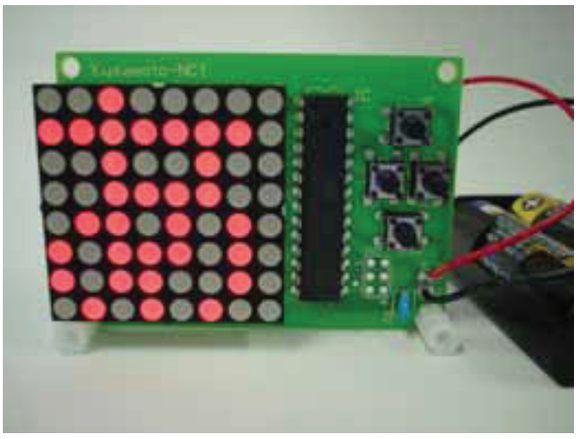

Figure 3 LED Electric bulletin board

Project 4: Small Craw Crane

Small craw crane is shown in Figure 4. It consists of two DC motors, a servo-motor, motor driver IC, Arduino UNO board, 5 push switches, and a battery box. Students study some technical skills such as, Arduino UNO programming, mechanical hardware design, making electric circuit on a breadboard, DC motor driving IC, and controlling servo motor.

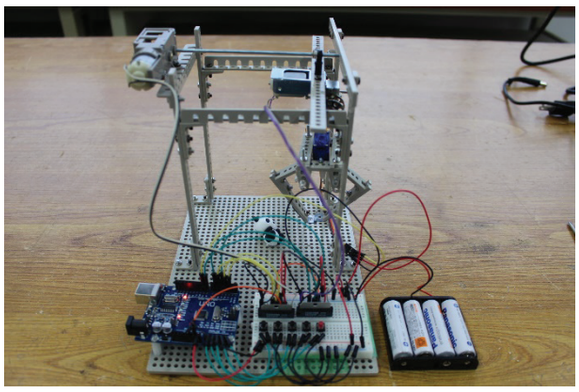

Figure 4 Small craw crane

Results and Discussion

For the preparation work, making prototype and creating slides were well done, but the creating slides finished at the day before starting the exchange program. Therefore, the students were able to practice the presentation only one day. Actually, almost all Japanese students talked with notes. However, some students talked without any notes. This results shows that they need more than two weeks for preparation works.

After the exchange program, students answered for a questionnaire about this exchange program and each technical project. Figure 5 shows the questionnaire result about international exchange activities and Figure 6 shows about the same question after the exchange program. This shows 51% students feel "Very fun" or "Slightly fun" before the activity. On the other hand, 90% students chose the above feeling after the activity, and the breakdown of the percentage was 44% of "Very fun" and 46% of "Slightly fun". Since the 72% of students that worked on the preparation were included in the number of percentage which answered "Very fun", the preparation work contributed to improve the satisfaction of the students that participated in the international exchange activity.

Furthermore, Figure 7 to Figure 10 show the questionnaire results about each technical project. 70% students were interested in electric manufacturing before the manufacturing project, but more than 90% students were interested in them after the project. This result shows that interest in engineering improves by not only passive lessons but also active teaching for other people.

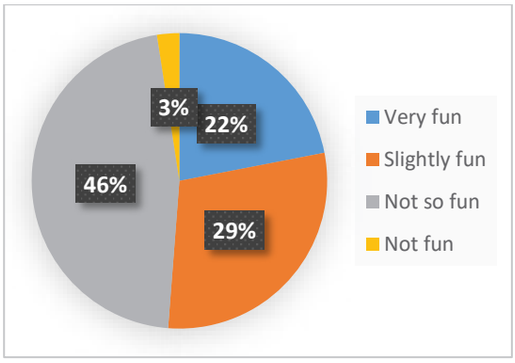

Figure 5 Questionair result about "international exchange program" befor the exchange program

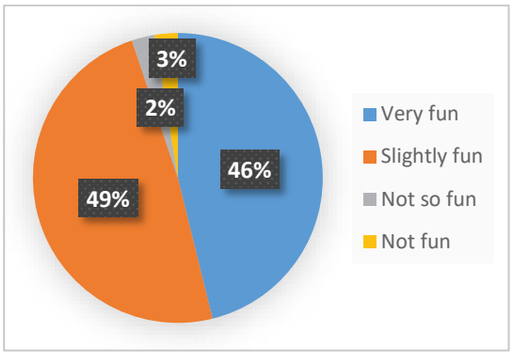

Figure 6 Questionair result about "International exchange program" after the exchange program

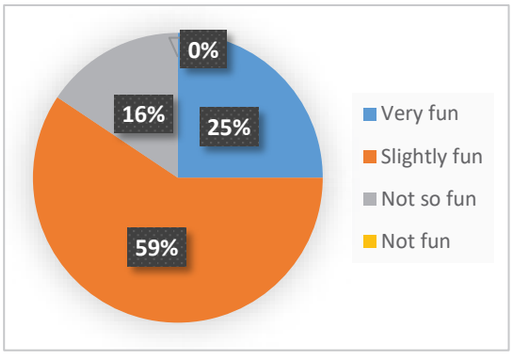

Figure 7 Questionair result about "Electric Music Box" after the exchange program

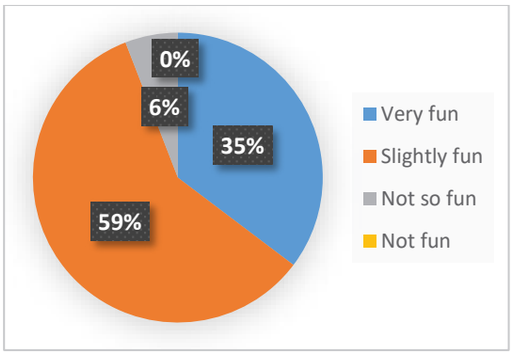

Figure 8 Questionair result about "Electric Guitar" after the exchange program

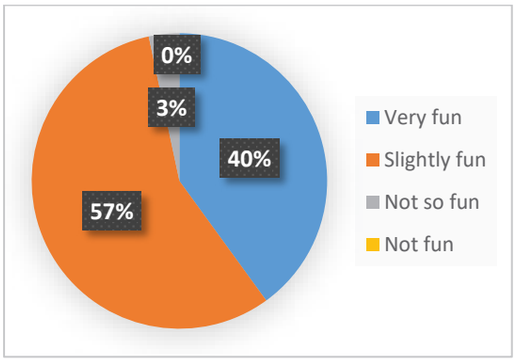

Figure 9 Questionair result about "LED Electric Bulletin Board" after the exchange program

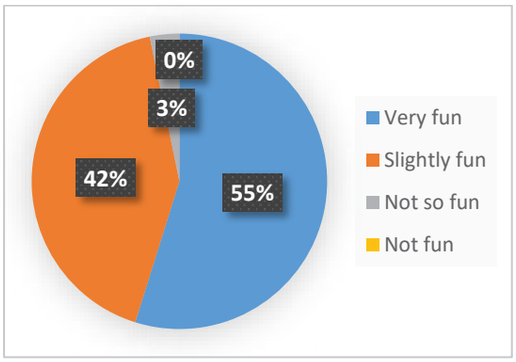

Figure 10 Questionair result about "Small Craw Crane" after the exchange program

Conclusions

This paper showed the effect of preparation works for international exchange program. The preparation works gave students confidence about telling technical know-how and speaking English, so that they really enjoyed exchange program. On the other hand, preparation works require more than two weeks for students. This is not so easy to hold the term for students and also staffs.

Acknowledgements

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DEVELOPMENT OF STEM WORKSHOP – DNA EXTRACTION FROM HUMAN CHEEK CELLS USING DESIGN THINKING APPROACH

C.K. (C. P.) Chak*,1, T.S. Lo*,2, K.C. Li, K.S. Li, T.F. Ng, T.Y. Wong and M.L. Yeung

Department of Applied Science, Institute of Vocational Education (Chai Wan), Hong Kong, PRC
*,1 sonicpong@vtc.edu.hk, *,2 tslo@vtc.edu.hk

Abstract

Education Bureau of HKSAR has introduced interdisciplinary learning concept called STEM education (Science, Technology, Engineering and Mathematics) in 2015 in response to global trend of education reform and competence requirement of rapid changing society in term of economic, science, innovation and technology. There are not many STEM educational activities available for children and youngsters in Hong Kong in the context of biotechnology. The reason may because the aforementioned activities involve the use of many sophisticated apparatuses and equipment, which cannot easily be transported and used in the environment of primary or secondary schools. Therefore, a STEM workshop of DNA extraction from human cheek cells, which is feasible and applicable to be launched in secondary school, was developed and tested with an adoption of design thinking approach in the project-based learning (PBL) curriculum of a tertiary education institute (HKIVE). The comments and expectations from the users and stakeholders were collected, analyzed and prioritized. Based on the defined needs and expectations on workshop (i.e. attractiveness, simplicity, total time, cost and safety), seven models of DNA extraction protocol were then devised. Their performance was evaluated in terms of DNA purity, concentration, integrity, size of pellet and successful rate in Polymerase Chain Reaction. The uniqueness, cost and time of the workshop were also considered. With embedding the learning content into the finalized prototype, a pilot run of the STEM workshop was conducted with 22 secondary school students and teachers. The feedbacks from the participants showed that they were highly satisfied with the content and learning outcomes of the workshop. In a score range of 1 (most unsatisfied) to 5 (most satisfied), >75% of participants scored 4 or 5 (average score at 4.61 ± S.D. 0.56) in terms of the knowledge learnt, workshop attractiveness and the final take-away product of the workshop. The workshop had also aroused their interest in the field. Continuous improvements of the workshop are underway to enrich the learning needs of students.

Keywords: *Biotechnology, STEM, design thinking, DNA, PBL, HKIVE*

Introduction

In response to the rapid change of global environment in term of economy, science, innovation and technology, HKSAR government introduced STEM (Science, Technology, Engineering and Mathematics) education in her policy address in 2015 and 2016.[1-2] It is believed that STEM education can help students to cultivate their interests towards STEM subjects with strong knowledge and skill background, to train them with innovative, collaborative, problem solving skills, the entrepreneurship and the lifelong, self-directed learning, which are essential in 21st century world.[3] The Education Bureau (EDB) released consultation paper and report on "Promotion of STEM Education - Unleashing Potential in Innovation", which introduced the collected views from different stakeholders and the strategies of EDB in the promotion of the STEM education.[3] The strategies include the renewal of curriculum, providing resources, enriching activities, enhancing professional development, strengthening partnerships with key stakeholders, etc. Within all these strategies, STEM workshop is one of the major activities that can help promotion of STEM education. These workshops can be offered by NGOs, private companies or tertiary institutes. Currently, STEM workshops in Hong Kong only involve science such as biology, engineering and technology such as programming, robotics, 3D-printing and virtual-reality.[4] However, there are not many bio-technology workshops for youngsters due to equipment limitation, this may inhibit the nurturing of the interests of students towards biotechnology, which is an important area of innovation for future development of Hong Kong.[5-9] Therefore, a STEM workshop with bio-technology based theme is sought to launch. It is reported in this paper for the design, implementation and evaluation of a bio-technology based STEM workshop of DNA extraction from human cheek cells, with the adoption of design thinking (DT) approach[10-12] in the project-based learning (PBL) curriculum[13-15] in the Institute of Vocational Education (HKIVE). The designed workshop would be launched in form of pilot test in a secondary school for evaluation purpose.

STEM education is an integrated curriculum that involves hybridizing of different key learning areas (KLA) in primary and secondary schools -Science, Mathematics, and Technology, there are mainly two approaches suggested by EDB for organizing the STEM

learning activities.[3] The learning activities is either based on topics in a KLA for students to integrate with relevant elements from other KLA or a project that integrate relevant elements from different KLAs. The element of engineering design is incorporated into the learning activities to facilitate integration and application of knowledge into practice with competent skills such as creativity, innovative and analytical skills.[3] In order to facilitate STEM education within and outside school, project-based learning (PBL) is a good mediator for IVE students to design, implement and evaluate a STEM workshop to secondary school. PBL is an important part of curriculum in IVE programme, which brings students in groups with practical experiences outside lecture.[18-20] It is the learning process for students to work together, to analyze in different angles and to apply the prior knowledge, skills and tools obtained into practical for solving problems in social reality. PBL is a student-centered pedagogy that facilitate interdisciplinary understanding such as STEM education, which is encouraged by EDB to facilitate students' integration, innovativeness and problem-solving skills. Within the PBL, students adopt the design thinking (DT) approach for the design, implementation and evaluation of STEM workshop. DT is a tool of human-need-oriented approach to solve problems through seeking innovative solutions in possibilities of technology and requirements of success in business.[10-12] Students can learn actively by transforming the knowledge and information of "human-needs" obtained into continuous improving product design through reasoning, problem-solving, creativity, innovating and collaborating skills, which are essential competent requirements for graduates in 21st century. DT involves five stages including "Empathize", "Define", "Ideate", "Prototype" and "Test", these steps are in cycles that continuous deconstruction and rebuilding of ideas and products is taken place, which transform the students from a fixed mindset to a growing mindset for continuous improvement and advancement. Therefore, DT can be incorporated as a tool of cultivating skills in student-centered PBL for interdisciplinary STEM education.[3]

Materials and Methods or pedagogy

Purpose and significance of study: The purpose of the project is to plan, design, implement and evaluate a STEM workshop with the content of DNA extraction of human cheek cell, which can be launched in secondary school, by using design thinking tools in project-based learning of IVE. The STEM workshop output involves the consideration of needs from teachers as user and students as stakeholder, which can help optimizing and smoothing the STEM workshop for launching. Therefore, it can be used to promote STEM education in Hong Kong for arousing students interests in STEM-related subjects and hence, for the future development of innovative expertise, particularly in the growing field of biotechnology.

STEM education[3] and PBL[13-15]: The STEM workshop is designed and implemented by HKIVE students through project-based learning curriculum. The STEM workshop involves biochemical Science and Technology as main theme involving the extraction of DNA, it also involves mathematics such as calculation of the concentration of DNA to optimize the experimental condition. Finally, it involves engineering design which utilize science and mathematics to solve the problems and optimize the DNA extraction workshop. Throughout the planning, designing, implementing and evaluating the project-based learning for STEM workshop output, it fulfils the students' curiosity, interests, needs and actualize the sense of self-determination as well as acquiring skills and knowledge in biotechnology through DNA extraction, Polymerase Chain Reaction (PCR), and gel electrophoresis, etc.

Design Thinking[10-12]: DNA extraction is a process to obtain and purify the DNA using physical and chemical methods. The general procedure for DNA extraction of animal cells, such as human cheek cell, is well documented, however, it is obvious that some criteria has to be considered in order to modify the experiment and bring it into the STEM workshop for launching in secondary school. The design thinking approach is introduced in order to optimize the product output of the STEM workshop. The steps of DT are empathy, define, ideate, prototype and test, the details of application of each step are reported below:

1. Empathy

It was to understand the users and stakeholders' needs for the characteristics of the product output of STEM workshop with content of DNA extraction. The information was obtained by interview.

2. Define

It was to analyze the information obtained in the first step by prioritizing the needs. Strategies were formulated using prioritized needs by the discussion among student team members.

3. Ideate

It was to generate various idea from strategy to fulfil the needs of users and stakeholders. Idea are generated through the discussion among student team members.

4. Prototype

It is to produce quick models for the possible solutions utilizing the idea generated. It involves the production of the prototype using various experiments methods and equipment according to the idea generated. In this context, the procedure of original DNA extraction experiment was modified and incorporated in the STEM workshop. The extracted DNA product was put in a specially designed souvenir.

5. Test

After the prototype was established, the pilot test of the STEM work is launched in a secondary school for 22 students and teachers on 21 March 2018. The comments of users and stakeholders are collected by questionnaire (n= 21) and analyzed. The questionnaire adopts the 5 equivalent points Likert score and the results are reported as mean ± SD.

Original DNA extraction protocol: Design thinking is employed to modify the existing documented DNA extraction protocol. The original protocol is described as below for reference:

Preparation of digestion buffer: The digestion buffer (100 nM NaCl, 10mM Tris-HCl (pH 8), 25 mM EDTA (pH 8), 1% (w/v) SDS, 0.1 mg/ml proteinase K (add fresh) was prepared at room temperature and the proteinase K was stored in -20℃.

DNA extraction method[16-21] and measurement: Swab was used to rub the cheek cell from mucus membrane for about twenty times of each side. After that, the cells were dispersed into the 2 ml microcentrifuge tube containing 200 µl of digestion buffer. The cell will be lysed by incubator at 56℃ for 45 minutes. Two hundred microliter of phenol-chloroform was added to purify the DNA from cell. The microcentrifuge tube was mixed gently by inversion for five minutes, then it was centrifuged at 3000 rpm for five minutes at room temperature. The upper layer was transferred to a new 1.5 ml microcentrifuge tube. Fifteen microliter of 3 M sodium acetate and 300 µl of ice-cold absolute ethanol were added into the 1.5 ml microcentrifuge tube. The solution was mixed by pulse-vortexing for fifteen seconds. The microcentrifuge tubes were placed at -80℃ for fifteen minutes. The DNA precipitate was collected by centrifugation at 14000 rpm for ten minutes at 4℃. The supernatant was then discarded leaving the DNA pellet. 400 µl of 70% ethanol was then added to the centrifuge tube for redispersion. The tube was then centrifuged at 8000 rpm for 1 minute. The supernatant was discarded as much as possible and the DNA pellet was dried in a Speedvac evaporator. The size of the DNA pellet can be measured. Fifty microliter of sterile water was added to the DNA pellet for resuspension and was incubated at 55℃ for 5 minutes. The A_{260}/A_{280} ratio and direct concentration were measured by using Nanovue spectrophotometer for the determination of purity and concentration of DNA extracted. The DNA integrity and target sequence quality were measured by agarose gel electrophoresis and PCR respectively.

NanoVue Plus spectrophotometer: Two microliter samples were pipetted directly onto the sample plate for measurement of A_{260}/A_{280} ratio and direct DNA concentration, and they can be then simply recovered using a pipette.

PCR protocol: Polymerase Chain Reaction (PCR) is a technique to amplify single copy or few copies of specific segments of DNA into several order magnitudes copies.[22-24] The primers used for the amplification of target GADPH gene with 205 base pairs.[25-27] The sequences of forward and reverse primers are GAPDH-F: 5'-AGG GCT GCT TTT AAC TCT GGT-3' and GAPDH-R: 5'-CCC CAC TTG ATT TTG GAG GGA-3' respectively. The protocol of PCR was described as follow:

Thermos Scientific PCR master mix included a 2X concentrated solution of *Taq* DNA polymerase (0.05 U/µL), reaction buffer, 4mM Magnesium Chloride ($MgCl_2$), and 0.4 mM of each deoxyribonucleotide triphosphates (dNTP). All PCR mixture were carried out in a 10 ul reaction volume containing 5 µl of PCR master mix, 0.3 µL each of 10 µM forward and reverse primers, 1 µL DNA template and 3.4 µL sterile distilled water. The reagents were mixed by vortexing and then they were spin down briefly. The temperature profiling of PCR was described as follow: Initial denaturation was performed at 95ºC for 30s, then 40 Cycles of three steps were performed. The first step was denaturation at 95ºC for 5s, followed by annealing at 60ºC for 34s and extension at 72ºC for 1 min. After that, 1% gel electrophoresis of PCR product was performed.

Agarose gel electrophoresis: 1% agarose gel electrophoresis was used to determine the band pattern and molecular weight band distribution of extracted genomic DNA and PCR product, which indicated the integrity and quality of the extracted DNA.[28-30] Six microliter DNA samples with loading buffer and 4 µL 100-bp molecular markers were loaded into separate wells. Power supply at 100 V was connected to the anode and cathode of the gel apparatus to perform gel electrophoresis. When the dye front had migrated three-fourths of the gel, the gel was disassembled from the gel tank and was visualized under UV screening system.

Results and Discussion

Design thinking (DT) is used for the design, implementation and evaluation of the STEM workshop with the content of DNA extraction. Starting from empathy, the information concerning the needs of users and stakeholders were collected through interview. The second process is "Define", the needs of users are collected, and the results of the interview were collected. Attractiveness, simplicity, time, cost and safety are the needs of the user concerned. For attractiveness, the DNA product should have a good-looking and can be taken home after the workshop. For simplicity, the procedure in the workshop should be easy to follow, the steps required to produce the product should be simple. For time, the STEM workshop with objectives accomplished should be finished within limited time (2 hours) due to the availability of school and students. For safety, the chemicals used in the STEM workshop should be safe and easy to handle. These needs are prioritized according to the interview conducted with the users. The third process of DT is "Ideate" to fulfil users' needs. For addressing the need of attractiveness of product, the DNA product should be with observable size of pellet and is stored using the well design and attractive bottle for increasing the attractiveness of the workshop.

In order to address the concern of the simplicity and running time limit of the workshop, the procedure including the chemicals and instruments used is modified to have a simple flow and to shorten the running time. Moreover, the cost and safety of the workshop is optimized by using cheaper but safer chemicals.

Step	Model	Testing material	Material to be replaced in original method	Addressed concern
Cell lysis	A	Household detergent	Sodium dodecyl sulfate(S.D.S.)	Simplicity Safety
	B	Meat tenderizer	Proteinase K	Cost
Concentration	C	Sodium Chloride (salt)	Sodium acetate	Simplicity Safety
Cell lysis and Concentration	D	Detergent + Sodium Chloride	S.D.S and Sodium acetate	Simplicity Safety
Cell lysis and Purification	E	Detergent + Chloroform	S.D.S. and Phenol/Chloroform/Isoamy alcohol (P.C.I.)	Simplicity Safety
Cell lysis	F	No Proteinase K	Proteinase K	Cost

Table 1. The modification of procedure from original DNA extraction protocol and its addressed concern.

Then, the "prototype" is constructed using different modification of procedure and chemicals. The related concern is addressed by formation of different model (A-F) through replacing chemicals used in the original DNA extraction protocol as shown in Table 1.

The attractiveness of DNA product is addressed by monitoring the DNA pellets size in the above model during testing and modified the procedure if necessary. Also, a well design and attractive container is designed to store the DNA product. The time of procedure is shortened from 3 hours to 2 hours by reducing time in cell lysis and tightly following the procedure step by step without break between steps.

The effect of DNA product produced by different models A -F was compared with the original protocol. The pellet size, concentration, purity, integrity and quality of DNA was tested in response to the impact of modified procedure according to the concerned needs in balancing of scientific grounds in STEM. A good modification of procedure should give a little negative, the same or even better impact on the DNA product. Therefore, the DNA extracted using different modified model is still valid for the future use of bio-authentication. The DNA pellet size produced by different models are rated from 0 to 5 points by observation. It was found that different models can produce similar (A-D and F; 1.5–2) or even better (E; 3.5) pellet size compared with original protocol. The concentration of DNA was measured directly by the Nanovue spectrophotometer, it was found that different models can produce little negative (E; 4.65 ng/μL, F; 4.75 ng/μL), similar (A-C; 10.25–15 ng/μL) or even better (D; 30 ng/μL) concentration of DNA compared with original protocol. The purity of DNA was measured by the A260/280 ratio through Nanovue spectrophotometer, it was found that different models can produce little negative (B; 1.076), similar (A and F; 1.374–1.376) or even better (C-D and E; 1.545-1.813) concentration of DNA compared with original protocol. As the typical A260/280 ratio is around 1.8, the model E (1.813) gave an even better result compared with original protocol, indicating the highest purity of DNA among all models.

The integrity of DNA was measured by the band pattern and size determination in 1% agarose gel electrophoresis. It was found that some models (A, C, D and E) can form single band with similar band size compared with original protocol. Extracted genomic DNA of satisfactory intactness should show a smear with a single band appeared above the resolution capability of the gel. It indicated that replacement of chemicals from original protocol for these models will not lead to failure in extraction of genomic DNA. The quality of DNA was determined by the PCR result of GAPDH gene found in extracted DNA in human cheek cell. The band size of the target DNA segment is 205 base pair which was analyzed by 1% agarose gel electrophoresis. It was found that model A to E can give successful PCR result as the target band size was obtained, it showed that the extraction of DNA was successful in model A to E such that the extracted DNA can be used in bio-authentication. Model E was chosen as the prototype as the performance is the best in term of attractive pellet size, in balance of the DNA properties (concentration, purity, integrity and quality) for potential future use of bio-authentication.

The final DT process is "Test", the pilot test of STEM workshop is launched in a secondary school on 21 March 2018. The comments from users and stakeholders were collected after the workshop. The questions in the questionnaire adopted the 5 equivalent points Likert score with 1 (most unsatisfied) to 5 (most satisfied) scores for each question (n = 21). The questions consist of comments concerning knowledge learnt, change in attitude, usefulness, attractiveness of the STEM workshop, etc. The feedbacks are listed in Table 2 and it showed that the participants were highly satisfied (average score more than 4 in each item) with the learning content and outcome of the STEM workshop in term of view on workshop (e.g. knowledge obtained, interest aroused, useful information for further study obtained, satisfactory production process, spatial and learning experience), and were likely to join similar

	5 (Most satisfied)	4	3	2	1 (Most unsatisfied)	Reported score ($\bar{x} \pm SD$)
This workshop						
1. is comprehensive and interesting	13	7	1	0	0	4.36± 0.60
2. can deepen the knowledge in related subjects	13	7	1	0	0	4.36± 0.60
3. can help to arouse the interest of participants in related subjects	15	6	0	0	0	4.50± 0.46
4. provide information that can help further study	13	8	0	0	0	4.41± 0.50
5. has a satisfactory production process of DNA souvenir	11	8	2	0	0	4.23± 0.68
6. has enough space	9	9	3	0	0	4.10± 0.72
7. is clearly delivered by lecturer and easy to understand	16	4	1	0	0	4.50± 0.56
8. is unique	14	6	1	0	0	4.41± 0.59
I (the participant)						
1. would like to join this type of workshop again	16	4	1	0	0	4.50± 0.56
2. am satisfied with the workshop	15	4	2	0	0	4.41± 0.67

Table 2. Questionnaire feedbacks result of the users and stakeholders

type of workshop again with satisfaction. The users and stakeholders also gave suggestions to the workshop in open-end question. Some of them gave suggestion to has a greater time allocation for souvenir making, or even to increase the time duration and space for the workshop. These suggestions can be taken into consideration in the next cycle of design thinking.

The design thinking cycle was completed through the STEM workshop design, implementation and evaluation.

The user-centered design thinking process produce a STEM workshop that enable students to learn STEM knowledge and concepts through addressing the users' needs. It also arouses the interests of participating students to learn science and technology. The workshop is practicable since it produces attractive product with simple procedure, short running time, reasonable cost and safe. It also has sustainability for the consideration of teacher's and student's feedback during the design thinking process and the workshop contains entertainment element and has a simple and repeatable procedure.

Limitation and suggestions: There are some limitations in this project, the workshop is still a pilot test that require further investigation on the efficiency and effect on users and stakeholders on STEM education. The number of schools participating in the workshop should increase to give a more concrete conclusion on the results. More space, time duration and appropriate time allocation of workshop are sought to be provided in next cycles of workshop. However, since the design thinking tool is highly users-orientated, each group of users may have different needs due to the school and users background. Therefore, it is expected that design thinking may be implemented for each workshop conducted to check whether the needs from each group of users vary. The project is a quasi-experiment with single group post-test of questionnaire, therefore, it has several limitations such as selection effect. However, the effect of history and maturation are not important as the treatment of workshop is one-shot of 2 hours. The post-test of questionnaire may not sufficient to test whether the users and stakeholders learned in STEM workshop effectively. In order to give a stronger conclusion on the
result of STEM workshop, it is suggested that pre-test and post-test of written format of STEM (including biotechnology) knowledge should be given, also, control group should be added to the experiment with randomization assignment of experimental and control group members to elimination selection effect.

Conclusions

A STEM workshop with content of DNA extraction has been launched in pilot test effectively, and it utilized the design thinking approach in IVE student project, the users' and stakeholders' needs were taken into consideration throughout the design of the workshop. The attractiveness of product, simplicity of procedure, time duration, cost and safety of workshop are the needs of users that have been catered by the modification from the original DNA extraction procedure with the addition of attractive container design, bigger DNA pellet size and in balancing of the validity of DNA (concentration, purity, integrity and quality) for future use in the aspects of scientific grounds in STEM, therefore, one of the seven proposed model of prototypes was selected for the STEM workshop procedure.

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INNOVATIVE USE OF EXIT TICKETS IN ENGAGING COMPUTER PROGRAMMING STUDENTS IN REFLECTIVE LEARNING AND SUPPORTING TUTOR IN DIAGNOSTIC TEACHING

Tan Geok Ling

Temasek Polytechnic School of Engineering, Singapore

geokling@tp.edu.sg

Abstract

This action research explores the use of exit ticket for diagnostic teaching and reflection on learning computer programming in an innovative and plausible approach. Students in School of Engineering often consider their first attempt in a software programming subject disconnected and uninteresting as they find the language very different from that used for interpersonal communication. They find it hard to remember the syntax of programming language and tend to forget the rules and special names or keywords used for specific purpose. Two different cohorts of students participated in this action research. I attempted diagnostic teaching (DT) in my first iteration with the main objective of understanding the knowledge gap of my students and to determine the next step of instructions or reinforcement necessary for that particular lesson. Based on students' answers to the questions I posed, I noticed a possible common misconception amongst students in the class. Students feedback that the follow-up diagnostic teaching clarified their misconceptions and reinforced their understanding. Though DT could be adopted in some cases to help students understand their learning gaps, it is usually adopted by teachers for the same purpose and to inform them of their teaching instructions and strategies.

In my second iteration of action research, I adopted exit ticket which comprises a set of reflective questions that help students reflect on their learning. I leveraged on their reflection to inform and support the reinforcement strategies and instructions I constructed for the subsequent practical lessons. This action research reviews how exit ticket for reflection on learning can benefit both students and tutor to achieve the goals of enhanced learning and facilitation respectively for the subject, Computer Programming for Problem Solving (CPPS).

Students' feedback revealed that exit ticket for reflection on learning is beneficial if well-implemented. I observed that regular use of such exit ticket, in a programming subject, at the end of a lab session for reflection on learning helps students make connections to their prior knowledge, be more mindful of common errors, remember solution for specific errors, and most importantly, envisage their learning gaps and needs.

Keywords: *exit ticket, diagnostic assessment, diagnostic teaching, reflection on learning, computer programming, action research*

Introduction

This action research was conducted in the premise of Temasek Polytechnic, for year 1 students taking a software programming subject called Computer Programming for Problem Solving (CPPS). As a practitioner and educator, I found that regular 'self-reflective inquiry' (Carr and Kemmis, 1986, p162 cited in Cohen et al., 2005, p227) and keeping abreast of current education innovation guide my belief system which form my knowledge base and influence my practice.

In this action research, I attempted diagnostic assessment in the first iteration with 22, year-1 semester-2, students taking the subject CPPS, with the objectives of understanding the knowledge gap of my students and to determine the next step of instructions or reinforcement necessary for that particular lesson. Besides informing my instructions to help close students' knowledge gap, I wanted the assessment to help students reflect on their learning needs. Students feedback that the discussion cum explanation given after the diagnostic assessment helped them understand the taught concept better. This assessment took up much of the class time. I felt that helping students improve their skills in reflection on learning would help them understand their learning needs, link and apply their prior knowledge to the current lab exercise, and note the mistakes they encounter in each lab practice.

In the second iteration, I used exit tickets to help students reflect on their learning at the end of lab lessons 3, 5, 6 and 8 in term 1. The purpose of using the exit tickets was to provide opportunities for students to reflect on their learning, to link the concept taught in the previous lessons with the current lab exercise and also to enhance

their ability to understand their learning needs. I used the exit tickets as a diagnostic assessment tool to inform me of their learning needs. With that, I constructed instructions and reinforcement strategies in the next lesson to close the learning gaps and address common misconceptions. Students were motivated to jot down their thoughts in the exit tickets, when they realised that I actually used what they wrote to address common misconceptions.

Focus of research

In this action research, I am collaborating with my students, using their reflections on learning in the form of exit ticket at the end of selected practical lessons. As a tutor, I hope to collect information of their learning needs which I could use to strategise my teaching approaches, in the form of diagnostic teaching in the subsequent lessons.

I observed that student who lacks the skills of reflecting on learning – unable to make sensible meaning of the situation without reflective inquiry and thinking (Dimova & Kamarshka, 2015), has poor ability to connect learning points, unable to quickly leverage on his/her prior knowledge, and hence, lack confidence in the project code implementation.

In my attempt to help students improve their ability to reflect on learning and using their reflections to diagnose their learning needs, I envisioned that these research questions would be beneficial in informing me of the effectiveness of the strategies I employed. These strategies would enhance my students' ability to reflect on their learning, to link the concepts taught in the previous lessons with the current lab exercises, and to enhance their ability to unravel their learning needs.

Research questions

1. How can exit tickets help students engage in reflective learning?
2. How can exit tickets help tutors in diagnostic teaching?

These research questions were formed after my observations and reflections on students' feedback on the first iteration of action pertaining to the use of diagnostic teaching, and discussion with my colleagues from Learning Academy of Temasek Polytechnic. Having carried out one round of diagnostic teaching and data collection in one lesson, it was revealed that there was a lack of class time in completing the intended lab practical exercises. This led to a change in the cause of actions for the second iteration, which will be described in detail in the methodology section.

In this paper, reflection on learning is construed as a thought process or cognitive activity that takes place, after an experience, event, lesson, and group or individual active participation for making connections to past experiences and generation of new knowledge (Hickson, 2011; Quinton & Smallbone 2010; Chirema, 2007). The literature review, in the next section, provides more insights of diagnostic teaching, exit ticket and students' motivation to learn.

Literature Review

Exit ticket for diagnostic teaching

The use of exit tickets for garnering inputs from students about their understanding, and to achieve the desired learning outcomes can be effective if it's well-planned and well-administered.

The prevalent use of exit tickets in different educational levels can be adopted for diagnosing students' current learning gaps. These information help teachers plan and facilitate their lessons (Danley, McCoy & Weed, 2016; Doug, n.d.b). Well-thought reflective questions in exit tickets help students to reflect on their learning (Learning Sciences International, 2012). Dimova & Kamarshka (2015, p. 37) mentioned the use of "reflective cards" for focused reflection on action to occur quickly. The idea of reflective cards for guided and fast reflection is similar to the use of exit tickets for reflection on learning. This practice promotes self-reflection on learning (Doug, n.d.a).

The process of diagnostic teaching comprises finding out individual students' learning needs with respect to the desired learning outcomes and designing teaching approaches to create learning opportunities to fulfill individual learning needs (Palmer et al., 2014; Eisele, 1967). Providing guidance and monitoring students' learning progress should be perennial throughout the diagnostic process (Bell, 1993; Bell, n.d.; Eisele, 1967). Diagnostic teaching contributes to forward learning and promotes transfer of current knowledge to applications in different context when cognitive conflict is encountered within a learning activity (Scaife, 2011; Bell, 1993). Figure 1 shows the iterative diagnostic teaching approach adopted in this study. The prior assessment of individual's current knowledge level is imperative for informed application of relevant and effective teaching activities and strategies (Palmer et al., 2014; Ontario, 2013).

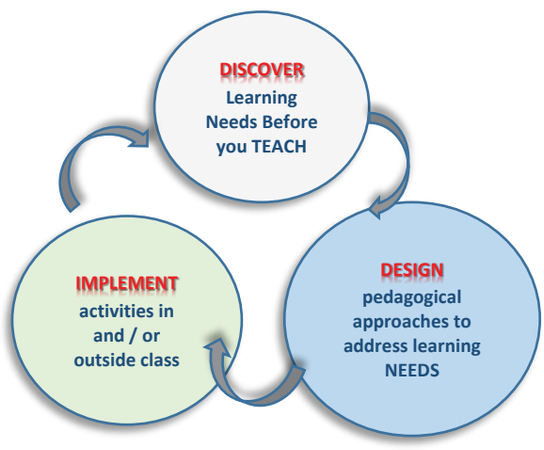

Figure 1. Diagnostic Teaching

The use of exit tickets in the lens of reflective journal writing aids in deconstruction of thoughts and assumptions (Hickson, 2011). There are many ways of

reflecting on learning; through journal writing, talking or discussing with teachers or peers, and self-deconstruction of thoughts and assumptions (Hickson, 2011).

Importance of reflection in tertiary & higher education

Quinton & Smallbone (2010) noted that students' engagement in reflection is salient in tertiary education, and that, it should be explicitly included in the curriculum design. Our exposures to past situations may encumber our ability to make sense of the present circumstances, and hence, to carry out a sensible act (Miettinen, 2000). Quinton & Smallbone (2010) stated that reflection in the form of writing is more powerful than that through discussion, and it allows students to view their reflections at a later stage in their learning. Though research on the effectiveness, outcome and processes of reflection is lacking (Hickson, 2011), writing of journal to encourage reflection and learning in the milieu of education is prevalent (Hickson, 2011; Chirema, 2007).

As my students are young adult learners in the first year of polytechnic education, the learning experiences, positive or negative, they garner now, engender self-directedness in learning.

Students' motivation to learn

Topala (2014) argued that students' motivation to learn can be increased when their learning needs are well-managed and fulfilled. Diagnostic teaching based on students' reflection helps to address learning needs and close the learning gaps. This in turn may enhance students' perceived self-efficacy in the subject, which is one of the factors that increases their motivation to expend effort in mastering the subject (Tan, 2014; Zimmerman, 2000). The reflection process improves their ability to perform self-assessment (Quinton & Smallbone, 2010) and self-regulation (Zimmerman, 2000). Critical reflection, being the ability to reflect on experiences, performances, and asking relevant questions to verify one's belief system is a core skill in self-directed learning (Hickson, 2011). Self-directed learning is an important skill to be acquired by our students.

Methodology and Participants

First Iteration

In the first iteration of the action research, I conducted diagnostic assessment to understand students' learning gaps in the topic, Functions. The diagnostic teaching tool consists of two technical questions about functions based on a given set of C language codes. I noted that more time is needed for such activities for a bigger class size. The activity took about 30mins; comprising time allocated for students to attempt two questions, explanation of misconception, discussion of students' answers, and doing a short survey. The survey consists of three five-point Likert rating questions and two open-ended questions to garner their perspectives pertaining to the usefulness of the activity and my explanation. All indicated that their level of understanding increased after the activity.

The 22 year-1 semester 2 participants were students from Diploma in Infocomm & Network Engineering taking Computer Programming for Problem Solving (CPPS). These participants generally found diagnostic teaching, done promptly after their attempt to answer the questions pertinent to the code, helped them better understand the concept that was taught in the previous lesson.

Second Iteration

Based on my observations and students' feedback from the first iteration, I decided to use exit tickets to help students reflect on their learning in this iteration. On one hand, students can learn to ask reflective questions for reflection on learning, and on the other hand, their responses were used for informing my teaching pedagogy. In the subsequent semester, 53 year-1 semester-1 students in two of my classes participated in the research. Before the start of the activity, I explained to the participants the reasons for writing their reflection on the exit tickets, and emphasised that their responses informed me of the areas that require my attention. I advised them to take a picture of the exit tickets with their hand phone before submitting them to me. This endows them the opportunity to revisit past reflections while learning the subject, and for future related developments (Quinton & Smallbone, 2010).

I gave out the exit tickets at the end of lab lessons 3, 5, 6 and 8 in term 1 (each semester has two terms). These lessons were chosen because they are the second or third lesson of a new topic. There is more about exit tickets in the next section. For diagnostic teaching, I went through each of the exit tickets and noted down the key common responses. During the next lesson, I employed targeted exercises with explanation to clarify misconceptions that was revealed through students' reflections.

Exit tickets, the intervention tool

The exit tickets comprise seven open-ended questions. Each question aims to promote thinking of the learning experience related to the key concepts, and making connections to the prior knowledge in drawing of flow charts, and coding to solve one or more authentic problems. The exit tickets help students recognise and remember the errors they make and what are done to correct those errors which served as self-learning moment.

One of the questions allows students to describe the concepts they do not understand. This question serves as a good feedback to inform teaching approaches for the next lesson (Exit Tickets, n.d.). The last question asks about other observations and comments they have of their learning. The nature of such question empowers students to reflect on their emotions (Learning Sciences International, 2012; Quinton & Smallbone, 2010), strength, weakness and areas in which they are open to make their voices heard.

The exit tickets were given to each student during the last 30mins of the 2-hour lesson. They were then instructed to spend no more than 15mins to reflect on the questions on the exit tickets. I had explicitly informed the students that I will use their exit tickets for planning my

teaching strategy insofar to close their learning gaps. I observed that using exit tickets for diagnostic teaching and engaging students in reflection helps information retention, and realisation of one's weakness and strength in this subject. These approaches motivated them to participate in reflective journal writing (Hickson, 2011; Chireman, 2007). The questions in the exit tickets are shown in Table 1.

1. What did I learn today?
2. What errors/problems did I make in my flowchart today?
3. What errors/problems did I make in my coding today?
4. What did I/ tutor do to solve the errors / problems indicated in question 3?
5. What knowledge did I apply from my previous lesson/s?
6. What concept I am still not clear about?
7. Other observations and comments about my learning.

Table 1. Exit Ticket

Questionnaire

The questionnaire in the second iteration consists of 10 five-point Likert rating multiple choice questions, 2 true-and-false and 3 open-ended questions. The five-point Likert rating questions provide the quantitative inputs while the open-ended questions garner rich qualitative data for better understanding of students' perspectives (Tan, 2014; Cohen et al., 2005). To avoid misinterpreting students' feedback in the questionnaire, participants' identity was authenticated, but was kept confidential throughout the research. My classroom observation together with the data collected provide more accurate interpretation of students' perspectives.

Data Collection

Multiple data collection processes may be essential in mixed method action research based on initial analysis and planning, with respect to the evolvement of the research iterations (Tan, 2014; Merriam, 2009). Triangulation of data through collecting data from different sources, employing various methods, and engaging different evaluators to validate the data increase its validity and reliability (Tan, 2014; Cohen et al., 2005).

My perspectives and observations were constantly reflected upon throughout the various phases of the research. This way of triangulation of data reveals the possible mismatch of mine against the participants' views (Tan, 2014; Cohen et al., 2005). To avoid being bias in analysing the data, I reminded myself that any discrepancies in my observations, and perspectives against the data, could be illuminating insights for further improvement in current and future research studies (Tan, 2014; Cohen et al., 2005). In the second iteration, an online questionnaire was published to the 53 CPPS students. The next section highlighted the results of the online questionnaire.

Data Analysis

33 out of 53 students participated in the online questionnaire. 18.2% of the 33 participants indicated that they have learned C programming before joining the course. This gave them an edge over other learners. I observed that these students could grasp the concept quicker than the majority. They generally gave little or no details in the exit tickets – this could be due to the fact that they hardly encountered difficulty in class.

81.9% found reflection helpful in summarising key learning points while 93.9% of the participants strongly agree or agree that reflecting on how they overcome the mistakes they made during lessons helped to reduce the occurrence of similar mistakes again.

84.8% of the participants felt that reflective journal writing helped them understand their own learning needs, and 94% noticed that it enhanced their ability to code in C language. 78.8% noted that their ability to code in C language for solving simple problem was in the range of 5 – 10; where 10 means good and 0 means poor. In my view, this confidence level is satisfactory for first time programmer. 93.9% of the participants found diagnostic teaching using information garnered from their reflections useful in clarifying misconceptions, and reinforcing their understanding.

From the qualitative feedback, the majority of the participants felt that 5 to 10 minutes were sufficient for them to reflect and complete similar reflective journal writing. All, except one participant, felt that the class time given for reflection was enough. Four participants revealed in the open-ended question that they disagreed that reflective journal writing was helpful. One student indicated that he had already learned and remembered his mistakes while attempting the lab exercises - I observed that this efficacious student was motivated to learn the subject right from the start. Another student indicated that she found it hard to reflect on her mistakes and problems. A student commented that doing reflection at the end of the lesson was a bad idea as he tended to rush through, so as to leave for home. The fourth student commented that the questions in the exit tickets were not specific enough to help her think of what she had learned.

The majority of the participants acknowledged that reflection on learning has enhanced their learning of this subject. The survey results revealed that most students felt positive about using exit tickets for reflective journal writing and diagnostic teaching. They observed an increase in confidence in programming, as compared to the beginning of the semester.

Careful analysis of their written reflections could unravel the level of engagement, positive or negative, in writing reflection journal. However, not all students gave useful details to the various questions they were asked to

reflect on. I believe these students need more practices and more time to reflect on their learning.

Results and Discussion

A well-planned and well-administered process of facilitating the use of exit tickets in promoting reflection on learning and diagnostic teaching is salient. Many students wrote on the exit tickets one to three of the most memorable mistakes they had made. Some included detailed explanation of the errors they made. I observed that having found relevance and knowing the advantages of writing reflective journal motivated these students in writing more details while reflecting on their learning.

When I reflected on my approaches to diagnostic teaching, I realised that students acknowledged the consolidated reflection outcome, with respect to their learning needs. They also appreciated the use of their reflections to inform my teaching approaches. The qualitative feedback students gave for my teaching evaluation showed that many found the strategy of diagnostic teaching, and my approaches to teaching effective. Table 2 shows some of the comments extracted directly from my staff teaching survey given by this group of students:

"My lecturer will always ask for feedback from the class and after that lesson she adapts from what the students feedback and tweaks her teaching to suit all."
"She always recap what we have learnt the previous lesson before proceeding to today's lesson."
"She summarises the previous topics before starting on the next lab session."
"She make sure that everyone understand what that particular lesson is talking about and showed us the difference between other things."

Table 2. Online Feedback on Staff Teaching

This was their first experience in using exit tickets for reflection on learning. Nevertheless, this experience has a positive impact on them in engaging in reflective practice in future learning. In class, I was confronted with fewer questions pertinent to troubleshooting syntax related errors, as compared with the past semesters. This unveiled a positive outcome of using exit tickets for reflection on learning. In this study, results and observations revealed that the use of exit tickets in reflective learning and diagnostic teaching is feasible and less time pressing if well-planned and well-administered.

Limitation

This action research and many others on using exit tickets or other approaches to foster reflection skills have not adequately assessed the effectiveness, outcome and processes of reflection. Future research can consider assessing the effectiveness, outcome and processes of reflection using a systematic model or developing criteria for assessing the quality and outcome of reflection. Though this study in the context of a programming subject cannot be generalised to other learning milieu, it provides practitioners and educators insights into how exit tickets and diagnostic teaching can be adopted in a programming subject. I envision that this research serves as a support for myself and practitioners who attempt to inculcate and develop reflection on learning, to promote deep learning and self-directed learning. As Prouty & Prillaman (1970) has succinctly put, diagnostic teaching can also be adopted to help younger students with learning difficulties and behavioural problems to cope with their learning. This research should be read by teachers and practitioners from different education milieu and levels as it gives them ideas on how they can improvise and strategise their teaching approaches to engage students in reflective learning.

Conclusion

The research questions pertaining to the use of exit tickets for engaging students in reflective learning and for teacher to apply diagnostic teaching had evolved from the initial idea of purely diagnostic teaching to strengthening students' reflective learning ability. The overall engagement level of participation in reflection on learning, though short, was a positive and relevant experience to many of the student research participants. With the benefits and positive impacts that this paper has illustrated in the literature review and data analysis sections, I envisage that inculcating students' ability in reflective learning and critical reflection (Mezirow, 1990), give rise to more deep than surface approaches to learning. In order for students to reap the benefits of reflection on learning, which is a cognitive skill for deep learning (Mezirow, 1990), self-assessment and self-directed learning, reflective writing in the form of exit tickets should be considered for implementation in tertiary education curriculum (Quinton & Smallbone, 2010).

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NURTURING ENGINEERS FOR IOT: NEXT-GENERATION EDUCATION PROGRAM OF KOSEN BY A VIRTUAL WORKSHOP

T. Ichimura[*,a], N. Hirakoso[b], N. Sasaki[c] and S. Tsurumi[a]

[a] Department of Information and Computer Engineering, National Institute of Technology, Gunma College, Japan
[b] Department of Mechanical Engineering, National Institute of Technology, Gunma College, Japan
[c] Department of Electronic Media Technology, National Institute of Technology, Gunma College, Japan

* ichimura@ice.gunma-ct.ac.jp

Abstract

IoT has been getting a lot of attention in the global industry. Recent education programs also adopt information technologies such as IoT and ICT to improve the teaching method. However, education of KOSEN is desired to teach how to realize IoT and ICT, not only to utilize information technology. In this education program, we give lectures about social needs of IoT and the management method of a project first. Based on the lecture, students investigate real information applications and then propose their new seeds of information applications independently. They discuss their proposal information applications and choose some seeds taking account of supervisors' suggestions. Furthermore, some projects are launched to realize the seeds. Students make their project plans and clarify the division of roles in the project. To move their project forward, they can use a virtual workshop in National Institute of Technology, Gunma College. Finally, students discuss their final products within the projects, and then we evaluate deliverables and processes of their projects. The virtual workshop includes visualization of existing equipment, which is placed in laboratories and facilities of our college, by network management. We connect the hardware and software resources to our college network and rebuild the resources to the virtual workshop which is shared across our college. Moreover, we employ new network-compatible IoT products other than existing equipment. This paper describes our plan to nurture IoT engineers in Gunma College.

Keywords: *IoT, Education program, Project based learning, Virtual workshop, 3D-printer, Small board computer, Interactive projector.*

Introduction

For several years now, IoT, Internet of Things, has attracted attention in the industry fields of the world. The phrase "Internet of Things" was made by Kevin Ashton in his presentation of RFID at Procter & Gamble in 1999 (Ashton, 2009). "IoT" is currently used to mean that various kinds of networked industrial products, e.g. smartphones, home electronics, electrical vehicles and smart homes, aggregate, exchange, and share their data each other to automate diverse human activities. The IoT technology was realized by the price reduction and miniaturisation of sensor devices and the spread of the internet.

Information technologies such as IoT and ICT have been introduced into some education methods too. The Japanese government proposed that companies should proactively utilize IoT, artificial intelligence (AI), big data and robots in order to increase productivity against a shrinking population (2016). In response, Ministry of Education, Culture, Sports, Science and Technology also has promoted an education reform to cultivate human resources capable of supporting the 4th industrial revolution (2016). Therefore, many primary and secondary schools adopted programming education as a mandatory subject and introduced tablet-type computers (hereinafter called just "tablet") and electronic blackboard systems. Teachers in the schools have been attempting to "visualization" of education to be helpful in finding student's learning problems by logs accumulated in the tablets, and "active learning" by using the tablets and electronic blackboard systems.

Present Situation of IoT Education in KOSEN

Basically, the goal of KOSEN education is to nurture excellent engineers in the industrial field. Therefore, education of KOSEN is desired to teach how to realize IoT and ICT, not only to utilize information technology.



Figure 1. Debriefing meeting in the PBL class of the production system engineering course.

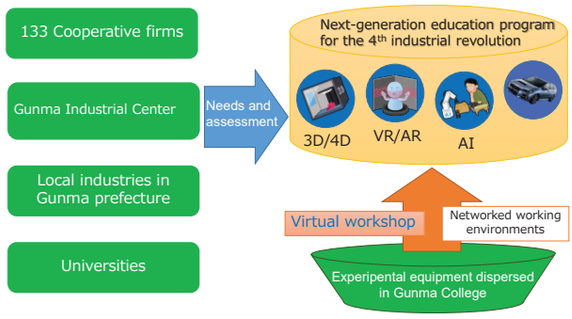

Figure 2. Implementation system of the next-generation education program for IoT engineers.

Most of the present colleges in KOSEN are comprised of conservative departments: mechanical engineering, electrical engineering, information engineering, chemical engineering and civil engineering. Practically, KOSEN has few departments that focus on the IoT technology, which includes the interdisciplinary field between mechanical engineering, electrical engineering and information engineering. However, education of the IoT technology is very important for all departments of the future KOSEN since IoT has a potential ability to fuse all technologies around us via the internet.

Gunma College has five regular courses, offered by above five departments, and two advanced engineering courses, which consist of a production system engineering course and an environmental system engineering course. The production system engineering course has conducted a PBL (Problem Based Learning) class since 2015 (see Figure 1). Students in the PBL class solve various problems given by real local companies, which need knowledge of the IoT technology.

Efforts to Reform KOSEN Educations: KOSEN4.0

National Institute of Technology, Japan, which organizes 51 Colleges of Technology (KOSEN), invited the proposals "KOSEN4.0" to reform education of each College in three aspects: 1) human resources development to lead the new industry, 2) regional contribution and 3) internationalization of education. Gunma prefecture, in which Gunma College is located, has promoted the next generation industries in six fields such as an autonomous car, a robot, healthcare, etc. since it is famous for the manufacturing industry like Subaru Corporation. To realize the next generation industries, human resources that can use the IoT technology and work with engineers in different fields are indispensable. Therefore, Gunma College applied for the KOSEN4.0 as "Nurturing Engineers for IoT: Next-Generation Education Program of KOSEN by the Virtual Workshop", which selected 1) human resources development to lead the new industry and 2) regional contribution in the above three aspects. Specific methods of the education program were designed based on the PBL class for the advanced course of production system engineering.

This education program plans to produce global IoT engineers who lead the 4th industrial revolution while endeavoring to strengthen partnerships between universities, local industries and Gunma Industrial Center (see Figure 2).

Next-Generation IoT Education Program of KOSEN

This IoT education program will offer a class "Laboratory of Interdisciplinary Creative Engineering". In this class, we give lectures about social needs of IoT and the management method of a project first. Based on the lecture, students investigate real information applications and then propose their new seeds of information applications independently. They discuss their proposal information applications and choose some seeds taking account of supervisors' suggestions. Furthermore, some projects are launched to realize the seeds. Members of each project are composed of students who majored in different fields. Students make their project plans and clarify the division of roles in the project. To move their project forward, they can use a virtual workshop in National Institute of Technology, Gunma College. Finally, students discuss their final products within the projects, and then we evaluate deliverables and processes of their projects.

Virtual Workshop

The virtual workshop includes visualization of existing equipment that is placed in laboratories and facilities of our college by network management besides machine tools related to IoT. Although Gunma College has IoT-related hardware and software such as AI, deep learning and robot, college faculty, staff and students do not know how to utilize the resources well. Therefore, we connect the hardware and software resources to our college network and rebuild the resources to the virtual workshop which is shared across our college. However, the resources are not necessarily network-compatible. In this case, we add the resource so that users can confirm whether it can be utilized or not via the network. Moreover, we employ new network-compatible IoT products, a 3D-printer, a small CNC, a stereolithography apparatus, a circuit board plotter, small board computers and Interactive projectors, other than existing equipment (see Figure 3).

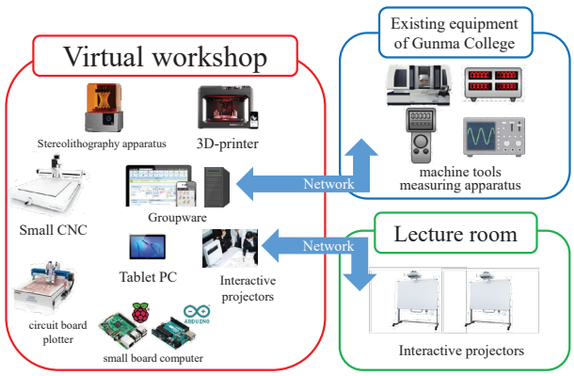

Fig. 3 Configuration of the Virtual workshop.

Table 1 Progress schedule

	Regular courses	Advanced courses
2017	・Construction of the virtual workshop ・Formulation of the class syllabus	・Construction of the virtual workshop ・Formulation of the PBL class syllabus in the environmental system engineering course
2018	・To offer the class in the mechanical, electrical and information engineering departments. ・Assessment of the program by external institutions	・To offer the class in all advanced course. ・Improvement of the PBL class ・Assessment of the program by external institutions
2019	・To offer the class in all departments. ・Assessment of the program by external institutions	・Assessment of the program by external institutions
2020	・To share the education program with a lot of KOSEN colleges by packaging the education method.	

Schedule and Final Gaols

Progress schedule of this education program is shown in Table 1. For five-year regular course, the virtual workshop was built and a class syllabus of “Laboratory of Interdisciplinary Creative Engineering” was formulated in 2017. The class will be offered to students in the mechanical engineering department, the electrical engineering department and the information engineering department in 2018. Furthermore, the same class will be offered to students of all departments including chemical engineering and civil engineering in 2019. On the other hand, we formulated a class syllabus of PBL for the advanced course of environmental system engineering in corporation with local companies in 2017 because the advanced course of production system engineering has already conducted a PBL class. The PBL class will be offered to students of all advanced course in 2018. The education program of the regular course and advanced course will be assessed by external institutions in 2019. Finally, we are going to share the education program with a lot of KOSEN colleges by packaging the education method. Final goals of the education program are employment growth in the next generation industries of Gunma prefecture and an increase of technological consultations with local companies.

Conclusions

In this paper, we reported the new education program to nurture IoT engineers in Gunma College. To date, the virtual workshop was built and specific educational methods of the program were decided. Practically, this education will be conducted this year (2018). IoT engineers will be increasingly necessary from now on since all the things around us will be connected to the network by the price reduction and miniaturisation of sensor devices and the spread of the internet. Gunma College will continue to nurture IoT engineers, who lead the 4th industrial revolution, in the education program to respond to the technological innovation of IoT.

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ENHANCE PROGRAMMING COMPETENCIES USING TEAM-BASED LEARNING SUPPORTED WITH ONLINE COLLABORATIVE LEARNING

S.K. Tan[*,a], S.F.Tay [a]

[a] Nanyang Polytechnic/School of Information Technology, Singapore

*TAN_Soon_Keow@nyp.edu.sg

Abstract

Common problems faced by ICT students are difficulties in understanding programming concepts and applying these concepts in programming. This research explores how Team-Based Learning (TBL) supported by Online Collaborative Learning (OCL) before class promote active learning among students and enhance their programming competencies.

Both TBL and OCL promote teamwork and collaboration. They align with Vygotsky's socio-cultural theory's "Zone of Proximal Development" which states that help and feedback of instructors and peers are necessary in picking up new ideas and concepts (Vygotsky, 1980).

The Experimental Group comprised 60 Year 1 students from the Diploma in Cyber Security & Forensics while the Control Group comprised 194 Year 1 students from the Diploma in Information Technology and the Diploma in Financial Informatics. The research was conducted for the "Web Applications Development & Project" module. The Control Group learnt under the traditional classroom approach while the Experimental Group underwent OCL before class and TBL in class.

For OCL, virtual rooms were created on the online platform Mural.ly where questions were posted for students to discuss, collaborate and attempt in Teams of 4-5 students. Meanwhile the instructor identified gaps in students' learning for clarification.

During classroom TBL, each student was required to solve a programming problem individually (termed as "Individual Readiness Assurance Test") before re-solving the same problem as a Team (termed as "Team Readiness Assurance Test"). The students could negotiate and appeal for their answers should their solution differ from the instructor's model solution. Finally, each Team is given a more challenging problem to solve to reinforce programming concepts taught.

This research indicates that the Experimental Group grasp programming concepts better and outperformed the Control group in their common test. Instructor's feedback, students' surveys and classroom observation also showed a higher level of student engagement.

OCL brings collaboration and problem solving beyond the classroom while TBL encourages students to think critically, collaborate, negotiate and solve problems as a Team during the face-to-face sessions. The author recommends tapping on the benefits of both teaching pedagogies as a form of blended learning to help students understand programming concepts better and prepare them for the future workforce.

Keywords: *Team-based learning, online collaborative learning, technology enhanced learning, blended learning, active learning, programming, pedagogy*

Introduction

A common observation made by lecturers is that students who face difficulties in programming often grapple with the understanding of the underlying programming concepts. This in turn leads to the students not being able to apply programming concepts into solving programming problems which result in a dip in their confidence towards programming as well as a drop in their programming competency.

To address the above challenges, this research explored the adoption of Team-Based Learning in a programming class with the support of Online Collaborative Learning as the teaching technique for the pre-classroom segment of the Team-Based Learning approach. Both Team-Based Learning & Online Collaborative Learning are teaching pedagogies that have been researched extensively. By tapping on the benefits of both strategies, the author aims to help instructors identify and address learning gaps in their students earlier. Meanwhile students, besides having their doubts clarified before attending class, can also have ample opportunities to apply programming concepts to solve programming tasks through their individual and team readiness assurance tests as well as the programming challenges posed to them in class.

Through active engagement of students both online and face-to-face, the author hopes to strengthen students'

understanding of programming concepts, increase their confidence towards programming and thus enhance their programming competencies.

Literature Review & Pedagogy

Team-based Learning is an instructional strategy that promotes active learning and participation through small group interactions (Michaelsen et. al, 2002). In Team-based learning, students go through pre-assigned materials before coming to class where each student is required to take an Individual Readiness Assurance Test (iRAT) before re-attempting the same test, termed as the Team Readiness Assurance Test (TRAT) (Michaelsen & Sweet, 2008) as a team. The TRAT encourages team discussion and collaboration among members. Finally, the team is given a group challenge to reinforce concepts and deepen their understanding. Both the TRAT and the group challenge encourage active group discussion and facilitate learning.

Though well-backed by research as an effective strategy, Team-Based Learning is conducted predominantly in the medicine field to help students apply concepts taught in an engaging manner (Parmelee, 2012).

Whittington (2007) implemented Team-Based Learning in a programming class and observed a higher level of engagement and enthusiasm in the students during class participation as compared with traditional classroom teaching. However, the results he collected from his study was not significant to conclude if Team-Based Learning is an effective strategy to adopt for use in programming. Whittington noted that programming tend to be individualistic in nature and might not be as suitable for Team-Based Learning (Whittington, 2007).

Lasserre (2009) also researched on Team-Based Learning in a programming class and reported that there was a drop in the attrition rate for the students exposed to this form of instructional approach in class. She observed that class time management and the provision of immediate feedback by instructors were important factors for success for this teaching approach (Lasserre, 2009).

Team-Based Learning has been known to pose practical challenges such as having to set aside substantial time for the iRAT and tRAT in the classroom segment, leaving limited time for instructors to clarify content and learning material in class (Kolar & Sabatini, 1997).

To address these challenges, in this research, the author explored the use of Online Collaborative Learning to support the pre-classroom segment of the Team-Based Learning instructional strategy. Online Collaborative Learning allows students to keep up with their lessons in a self-paced, asynchronous manner while supporting team collaboration and interactions among students and instructors in-between their face-to-face sessions (Gomez et al., 2010). With Online Collaborative Learning, students can clarify their doubts and misconceptions with peers and instructors before coming to class. This helps them to perform programming tasks in class better. Through Online Collaborative Learning, instructors can also identify the learning gaps in their students as well as pinpoint challenging concepts that the students may have difficulties understanding even before class. This in turn helps the instructors to be more focused in class, enabling them to allocate more time to explain concepts that students deem as challenging. Over the years, collaborative learning has proven to be effective in helping learners pick up new ideas and concepts (Ku et. al, 2013).

Both Team-based Learning and Online Collaborative Learning promotes teamwork & collaboration, and align with Vygotsky's socio-cultural theory's "Zone of Proximal Development" that states that help and feedback of instructors and peers are necessary for a learner to pick up a new idea and concept (Vygotsky, 1980). According to Vygotsky, interaction between social, affective and cognitive states in a student's development is important for learning to take place (Vygotsky, 1980). Team-based Learning and Online Collaborative Learning support this interaction.

Tapping on the benefits of both instructional strategies, this research aims to increase students' confidence in programming and help students enhance their programming competencies by letting them work in teams to validate and reinforce the programming concepts in an engaging manner before and during class.

Methods and Measurement

To investigate the effectiveness of tapping on Team-Based Learning supported with Online Collaborative Learning to enhance programming competencies, 60 Year 1 Diploma in Cyber Security & Forensics students taking the module ITP1911 "Web Application Development & Project" during 2017 Semester 1 were identified as the Experimental Group. The research was carried out for the topic on "JavaScript" which is a programming language that allows dynamic creation of web content. Year 1 students from the Diploma in Financial Informatics and Diploma in Information Technology taking the same module in the same semester were identified as the Control Group. Both Experimental & Control groups consisted of freshmen new to programming. At the end of the research, both groups of students were required to take the same summative Javascript test as part of their in-course assessment.

The research was conducted over a period of 3 weeks. At the start of the research, the students in the Experimental Group were randomly assigned into groups of 4s to 5s. They would remain in this same group throughout the 3 weeks of the research study.

For the Online Collaborative Learning segment, the author used Mural.ly, a cloud-based, online visual workspace that provides shared, digital whiteboards for online team collaboration (Mariano, 2012). Accounts were set up for each student and invitation were sent for them to join virtual rooms created in Mural.ly for their Online Collaborative Learning before class. Exercises were posted on Mural.ly by the instructor for the students to attempt as a team before they attend their face-to-face session in class. To aid the students in these exercises, pre-assigned online reading materials were made

available to them on Blackboard, the learning management system adopted by the institution. The students were also encouraged to raise their queries about Javascript on Mural.ly for peers and instructor to clarify.

Online Collaborative Learning on Mural.ly allowed the instructor to track and participate in students' discussion as well as clarify doubts that the students might have regarding the Javascript topic before they attend the face-to-face classroom session.

Figure 1 below shows a snapshot of the online exercises posted by the instructor for students to attempt as a Team.

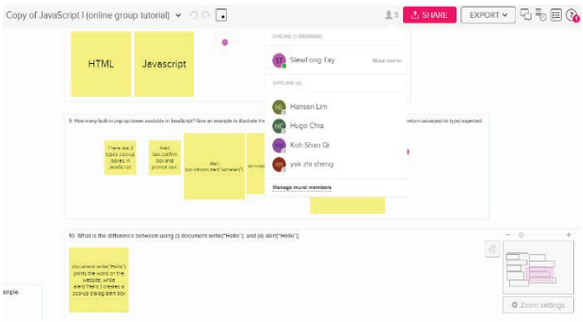

Figure 1: Online Collaborative Learning On Mural.ly

Figure 2 below shows the snapshot of the instructor tracking the progress of a student on Mural.ly and giving feedback to the latter.

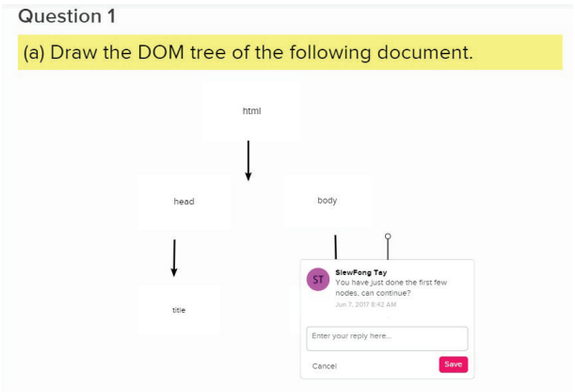

Figure 2: Instructor Tracking Student's Learning Progress On Mural.ly

Following each session of Online Collaborative Learning is the face to-face classroom session which was aligned to the Team-based Learning instructional approach comprising the following segments:

individual Readiness Assurance Test (iRAT)
For the iRAT, each student was required to take a test individually. As this is a programming module, the author intentionally designed the iRAT to be application-based where coding was required. Each student would be required to solve a programming problem within a given time-frame. The iRAT was meant to test the student's understanding of the topic, how familiar the student was with the programming syntax and how well he had grasped the Javascript concepts.

team Readiness Assurance Test (tRAT)
For the tRAT, the students were required to re-attempt the same programming problem as a team. As they discussed on the best algorithm to adopt to solve the problem, further learning would take place and the students could exchange programming techniques with one another.

Clarification
After the tRAT, the instructor would disclose the model solution to the students and allowed the students to negotiate and appeal for their solution to be accepted in the case where their solution worked but differed from that of the instructor's solution. Through this, students would be exposed to a variety of programming techniques.

Further Challenge
Finally, a team challenge in the form of a more advanced programming problem was posed to every Team for them to collaborate and work on together to further strengthen their programming concepts. This provided the students with further opportunity to practise their programming skills.

To evaluate the level of success in using Team-based Learning supported with Collaborative Learning to enhance students' programming competencies, the author used "Learning Effectiveness" and "Students' Confidence Level Towards Programming" as learning matrices to be analysed against students from the Diploma in Information Technology and the Diploma in Financial Informatics who were taking the same module under the traditional classroom approach.

At the end of the research, both the students in the Experimental and Control Groups took a Javascript test as part of their module in-course assessment. This assessment constituted 10% of the overall module. For Learning Effectiveness, the following facets of measurements were being considered:

- passing rate of the students in the Javascript test
- mean score of the students in the Javascript test

To investigate whether students' confidence level towards programming had increased, we looked at the qualitative feedback that was collected via various channels:

- survey questionnaires for students at the end of the research study to gather their experience in Online Collaborative Learning and Team-based Learning
- lecturer's observation on students' participation

The qualitative data collected would provide additional insights into how students perceive this method of teaching, whether they enjoy this form of

learning and also how this instructional approach can be further improved for future sessions.

Results and Discussion

Improved Learning Effectiveness

The author based the learning effectiveness on students' passing rate as well as the mean scores in their Javascript assessment. The assessment constituted 10% of their total score for this module. Figure 3 below depicts the passing rate of both Experimental and Control groups.

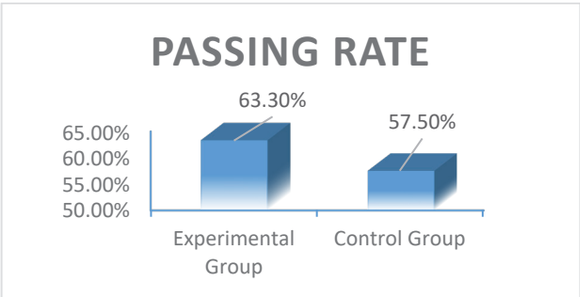

Figure 3: Passing Rate Of Students In Their Javascript Test

From Figure 3, it was observed that there was a higher percentage (63.30%) of Diploma in Cyber Security & Forensic students passing the Javascript assessment compared to students from the Diploma in Information Technology and Diploma in Financial Informatics (57.50%). The higher percentage of pass in the Experimental group can be attributed to the students having a better grasp of Javascript concepts.

Next, comparison was made to see how each group fared in terms of their mean score.

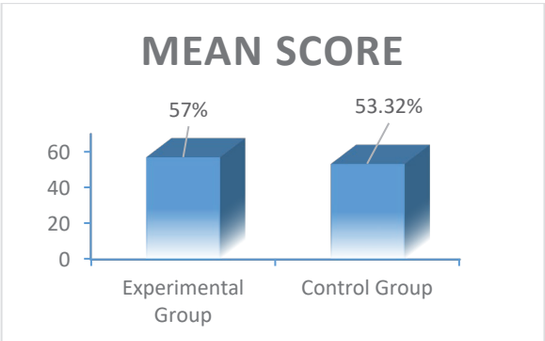

Figure 4: Students' Mean Score In Their Javascript Test

Figure 4 shows that the mean score attained was higher for students in the Experimental group (57%) compared to the students in the Control Group (53.32%). The results indicated a positive correlation between this form of instructional approach and students' learning.

In the survey conducted to gather students' perception on whether Team-Based Learning supported by Online Collaborative Learning had been helpful, 78.79% of the respondents agreed or strongly agreed that online collaboration before class had helped them grasp concepts better while slightly more than 20% disagreed or strongly disagreed on that. This is shown in Figure 5. The reason for the students' disagreement could be attributed to them not being able to work well with their team-mates which in turned affected the effectiveness of their online collaborative learning. From the qualitative feedback collected, three respondents specifically requested to form their own groups for future collaborative learning.

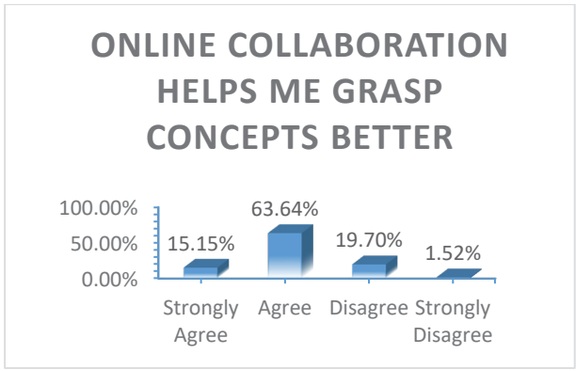

Figure 5: Survey Results On Whether Online Collaboration Helped Students Grasp Concepts Better

Figure 6 below shows the students' response when asked whether their confidence level in programming had increased as a result of this instructional approach. More than 77% of the students agreed or strongly agreed to that. There could be varying factors attributing to the reason why students disagreed or strongly disagreed on this. As observed by the instructors, some students did not accept the online invitation to join Mural.ly for their online collaborative learning. The lack of practice could have affected their programming confidence and competency during class.

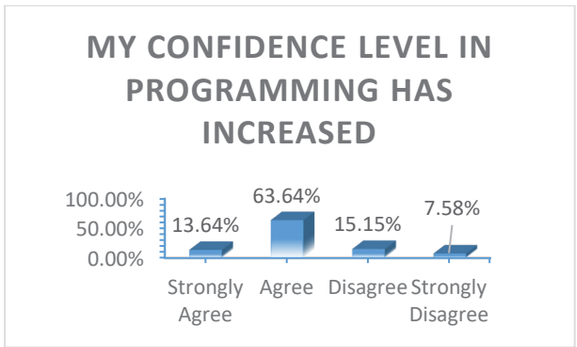

Figure 6: Survey Results On Whether Students' Confidence Level In Programming Has Increased

Overall, the research findings indicated that Team-based Learning supported with Online Collaboration has a positive impact towards students' grasp of programming concepts and confidence.

From the survey questionnaires done by the students, it was observed that majority of the students enjoyed this teaching approach and indicated that it was better to work in groups than alone. Only 1 respondent requested not to have this form of learning. The qualitative feedback collected was also very positive with a number of similar responses from students such as "I like it", "It's fun", "Good job", "Engaging", etc. When asked how they would like the lesson to be further improved upon, students commented that they wish to have more time for the Readiness Assurance Tests.

Classroom observation showed an increase in the level of student engagement. The instructor gave the following positive feedback with regards to this instructional approach:

- Most students participated actively during classroom discussion.
- Students were enthusiastic and continued to code beyond the time limit set for them.
- When the model solution was revealed, the students were very engrossed with the solution, which sparked off many questions for instructor to clarify.
- Instructors were able to gauge the programming ability of each student better.
- Students had learnt more through this instructional teaching approach

The following challenges were faced by the instructor:

- For the Online Collaboration segment, some students did not accept the invitation sent by the lecturers for them to join the Mural.ly platform to collaborate online before meeting face-to-face.
- Shortage of time to run the various activities in the Team-based Learning segment. Time management is critical for the face-to-face segment. A few students came in late and affected their team's performance.
- Students displayed a higher level of stress for this form of instructional approach, where marks are allocated for the iRAT and the tRAT, compared to traditional instructional approach.
- Some students continued with their coding challenge despite the time limit for the iRAT and tRAT being up.

Overall, instructors felt that they were able to identify learning gaps, assess the technical competency of each student and help them understand concepts better. Generally, it was observed that Team-based Learning with Online Collaborative Learning led to students being more inclined to take ownership for their learning as they are exposed to course content through preparation before class. Majority of the students enjoyed this form of learning compared to the traditional mode.

Addressing the challenges encountered, improvement can be made to future research studies of similar nature by ensuring all students participating in the study have access to the online collaboration platform before the start of the research. Instructors can also communicate the purpose of the research to the students participating in the research study to help them understand the motivation behind this instructional approach study, to prepare them better and alleviate the stress that they may be facing. More guidance can also be given to the students on how they can better manage their time during the readiness assurance tests.

Conclusions

Challenges faced by our students in programming are difficulties in grasping programming concepts and not knowing how to apply these concepts to solve programming problems. This research explored the Michaelsen's Team-based learning approach supported with Online Collaborative Learning to increase students' confidence towards programming and enhance their programming competencies. The research results showed that, harnessing the effectiveness of both strategies, there was a positive correlation in students' confidence levels towards programming and students grasp programming concepts better compared to traditional teaching methods. It was observed that students have turned from passive into more active learners with this approach. Instructors also found this form of blended learning beneficial with students taking more ownership in their learning.

Team-based Learning and Online Collaborative Learning encourage students to think critically, collaborate, negotiate and solve problems as a Team. These are skills listed as among the top 10 future skills required in 2020 by the World Economic Forum Report (World Economic Forum, 2016). The author recommends adopting this pedagogical approach to help students enhance their programming competencies.

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AN ATTEMPT TO USE A PHYSICS EXPERIMENT CONDUCTED BY A FIFTH-GRADE KOSEN STUDENT FOR LOWER-GRADE STUDENTS BY EMPLOYING LEARNING MATERIALS ON ELECTRONIC DEVICES

N. Kakuda*,[a] and T. Kobayashi [b]

[a] Department of Electronic Control Engineering, National Institute of Technology, Yonago College, 4448 Hikona, Yonago, Tottori 683-8502, Japan
[b] Department of Liberal Arts Education, National Institute of Technology, Yonago College, 4448 Hikona, Yonago, Tottori 683-8502, Japan

*E-Mail Address of the corresponding author: kakuda@yonago-k.ac.jp

Abstract

In order to become an engineer who has scientific analytical skills, gaining knowledge about physics is crucial for lower-grade Kosen students during their five-year curriculum as physics is the foundation for studying engineering subjects. However, it may be difficult for these students to understand the usefulness of their future businesses while studying. In advance, we are engaged in using the contents of the higher-grade engineering course for lower-grade physics in order to combine liberal arts subjects and specialized subjects and enrich career education. In this study, we examine learning materials on electronic devices, which were used in an experiment on gravitational acceleration conducted by a fifth-grade student.

The learning material was developed by several fourth- and fifth-grade students as a graduation-research task. The material can detect a falling object by employing semiconductor lasers and photo-integrated-circuit diodes in vacuum and recording the number of seconds taken by the object to fall, by using a microcomputer (Arduino Mega 2560 Rev. 3). In experiment training, a fifth-grade student demonstrated the material to 214 first-grade students and asked them to analyse the gravitational acceleration as per the seconds recorded by the microcomputer. Some simple questionnaires were completed before and after the training.

There were two important reasons for the first-grade students to attend the experiment training. First, the lecturer was a fifth-grade student, and the learning material was handmade. Many of the first-grade students had an affinity with the fifth-grade student and thought positively about learning advanced techniques in higher grades. Second, an understanding of gravitational acceleration is crucial. It appeared that the first-grade students had little quantitative understanding of the concept as 90% of them answered that the acceleration of a falling iron ball was greater than that of gravity (9.8 m/s2) in the air. However, it was found that the training promoted qualitative as well as quantitative understanding.

In conclusion, a physical science experiment was performed for lower-grade students by employing learning materials on electronic devices by a fifth-grade student. This attempt effectively integrated liberal arts subjects with specialized subjects.

Keywords: *Physics, specialized subjects, cooperation between subjects, teaching by a student, learning material, electronic device, teaching effort*

Introduction

There are 3.4 million Japanese students who graduate from junior high school [International Standard Classification of Education (ISCED)-11 level 2]. A total of 3.30 million students (97%) go on to high school (ISCED-11 level 4) for three years and 0.05 million (1.5%) go on to the National Institute of Technology (Kosen) (ISCED-11 level 3 and 5-6) for five years. Among those who graduate from high school, 2.56 million (78%) attend university or college (ISCED-11 level 5-8). Since 73% of high school students follow general courses of study, where the ratio of literary and science subjects are comparable, it follows that 1.87 million junior high school students (57%) only begin to study specialized subjects in university or college. On the other hand, the Kosen curriculum, which includes engineering courses that range from high school to first-year college level, offers five years of specialized subjects. Therefore, Kosen students are a minority group that studies specialized subjects from an early age. These future engineers study science, mathematics, and other specialized subjects to acquire knowledge about natural science and data analysis. The early study of such subjects has both benefits and drawbacks due to individual differences for strength of intentionality to engineer in admission to Kosen. On the one hand, Kosen students can begin their engineering education early and acquire wider knowledge and skills, which benefits students with strong directionality. However, students with weak directionality lose motivation to study in the

initial stage. Therefore, it is important that Kosen students improve their career consciousness in addition to their study of science and mathematical subjects.

For lower-grade Kosen students, gaining knowledge about physics is crucial, as physics is the foundation for studying engineering subjects. However, it may be difficult for these students to understand the usefulness of their future businesses. Furthermore, physics is difficult for them because they are not used to mathematical description of physical laws and principles. In advance, we use the content of the higher-grade engineering course for lower-grade physics in order to combine liberal arts subjects with specialized subjects and enrich career education. In this study we examine learning materials on electronic devices, which were used in an experiment on gravitational acceleration conducted by a fifth-grade student. This study provides useful insight into collaboration between universities and high schools.

Materials and Methods

The physics experiment materials included free fall equipment in a vacuum. It was developed by several fourth- and fifth-grade students as a graduation research task. The knowledge and skills for making the equipment are tied to the department to which the graduation research students belong (Department of Electronic Control Engineering). Since the curriculum of the Department of Electronic Control Engineering includes complex electrical and electronic engineering, computer science, and mechanical engineering ("Mechatronics"), it can be said that this equipment controlled by a microcomputer and sensors embodies the department. Figure 1 shows an image of the equipment. The

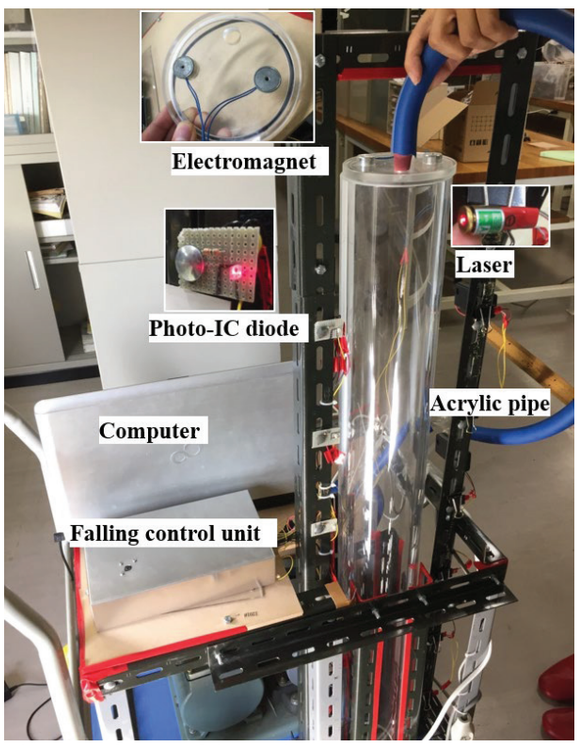

Fig. 1. An image of the equipment.

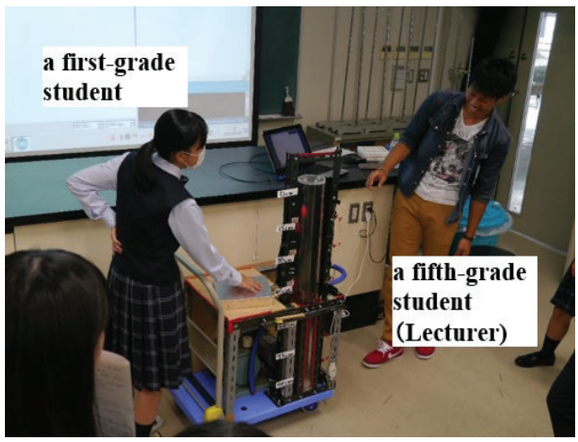

Fig. 2. A typical scene of the experiment.

equipment detects a falling object by employing semiconductor lasers (output power of 1 mW and emission wavelength of 650 nm) and photo-integrated-circuit (IC) diodes (Hamamatsu Photonic S7183) in a vacuum made by a rotary pump and an acrylic pipe and recording the number of milliseconds it takes for the object to fall by using a microcomputer (Arduino Mega 2560 Rev. 3). The acrylic pipe is 1 m long due to improvement of portability. The semiconductor lasers and the photo-IC diodes are arranged in a pair in increments of 150 mm on the pipe. The fall of objects is controlled by an electromagnet and solid-state relay module. An execution program is written by Arduino IDE (Version 1.8.3) for the microcomputer. The microcomputer is connected to a laptop computer (Operating system: Windows 10) with Universal Serial Bus 2.0. The microcomputer and drive parts of the electromagnet are in an aluminium container. The equipment sits on a carriage and can be transported by hand. The power supply for the equipment can be drawn from a classroom outlet.

The experiment and training was composed of: (1) a questionnaire before the experiment, (2) introduction of the lecturer (a graduation research student), (3) experiment and analysis of gravitational acceleration and (4) a questionnaire after the experiment. The questionnaires before and after the experiment asked about gravitational acceleration and attempted to ascertain the educational effect of this training. Figure 2 shows a typical scene from the experiment. In the experiment first-grade students observed a steel cap and a wrap film with a small steel washer that fell simultaneously from the top of the acrylic pipe both in a vacuum and in the air. The steel cap was only used to measure falling time for the gravitational acceleration. Table 1 displays data on the distance of the steel cap and its falling time. In this table, the theoretical value is also shown for reference. The measured times were several tens of ms longer than the theoretical ones. This difference of time is thought to be due to the magnetization of the steel cap. In fact, the falling time was within 1 ms compared to the theoretical value after 150 mm. Therefore, gravitational acceleration g was analyzed by the difference in fall time t from 150 mm to 900 mm and then substituted the time with the following

Table. 1. A data of distance of the steel cap and its falling time.

Distance (mm)	0	150	300	450	600	750	900
Time (theoretical) (s)	0	0.1749	0.2473	0.3029	0.3498	0.3911	0.4284
Time (sample 1) (s)	0	0.177	0.250	0.307	0.354	0.397	0.435
Time (sample 2) (s)	0	0.205	0.279	0.335	0.382	0.424	0.463
Time (sample 3) (s)	0	0.187	0.260	0.319	0.373	0.409	0.448
Time (sample 4) (s)	0	0.191	0.263	0.320	0.366	0.408	0.448
Time (sample 5) (s)	0	0.177	0.252	0.309	0.357	0.399	0.436
Time (sample 6) (s)	0	0.225	0.297	0.354	0.401	0.443	0.481
Time difference (theoretical) (s)		0.0724	0.0556	0.0469	0.0413	0.0373	
Time difference (average) (s)		0.073	0.057	0.048	0.042	0.038	

mathematical formula, $y = \frac{1}{2}gt^2$. Here, y is distance. Finally, the arithmetical mean gravitational acceleration was calculated. The first-grade students were divided into groups of nine or 10 and watched a demonstration by the lecturer. During the demonstration, the lecturer let the first-grade students perform the operation (rotation of vacuum valve and pressing a button to turn off the energization of the electromagnet, and so on) as much as possible. After the demonstration, the first-grade students drew a diagram of coordinate versus time characteristics on grid paper. Then they calculated the average gravitational acceleration and compared it with the theoretical value.

The graduation research student (lecturer) carried this equipment into the classroom and lectured to first-grade students (5 classes, 214 people total) during 90-minute physics classes. Classroom teachers helped facilitate.

Results and Discussion

Figure 3 shows results of the questionnaire before the experiment training. In response to the question, "Which iron ball and wing dropped from the same height falls quickly in vacuum?", 98% of the first-grade students understood that they fell at the same time. However, in response to the question, "Is the acceralation of iron ball falling in the air larger or smaller than the gravitational acceralation 9.8 m/s2?", up to 53% of the first-grade students answered "small." Of course, this answer is incorrect because the iron ball decelerates due to air resistance. The correct answer is "same" (any objects have the same gravitational acceleration), and the ratio

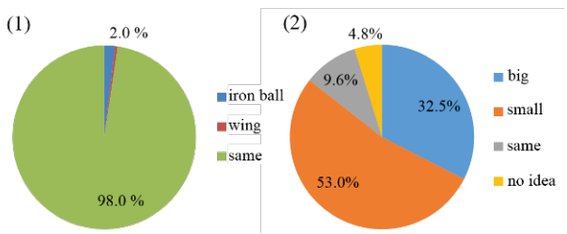

Fig. 3. A result of questionnaire before the experiment training. (1) Which iron ball and wing dropped from the same height falls quickly in *vacuum*?, and (2) Is the acceleration of iron ball falling in the *air* larger or smaller than the acceleration of gravity 9.8 m/s^2?

was only 9.6 %. Although air resistance exceeds range of the first year, it was thought that qualitative and quantitative understanding about free fall does not combine well and that allied force was not nurtured.

Figure 4 provides results of the questionnaire after the experiment training. In response to the question, "Did your understanding of acceleration of gravity deepen?", 84% of the first-grade students answered yes. Some students commented that they deepened their understanding because they were able to confirm what they knew as knowledge. Furthermore, in response to the question, "Did you understand the structure of experiment equipment and the principle of measuring time?", 87% of the students answered yes. Thus, the first-grade students could see that they can fabricate hand-made devices using technical knowledge and skills such as mechatronics and make them useful in upper grades. In addition, in response to the question, "Was the lecturer's explanation easy to understand?", 94% of the first-grade students answered yes. The graduation-research student, who is a senior student, helped the first-grade students tackle the experiment training with a feeling of familiarity and got them interested in the experiment equipment. It seems that it was good to have a part that spoke his school life and course after graduation as a self-introduction of the graduate student

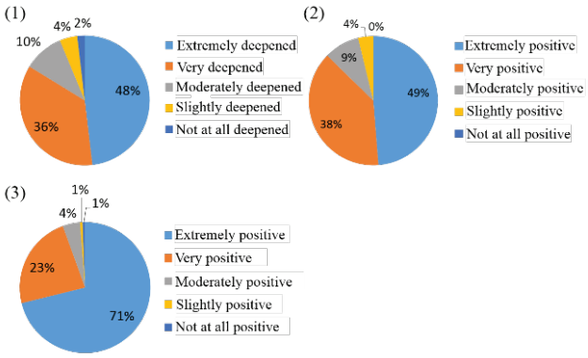

Fig. 4. A result of questionnaire after the experiment training. (1) Did your understanding of acceleration of gravity deepen?, (2) Did you understand the structure of experiment equipment and the principle of measuring time?, and (3) Was the lecturer's explanation easy to understand?

himself in the first half of the experiment training class. Using free-fall equipment, the graduate student conducted the experiment with the first-grade students and obtained two educational effects: a deeper understanding of gravitational acceleration among young students, and improvement of motivation for the study of specialized subjects in upper grades.

Conclusions

In this study, we conducted an experiment about gravitational acceleration for first grade students using free-fall equipment. The first grade students deepend their understanding of gravitational acceleration and strengthened their motivation to study specialized subjects in the upper grades. Since motivation for learning improves career consciousness, it can be said that they are essential components to help students select their occupations. We think that improvement of academic achievement and of career consciousness is like knitting; the students choose their desired occupations because the two factors are braided together. While orienting toward such a philosophy, we will continue to increase opportunities that combine liberal arts subjects and specialized subjects.

Acknowledgements

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NEW CURRICULUM INCORPORATING CLUSTER-BASED, PROJECT-DRIVEN APPROACH TO TEACHING COMPUTER SCIENCE FUNDAMENTAL SKILLS

S. Sathish[*,a], S.P. Tan[a], A. Tan[a] and E. Nalaka[a]

[a] Temasek Polytechnic School of Informatics & IT / Diploma in Information Technology, Singapore

*sathish@tp.edu.sg

Abstract

Teaching computer science fundamentals effectively has been a challenge over the past twenty years. Many independent approaches have been tried with differing levels of success. In addition, with the increasing pace of change of technology in light of emerging areas, it is imperative for students to be able to learn core computing skills that, not only help them master their domain, but become a strong foundation from which to launch into a career of lifelong learning. In response to this, at the Temasek Polytechnic School of Informatics & IT, the first year curriculum was re-envisioned. The curriculum was reviewed and revamped based on the following three pillars: (a) developing cluster-based competencies, (b) integrating a project-driven focus and (c) incorporating greater industry engagement. This paper highlights the design and delivery of the revised curriculum that was adopted for over 500 students in 2017. It describes the structure of the curriculum in terms of the three pillars. Specifically, this paper will focus on the delivery of the software cluster of subjects to the first year students during their first semester. In this cluster, the students learned two subjects related to (1) mobile application development and (2) the design of the user experience and interface. Students were then tasked with integrating what they learned from the two subjects and developing their own mobile application. The paper concludes by sharing about how the students performed with this new curriculum compared to the previous curriculum that comprised of multiple disparate subjects. The paper also examines how this new curriculum enhanced student interest and motivation in programming. Finally, this paper discusses the key learning points that the teaching team garnered from this mode of teaching.

Keywords: *cluster-based competencies, integrated project, industry engagement, mobile application development, user experience, user interface, student interest, student motivation*

Introduction

As part of Singapore's Smart Nation vision, the government, companies and educators advocate that learning core computing skills can help students to gain an edge when they enter the workforce because computers and information technology have permeated almost every discipline and profession (Lauw, 2018; Tham, 2017). These skills will enable students to build a strong foundation so that they can contribute more effectively to their domain and start them on a path towards a career of lifelong learning.

In Singapore, coding fever is growing with kindergarten kids being introduced to coding, schools offering computing as GCE O-level and A-level subjects, and an increasing number of enrichment centres even offering coding boot camps (Lauw, 2018). For example, in 2017, Singapore launched a Digital Maker Programme that aimed to distribute 100,000 micro:bits to school-going children and adults over two years to encourage them to learn basic coding, while since September 2014, a coding curriculum became mandatory in all British primary and secondary schools (Tham, 2017).

However, numerous studies have highlighted that teaching computing and programming can be very challenging (Ahmed et al., 2018; Kannan et al., 2018; Mow, 2015), as it poses a different set of challenges and techniques compared to learning other traditional subjects such as learning reading, writing or physics (Brown and Wilson, 2018). In response to this, the first-year curriculum at the Temasek Polytechnic School of Informatics & IT (IIT) was re-envisioned to enhance student interest and motivation in programming. The revamped curriculum focused on three key pillars – developing cluster-based competencies, integrating a project-driven focus, and incorporating greater industry engagement.

This paper will present a review of prior literature on teaching computer science fundamentals, describe the new curriculum offered by IIT, elaborate on the impact of the new curriculum on student interest, motivation and skills in programming, and discuss the key learning points of the teaching team after adopting this new mode of teaching.

Teaching Computer Science Fundamentals

One of the core challenges is how teachers can help students to better understand and apply programming skills and knowledge so as to increase their motivation to continue to learn and eventually embrace a computing related career. Motivation here is defined as a "student's willingness, need, desire and compulsion to participate and be successful in the learning process" (Mow, 2015). In particular, this paper focuses on how IIT enhanced students' intrinsic motivation by growing their interest in programming, and how they structured their subjects and assignments to provide students with a greater sense of achievement to further motivate them (Mow, 2015).

Teachers need to adopt learning methods that enhance the engagement of students to increase their interest in the subjects (Kannan et al., 2018). This is particularly important because a number of the first year students possess little or no background in computing or programming (Kannan et al., 2018), so they may find it challenging to learn these computing skills. So they require greater resources and support to scaffold their learning so they achieve success and bolster their confidence, self-efficacy and ultimately their motivation to learn programming (Mow, 2015). This is necessary because competence in programming is not an innate ability but rather a skill that can be acquired and improved with practice (Brown and Wilson, 2018).

There is also a need to go beyond simply understanding the syntax of a programming language, to developing multiple skillsets and knowledge (Ahmed et al., 2018) to help learners become more effective problem-solvers (Lauw, 2018). As Steve Jobs once said, "Coding teaches you how to think" (Tham, 2017). Furthermore, this includes skillsets and knowledge related to managing the data and databases used by the application, and enhancing the user experience and interaction design (UXID) of the application.

Classroom teaching and lectures are, however, only beneficial for teaching programming if the students already have a certain level of comprehension and logical thinking and can fill in the gap between the lessons and actual practice on their own (Ahmed et al., 2018). First year students though, typically have little or no such background knowledge in programming and thus have difficulty in writing codes or detecting syntaxial or logical programming errors (Ahmed et al., 2018) so they need more hands-on practice to help them apply what they are being taught. Moreover, through traditional classroom style teaching or lectures, students are merely passive recipients of knowledge so they often perceive programming lessons as dry, boring and tedious (Ahmed et al., 2018).

Instead, students often prefer more hands-on activities to help them to learn through doing (Mow, 2015). This is in line with studies that advocate that higher levels of student engagement in the learning process can facilitate deeper learning (Mow, 2015). For example, in a study by Ahmed et al. (2018), 65% of their survey respondents listed lab sessions as their most favorite resource for learning programming compared to just 18% who preferred using books. In particular for first year students, instead of merely asking them to complete a series of tasks on their own, teachers should engage in live coding to create the solutions in front of their students so that they can better respond to "what if" queries from their students as they code along with their teachers and understand how their teachers diagnose and correct their mistakes (Brown and Wilson, 2018).

However, it is challenging to find the right balance of hands-on practice activities for them. If they are given multiple small lab tasks, they may find it easier to complete each task but may struggle to understand how these tasks are related or how they can solve more complex problem. Alternatively, if they are given a big project, they can better appreciate how the different components of the application, such as the functions, database and UXID, are inter-related but without adequate scaffolding, they can easily be overwhelmed by the project and thus de-motivated from continuing to learn programming. Teachers therefore need to provide students with a sufficiently complex sample application which has been broken down into multiple sections, each with its own step-by-step guides on how to achieve that particular sub-goal (Brown and Wilson, 2018).

Finally, teachers should provide students with authentic tasks that they will find more engaging compared to abstract coding examples that students may have difficulty appreciating or linking to the real-world problems that they need to solve (Brown and Wilson, 2018). For example, instead of merely asking students to program an application to find the maximum number from a list of numbers, it could be more meaningful if they were asked to find the highest student grade from a list of grades for a class. It would be even more meaningful if teachers could relate the course content to the industry and real-world problems through the use of real examples and cases (Kannan et al., 2018).

Description of the New First-Year Programming Curriculum

In the past, first-year IIT students learned each core computer science skillset separately. For example, programming, databases and UXID were taught as disparate subjects. This provided students with the opportunity to learn each skill in greater depth without the additional complexity of trying to integrate the skills. This was particularly useful in helping students who were new to computing to understand the basics of programming. However, the students subsequently faced challenges in learning more advanced computing subjects later in the course as they had not fully understood how these different skillsets need to be implemented in tandem, such as to develop complete mobile and web applications.

In the new curriculum, students learned the related subjects collectively as a cluster. They were taught how each component was related to the others and how they should manage each component as part on a single comprehensive application development process. The students were then given one project task – to develop a mobile application in semester one and a web application in semester two – and they had to integrate all these skills

to develop a complete application. To help the students to better understand and develop this single big project, they were given multiple hands-on tasks during lessons to scaffold their learning. Each task focused on a different programming skillset or piece of knowledge.

Students were thus forced to apply what they learned each week to complete each task in class under the guidance of their teachers. Furthermore, all the tasks were related to one another so that in effect, they students were building a simplified version of the actual application during their lessons. In this way, the teachers could help the students to understand how these different components of an application were inter-related, and concurrently build their skillsets and knowledge step-by-step until they were ready to develop their final project.

To increase student interest and help them to better understand the real impact of the application of their computing skills, their final project was based on a real context that the students regularly experienced. In semester one, they developed a music streaming mobile application and in semester two, they developed an F&B related web application.

Impact of the New Curriculum

Students were asked to complete a survey at the end of each semester so that the teaching team could gather feedback on their experiences with the new curriculum subjects. Generally, the feedback from the surveys were positive.

During the first semester, students were first introduced to Java programming and UXID, and were tasked with developing a mobile application (see Figure 1). About 500 students took these subjects and 322 of them responded to the survey.

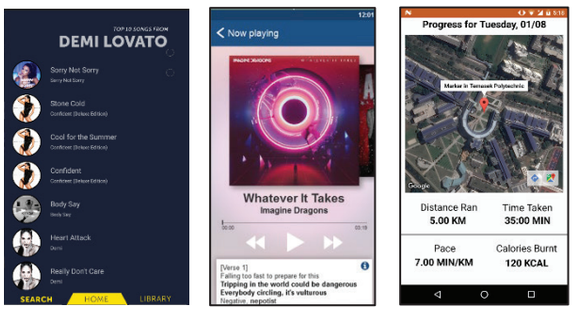


Figure 1: Screenshots of Mobile Applications Developed by First-Year Students in Semester 1

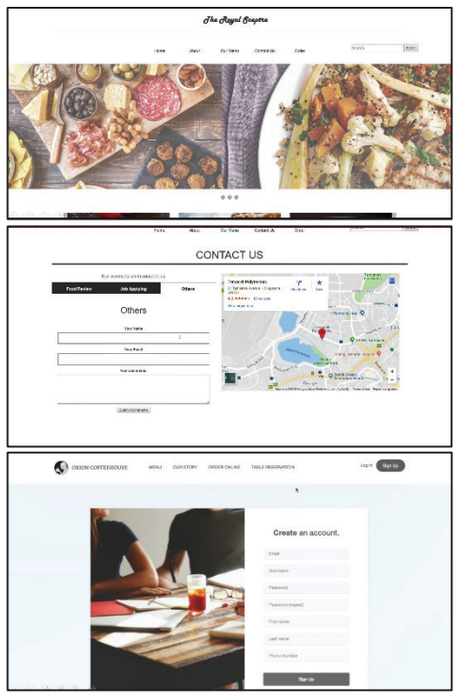
About 94% of respondents feedback that their learning experience helped to raise their interest in coding, with about 95.7% finding it interesting that they learned computing by developing an actual mobile application. This was evident during lessons as teachers found the students to be more willing and pro-active in engaging in self-directed learning to search for online resources, such as forums and videos, so that they could learn how to implement other functions into their applications, beyond the scope of what was taught in the subjects.

This behaviour was particularly encouraging to see in students who were new to programming, who in past would typically have been apprehensive about learning coding. As one student, with no prior programming experience, shared, "I found it enjoyable, perhaps because I have not experienced using other programming languages yet. It feels great whenever I am able to come up with and implement my ideas successfully into my app."

In fact, 75.2% of respondents expressed that they felt at least somewhat confident in their ability to develop other mobile applications in the future, with 80.1% stating that they were at least somewhat interested in developing other mobile applications and releasing them on a mobile app store such as Google Play.

The students were also generally more confident in their programming abilities when they saw that they were able to develop a fully operational application that was in some cases comparable to the applications that they found on the iTunes and Google Play stores and had drawn inspiration from. During the semester break, this motivated a number of students to pro-actively engage in further self-learning to deepen their programming skills and improve their applications in preparation for the next semester, which was a good sign that they were being intrinsically motivated to start their journey of being lifelong learners.

During the second semester, the students were introduced to more advanced programming concepts and multiple new programming languages, including HTML, JavaScript, CSS and MySQL, as well as how to work with databases, and develop both client-side and server-side codes as part of a web application (see Figure 2). About 500 students took these subjects and 114 of them responded to the survey.



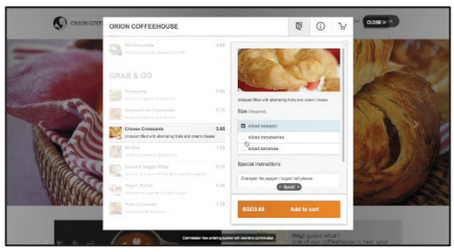


Figure 2: Screenshots of Web Applications Developed by First-Year Students in Semester 2

About 96.1% of respondents felt that their coding skills had improved at least somewhat after this second semester. About 88.5% of respondents also acknowledged that the subjects stimulated their thinking beyond the content covered in the lessons. As one student put it, "I found it really challenging to do but at the same time it really stimulated my thinking."

This was despite the challenge of having to pick up so many different programming languages during the semester. As one student shared, "At first I found all the things taught to be very difficult but after understanding each one at a time, all of it started to fall in place and make sense."

Finally, about 93.3% of students were at least somewhat interested in developing their own web application after completing the subjects in this semester. As one student put it, "I find the entire web building very useful as I can use the skills that I have learned and apply it outside of school." Likewise, as another student shared, "As a person who is always using the website, I did not know a single thing about the process of building a website. And now that I know more, I am interested and excited to begin building my own web applications to publish online!"

Key Learning Points of Teachers

One of the key learning points was the fact that students found it interesting to learn by doing instead of merely from lectures. They could see for themselves what worked and what did not. They could encounter and solve real problems in their applications. Overall, this gave them a greater sense of achievement when they finally managed to get their mobile and web applications to work, as compared to just completing multiple disjointed lab activities or a lab test.

Another learning point was that by clustering several related subjects together, it enabled students to better appreciate the holistic picture of how an application worked. They could thus better understand what each component did and how they were inter-related. For example, they could develop a more comprehensive function by designing a more user friendly screen for users to create new user accounts, writing the necessary functions to not only capture the user data but also verify whether the data was valid, and storing the data in a database so that subsequently, they could access this data for login verification.

Several teaching staff were initially sceptical about whether first year students were capable of picking up the necessary skills and knowledge to develop a mobile or web application, which in the past was only attempted by second year students. However, the teaching team learned that the students were not only motivated to do well but also able to produce higher quality applications when they were given projects that were more relevant to them, experienced the development of a complete application that incorporated multiple inter-related components, and received comprehensive scaffolding to support their learning and application development.

However, since many of the students were new to programming, they initially found the task of developing their own mobile and web applications to be rather daunting. They required much more scaffolding to help them to understand and apply the various computing principles and codes. As this was a first attempt at giving the students such challenging projects, the teaching team provided the students with additional ad-hoc scaffold throughout the semester based on the feedback from students and teachers' observations of students' performance in class. For example, the team identified and provided access to online learning packages, such as on Lynda.com, and developed mini-coding-tasks and e-learning activities to help students reinforce what they had learned. All of these additional scaffolds will be evaluated and incorporated into the learning materials for future runs of the subjects.

Conclusion

If this approach successfully enhances students' skills, interests and motivation in computing, it is potentially easier for teachers to teach them further programming subjects in subsequent semesters (Kannan et al., 2018).

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ACTUALIZING AN APPLICATIVE, AUTHENTIC SUMMATIVE ASSESSMENT USING A HYBRID MODEL OF AN INSIGHTS-DRIVEN DATATHON FOR IT STUDENTS

Jin Sze Samantha, Sow

Temasek Polytechnic, School of Informatics & IT,
Diploma in Business Intelligence & Analytics, Singapore

sowjs@tp.edu.sg

Abstract

Next generation innovations and increasingly higher expectations for business value and security are rapidly shaping the Information Technology (IT) industry and workforce of today. Against this backdrop, a datathon can address the skill gaps and various constraints of traditional modes of summative assessments which include projects and assignments for computer science students. A datathon is a portmanteau, coined from of the words "data" and "marathon". It is a variant of a hackathon with the focus shifted towards participants from the data science community working with data and predictive models to complete a given challenge. At the School of Informatics & IT, the module Statistics and Analytics (SANA), which is offered to Year 1 students, incorporates learning both statistics and data science skills. This module's learning objectives include data-driven activities, such as filtering through datasets with multiple variables, handling non-traditional data types, learning essential statistical models, categorizing raw data and collaborative team work. We hoped to elevate students' achievements to higher levels than traditional projects through an authentic and performance-based datathon. This paper highlights the design, structure and eventual actualization of the assessment metrics of the datathon. It describes how the lecturers prototyped a hybrid model of a datathon to meet the principles of assessment criteria. We also elaborate on how the datathon can gauge students' underlying skills and the quality of the assessment outcomes. Finally, this paper will indicate the results of the study and propose recommendations for future datathons.

Keywords: *Digital innovative learning, datathon model, collaborative learning, learning analytics, data-driven*

Introduction

Generally, Warner, J. & Guo. P. J. (2017) has characterized datathon as a data focused computer programming event or a pitching competition to display cases of programmed prototype digital innovations driven by analytical insights. Datathon is a variant of a hackathon with its focus shifted towards data. The purpose of a datathon (Anslow. C, 2016) is for data science community's participants to practice data science and analytics skills for either work or studies. Organizations have began to provide data to encourage external stakeholders to participate by improving existing services (Hjalmarsson & Rudmark, 2012). In Calgary, datasets are provided by non-profitable organizations for 'Data for Good' event in exchange for data-driven insights resulting from the datathon. (S. Seyffarth, 2015). Similarly, in Sweden, Innovation for Sustainable Everyday Travel (ISET), (Hjalmarsson, A., and Lind, M., 2011) provides open data for innovation to enhance sustainable everyday travel.

Briscoe, G. & C. Mulligan (2014) have traced the origins of hackathon back to 1999 when open-source software developers OpenBSD and Sun Microsystems introduced hackathons for developers to create software on their respective platforms. In contrast to the earlier hackathons, hackathons are now prevalent activities for software companies, like Google and Facebook (Alexandra Chang, 2012). This rising popularity is due to the alignment of company culture with hackathons' rapid-fire prototyping, fusion of expertise, experience, skills and innovation. The hackathon phenomenon is known for its innovativeness and creativity on how a problem is solved (S. Zheng, 2013) at events. The proliferation of hackathons, over 400 hackathons are reported from 2000 to 2012 worldwide (S. Leckert, 2012) across several disciplines forms the culture of digital innovation. Being more collaborative than competitive, the present events contain a spectrum of activities, enabling students to pilot new ideas, synergizing technopreneurs and innovators in context on emerging trends, and serving as de facto hiring arena for tech companies.

Briscoe, G. & C. Mulligan. (2014) explained that hackathons have spiraled into different alternatives. With the burgeoning amounts of data and a growing data science community, *datathons* assemble data enthusiasts to model data-driven solutions. Typically, datathons are known to be intensive and accelerated competitions which are coordinated in a business environment. It is

recommended to assemble datathon participants in interdisciplinary teams (Aboab et al., 2016), although monodisciplinary teams are fine. So-called datathons transfer the hackathon concept to challenges with regards to data analytics (Aboab et al., 2016). Applying analytics requires a combination of capabilities: analytics, statistical, mathematical, and programming skills (T. H. Davenport & Patil, 2012). The range of tasks can be varied, from data preprocessing and cleansing to data mining and data visualization (Anslow, Brosz, Maurer, & Boyes, 2016).

The purpose of this study is to explore how the synergies and innovations in a hybrid model of datathon can fit into the complex educational system as an alternative, authentic and summative assessment. What are the modifications needed and constraints encountered to introduce it into the intricate educational system to measure learning? Concurrently, we will investigate corresponding assessment metrics and their mapping.

The research questions of this paper are: (1) What are the design parameters for a summative assessment using a hybrid datathon model? (2) How can we design effective assessment criteria and rubrics? (3) What are the perspectives of the participants?

Implementation and structure of the hybrid datathon

In the School of Informatics & IT, we propose and implement a hybrid model of datathon in place of a summative assessment. The primary reason is to evaluate students in environment similar to the IT workplace. In the educational context, (Wiggins, G., & McTighe, J. ,1998) define summative assessment as a formal measurement of determining if students have sufficiently understood learning goals after a designated time period. Fulfilling such criteria is critical in tests, examinations and final projects.

In a datathon, identifying the right problem usually leads to success because a quick, tangible hack can be demonstrated at the end. Contrary to a datathon, it is imperative for us to concentrate on the design process (Artiles, J. A., & Wallace, D. R. ,2013). In the educational context, we are expected to establish the problem, execute brainstorming, prototyping, end user feedback and evaluation. Thus, the design of an educational datathon has to incorporate all these parameters.

In the initial phrases of planning, two Year 1 logic and analytics cluster modules: Logic & Mathematics and Statistics & Analytics which were taught over 17 weeks are chosen for the datathon. These are core modules and their learning objectives are analytics acquisition, algorithm thinking, data cleaning and dashboard creation skills.

The datathon was held in the last week (week 17) of the semester. A week before the datathon (week 16), smaller groups of 5 to 6 students are already formed for individual classes. On the actual event, 12 tutors are deployed to 21 participating classes. The tutor's role is to check the attendance of group members, introduce the dataset, provide directives and a set of general guidelines before its commence. Since it is a scaled down hybrid model, time given for the various groups to brainstorm, acquire data, investigate complex relations and code a dashboard is limited to 6 hours at the learning labs with unlimited access to the internet.

Once the datathon begins, groups work intensely within the time frame from 9am in the morning till 3pm, after which they must cease work and present the dashboard end product with analytical insights to the panel of 3 judges, who are making their rounds to the teams. In the brainstorming session, certain innovative and resourceful groups are seen engaging with online tools which are not taught in the modules for further exploration and processing of given datasets. Some groups tend to be distracted and may take a much longer time to settle in. Many groups quickly work towards their goals and strategize their approach (Figure 1). In a few groups, a visible leader is leading and delegating work to the group in their distributed tasks. Finally, at the end of the 6 hours, teams have to cease work, upload their source codes to a server and give a demonstration. The judges would walk around the venue to assess the insights analysis of the end product using a standardized marking rubric.

Design parameters for hybrid model of datathon

In this section, we shall discuss the principles when we design the hybrid model datathon for its suitability as a summative assessment in the educational context.



Figure 1.0: (a) Teams brainstorming in a learning space (b) Data analysis using external tools (c) A team exploring the dataset (d) End-product from a team

Firstly, it is essential to evaluate the curriculum of the analytics cluster modules to ensure relevance of knowledge learnt. Analytics or data science addresses the exploration of data sets with different quantitative methods motivated from statistical modelling (James et al., 2015). Cleveland (W. Cleveland, 2001) emphasizes that students should analyze data and it should be a major part required of undergraduate programs in data science. The analytics cluster modules seek to introduce basic data science or knowledge generation from data. The general learning outcome expects students to transform raw datasets and build a dashboard. (Table 1.0). It is fitting to translate a small-scale datathon into several assessment tasks which fulfill the specific learning goals (Boud. D., 1995). The key activities identified in data value chains include data generation, data acquisition, data processing, analytics and visualization. (Miller &

Mork., 2013) (Curry, 2016). Since, a data challenge emphasizes on analytics skills such as organizing raw data, using different data types, sorting through datasets with variables and dashboard creation of insights, it is appropriate to model a summative assessment after a data challenge. As we can see, some key development phases in a data life-cycle are linked to the specific learning outcomes too.

Table 1.0: General and specific learning outcomes.

Topic 5	Dashboard Building
General Learning Outcome Students should be able to:	Specific Learning Outcomes Students should be able to:
5. transform raw datasets and build a dashboard.	5.1 **identify data quality problems** in a data source; 5.2 **apply data transformation** techniques to clean data; 5.3 **build a dashboard** using a visualization tool.

Secondly, the datathon is both focus-centric and tech-centric where the end product will address specific learning outcomes in our educational context. Briscoe & Mulligan, (2014) distinguish between tech-centric and focus-centric. Our datathon is tech-centric datathon as it focuses on software application with a specific visualization software, Microsoft Power BI. We assess our students' notions of competence with respect to learning and software skills on dashboard building using this application. The assessment is suitably refined to map the datathon's problem statements to our specific learning outcomes. Being focus-centric, our students have to demonstrate the ability to prepare data, discover insights and charts. In fact, (Boud., D. 1995) deems good assessment as one which closely reflects desired learning outcomes and the process of assessment has a directly beneficial influence on the learning process. We decide to challenge students on a formative approach in our problem statement for deeper cognitive thinking.

For example, a summative approach with specific learning outcomes (Table 1.0) is very structural, such as giving students a dataset, asking for step-by-step computation of variance, mode and inter-quartiles, plotting of data charts and building the final dashboard. Alternatively, a formative approach requires students to explore the same dataset and significant variables. Relying on their cognitive abilities, students have to compute suitable statistics and data charts to discover significant causal variables and their relations within the dataset without pre-identified variables (Table 2.0).

The application of data science is diverse, with focus on areas such as information security (S. Kumar, 2014), healthcare informatics (G. Zheng, C. Zhang, L. Li, 2014) and software engineering (T. Menzies, E. Kocaguneli., F. Peters., B. Turhan, 2013). Additionally, data understanding and domain knowledge are key prerequisites in the analysis process (Waller & Fawcett, 2013). Thus we provided 5 datasets in different contexts consisting information of hospital discharge rates, workers' salary and age, geographical transport connectivity, industrial employees' demographics, credit loans with customers' credit ratings to the participants.

Thirdly, it is an authentic assessment, with what Wiggins, G. (1989) described as "contextualized complex intellectual challenges, not fragmented and static bits or tasks". Cleveland (W. Cleveland, 2001) highlights that the practicing data analyst faces two critical tasks (1) the building of a model for the data; (2) estimation and distribution of the model. Cleveland (W. Cleveland, 2001) comments that it is vital for data science subject to carry statistical thinking to subject matter in various disciplines. Our fundamental datathon will allow students to deliver tangible products, a report and dashboard where new data insights are discovered from the quantitative charts while building real data analytics practices.

Table 2.0: Problem statement for the datathon.

Specific criteria tested Deliverables: A report **not more** than 1000 words.	**Specific Learning Outcomes**
State what you want to investigate in this given dataset. E.g. "Over the years, can we see some trends in the discharge rate of some diseases?" Do **not** use this question for your project.	5.1 **Identify** data quality problems in a data source;
Data preparation or data cleaning steps that you have taken. Take screenshots of the step by step procedure that you have done.	5.2 **Apply** data transformation techniques to clean data;
Different charts that you have created. Take screenshots and do explain your choice of charts.	5.3 **Build** a dashboard using a visualization tool;
The insights or new things that you have discovered while looking at your charts.	5.2 **Apply** data transformation techniques to clean data;

In higher education, concerns about learning outcomes oriented perspectives in a discipline have been open to critical scrutiny. Some questions we need to answer are: Can graduates perform in the current "analytics 3.0" environment (Davenport, 2013)? Are current assessments the best performance measurement for related methods of analytics such as text, web and network analytics? (H. Chen, Chiang, & Storey, 2012) As Boud comments that traditional mastery tests are inadequate as the questions are often contrived and the cues are artificial as standard right answers equate to adequacy in achievements. Hence, the preference for a datathon in our case (Boud, D.,1995).

Assessment rubrics and criteria for datathon model

All assessments require evaluation parameters and these can either be explicit or implicit. (Black and William, 1998). The rationale of assessment is to capture complicated learning outcomes, implement realistic tasks, and use good instructional tools to include elements of collaboration and interaction among students. Earlier, we have devised the problem statement and students' deliverables as criteria to match specific learning outcomes. Sadler (1998) commented that assessment

begins with identifying a number of relevant criteria, then we measure the amount present on each criterion and we combine the various levels or estimates into an overall measure of merit by means of a formula (Sadler, 1998). In an educational context of an assessment, Scriven points out that it is usually necessary to justify (a) the data-gathering instruments or criteria, (b) the weightings and (c) the selection of goals (Scriven, 1967).

In the design of the datathon, there are 2 deliverables, a report and a dashboard. We map the specific criteria of the deliverables to the specific learning outcomes in our modules. (Table 2.0). In the report deliverable, all the specific learning outcomes are translated into essential criteria for measurement of learning competency of data analytics.

To provide clarity in the data challenge's grading process, we propose a rubric with evaluative criteria. In this paper, assessment rubrics broadly refer to detailed grading with numbers or formulae and they are suggestive of broad quality levels (Sadler, 2009a). The creation of rubrics is in the teachers' domain and we adopt Bigg's structure of observed learning outcomes (SOLO, Biggs and Tangs 2007) where there is a transparent alignment between objectives, learning activities and assessment tasks. Likewise, each grade description has embedded within it a number of criteria and descriptors of our learning objectives. The rubrics for the panel of assessors are provided below (Table 3.0).

As an overview, we will discuss the design elements present in the datathon rubrics: specificity, scoring strategy, evaluative criteria and process. The rubrics enable assessors to grade tasks meaningfully and consistently. We have built evaluative criteria into the rubric to break down the grading into several smaller criteria.

Table 3.0: Marking rubrics for end-product dashboard

Criteria	Excellent	Good	Average	Poor
Solve data quality problems in the dataset	(At least 4) Evidences of cleaning erroneous data values	(3) Evidences of cleaning erroneous data values	(2 or less) Evidences of cleaning erroneous data values	(No) Evidences of cleaning erroneous data values
Integrate appropriate statistical charts for visualization purposes	(At least 4) Intuitive charts and easy to understand	(3) Charts that can be understood	(2 or less) Charts can be improved	(No)/ Charts are minimal and not intuitive
Apply suitable data transformation techniques on variables	(At least 4) Show significant relations of quantitative variables	(3) Show relations of quantitative variables	(2 or less) Show important relations of quantitative variables	No relations of quantitative variables
Deduce data insights based on variables relations	Deep insights based on observation & charts analysis	Good insights based on observation & charts analysis	Surface level insights based on observation & charts analysis	No insights based on observation & charts analysis

With the rubrics constructed, a scoring strategy can be effectively put in place. For the modules, there is a desired level of skills expected from our learners. Each of the quality definition descriptors occupies one cell in our table and each row represents a particular evaluator criterion. To differentiate the varying quality levels, words from Bloom's taxonomy or Bigg's structure of observed learning outcomes are used in our rubrics. These words help to differentiate the varying complex levels of the learning goals. The same weightage of marks can be distributed and totaled to a final score of 25. At the start of the process, all the members of the judging panel share a common understanding of the assessment rubrics. A 'calibration exercise' is carried out and it includes marking a subsample and discussing the agreed marks. In our current assessment grading, feedback is not given. However, to close learning gaps in future, the graded rubrics can be used as a formative class tool to articulate feedback to the respective teams.

Results and Discussion

In this study, we conducted a questionnaire survey comprising of closed and open ended questions on participants' learning experience, satisfaction and team effectiveness among 25 randomly selected participants.

As shown in Figure 3.0, 80% of participants agreed or strongly agreed that datathon as an assessment tool has helped in their learning experience [Qn.1]. Despite this, 20% of participants prefered not to have datathon as an alternative assessment [Qn.3]. In the open-ended question [Qn.4], students cited their reasons such as the time challenge, difficulties of finding suitable team members and the grading in a datathon. 48% of the participants disagreed the datathon helped them to visualize real world applications, citing reasons that classroom learning is a less stressful mode of learning than a graded datathon where they need to deliver an end-product in such a short time [Qn.5,6]. Finally, a large proportion, 96% of participants agreed they have to collaborate or learn to work in a team for this authentic form of assessment [Qn.7].

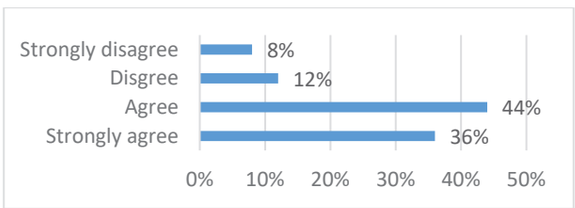

Figure 3.0: Survey Question 1: The datathon assessment helps me in my overall learning experience.

Questions 9 to 13 assessed the participants' opinions on team effectiveness [Qn. 9 - 13] in the

datathon. The team effectiveness is defined as a dependent variable, with suggested independent variables corporative role, work methods, team achievement, commitment and membership suitability [Table 4.0]. Participants ranked the variables based on a 10-point Likert scale ranging from "1" to totally disagree to "10" as totally agree.

Most participants felt team members were committed, cooperative and they experienced team achievement. This is supported by a mean of 7.37 [±2.056], 7.33 [±1.366] and 7.16 [±1.732] respectively. However, students felt members may not develop systematic and effective work methods to solve problems together and there may not be an appropriate balance in every team in terms of a good "mix" of skills: mean of 6.83 [±1.471] and 6.66 [±2.875].

Questions 14 to 19 assessed the participants' learning from a learners' perspective [Qn. 14 - 19] in the datathon. Suggested independent variables influencing learners' learning perspectives are individual development, creative capacity, learning relevancy, real life engagement and satisfaction.

From the results, participant rated satisfaction, learning relevancy and real-life engagement highly: mean of 8.23 [±0.923], 7.67 [±0.517] and 7.50 [±1.049]. Individual development was rated higher than creative capacity: mean of 7.00[±1.090] and 6.50[±2.258].

Table 4.0: Means, standard deviations of variables on a sample (n = 25)

Variables	Ranked Mean	Standard Deviation
Team Effectiveness		
Team Commitment	7.37	2.056
Corporative role	7.33	1.366
Team Achievement	7.16	1.732
Work Methods	6.83	1.471
Suitable Membership	6.66	2.875*
Learning from the learners' perspective		
Learning satisfaction	8.23	0.923
Learning relevancy	7.67	0.517
Real-life engagement	7.50	1.049
Individual Development	7.00	1.090
Creative Capacity	6.50	2.258*

Conclusions

As we move towards a holistic conception of assessment as a total package of both learning and assessment, we decide to adopt datathon as a measurement of our students' learning.

It is observed that the nature of the hybrid datathon contributes to the development of student expertise in data-driven activities such as algorithm thinking, data cleaning and dashboard creation on their datasets. It compels participants to create a feasible end product in an authentic environment and experience team commitment, team achievement and teamwork in the process. The entire process is cognitively beneficial because students sharpen their own self-evaluative capacities in the teams. Building models with data analytics and statistical, mathematical and programming skills in a team setting are important areas of data science for the data analysts. Hence, a datathon provides practical experience among our students in key data value chain and analytics skills. There will be exciting new frontiers in data science for analyst who are involved in computing with data and able to cross subject matter disciplines.

A future area of study is the usage of open data and cross collaboration with organizations in educational datathons. Open data are data repositories that are not subjected to restrictions on their distribution and uses Opportunities of institutes collaborating on datasets for the benefits of communities and public good is a possibility with the advent of "analytics 3.0" organizational analytics. Finally, we can look forward to combination of innovation, analytics and open data in the future.

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STUDENT ENGAGEMENT IN DIGITAL MEDIA DOMAIN

A.B. Sherlyn Tang*,[a], C. Leong Chee Loong[b]

[a] Nanyang Polytechnic/School of Interactive & Digital Media, Singapore

*sherlyn_tang@nyp.edu.sg

Abstract

This research paper seeks to examine how instructional strategies can influence students, from the digital media domain, to stay engaged in active learning that in turn improve their performance. Davis (1993, p15) mentioned that for effective teaching, the instructor's need to interact with students in ways that enable them to acquire new information, skills, and expand on what they already know. Engaged students will enjoy the learning process and will be curious, interested and persist through challenging tasks and take pride and satisfaction in their learning.

Action research method was employed. Quantitative research tool like survey questionnaire was used to gather and collect statistical data from 150 second-year students from 3 diploma programs; Interaction Design, Digital Visual Effects and Motion Graphics & Broadcast Design. Qualitative studies were also carried out for 30 year 2 students, 10 from each of the 3 courses, to collect findings through focus group discussion.

The results show that student motivation is largely rooted in subjective experience identified in the following five themes: Friendship & Fun, Do-Learn-Interact, Explore & Experiment, Varied Problems, and Collaborative System. The findings suggest that a learner-centered approach optimizes students' learning, helps the student connect to the course materials and enhances their learning experience to engage them in the learning process better.

Through these active learning strategies, we can aim to produce better conceptual and problem solving creative individuals in School of Interactive & Digital Media (SIDM). Integrate out-of-class activities into passive tradition classroom bounded learning by designing instructional approaches that facilitate student learning and self-assessment. Encourage peer-to-peer and lecturer to student interaction to engage and enrich their learning abilities.

The Net Generation is interactive and social learners. Students want to experience work that is meaningful, solve real problems, learn from people within their communities, and subject experts. Engage in dialogue and know that their learning contributes to making a difference in the world. (Dunleavy, J., Milton, P. & Crawford, C., 2010). The findings of this paper suggest that a learner-centered approach optimize students' ability to construct their own learning and knowledge acquisition thus it could be widely applied to students from a different discipline within SIDM.

Keywords: *Student Engagement, Instructional Strategies, Digital Media Domain, Learner-Centered, Active Learning*

Introduction

In this research study, we seek to examine how instructional learning strategies can influence student engagement in active learning that in turn improve their motivation and performance. Davis (1993) mentioned that for effective teaching, the instructor's need to interact with students in ways that enable them to acquire new information, new skills, and expand on what they already know. If the students are truly engaged, they will enjoy the learning process and will be curious, interested and persist through challenging tasks and take pride and satisfaction in their assignments.

Incorporating different active learning instructional activities such as in-class activities, out-of-class activities or interactive activities to help the student connect to the course materials and enhance their learning experience to better engaged and involved them in the learning process. Agnes Chang Shook Cheong and Ian David Smith (1998) contended that Singapore students are capable of self-regulated learning and it is correlated positively with achievement. The hypotheses we are establishing are through various active learning instructional activities, students will be better engaged, and better learning occurred. The students will also take responsibility for their own learning, and their performance is likely to increase.

There is no best instructional activity; it will depend on the student, the context, and the discipline. The objective of this research is to re-think how our courses are delivered and assessed, investigate how we can improve our current education practices in our school, School of Interactive & Digital Media (SIDM). Like many design courses, our diploma programs do not have any form of examination; all assessments are via assignments, group projects, presentations and class exercises. So our students need to be constantly motivated and discipline to complete their work. The finding of this study will enable us to create a learning environment that is engaging and enjoyable for the students that will positively impact their learning. This will also make teaching enjoyable for the lecturers.

Methods

Action research method was adopted for this study. Quantitative research tool like survey questionnaires was conducted by the respective lecturer, to gather and collect statistical data from sample participants. Qualitative studies were also carried out for selective random students to collect findings through focus group discussion. This research aims to achieve practical and applicable solutions through our findings that can be implemented within SIDM.

This research sampled data from 150 second year students from 3 different diploma programs in SIDM, namely; Diploma in Interaction Design (IXD), Diploma in Motion Graphics & Broadcast Design (MGBD) and Diploma in Visual Effects (DVE). The active instructional learning activities were grouped into three main categories, in-class activities, out-of-class activities and interactive activities. In-class instructional activities include lecture slides, online video materials, individual and small group collaborative task-oriented exercises and minute paper. Outdoor learning consists of educational field trip like on-set production, visitations and observatory excursions that encourage the student to experience the real-life problem. Lastly, the interactive learning looked into peer to peer and student to instructor interactions through activities like group discussion, presentation, formative assessment and active questioning. During in class or outdoor learning, a crucial technique of Socratic questioning was applied. Questions with the how, what and why was regularly asked to encourage students to interact with one and other and participate in conversation with the assurance of a safe environment for students to share their views and that there are no right or wrong answers. The various tests were conducted and designed by the lecturers that best fit each category for the diploma, and all three categories were carried out for each diploma.

Survey questionnaires were conducted after the completion of each activity to collect quantitative data on students' responses to evaluate the effectiveness. All students from the 3 diploma programs anonymously respond to 2 questions. First question, based on a 3 point scale, whether instructional activities was a waste of their time (1 point), worth the effort (2 points) or very supportive of the activity (3 points). The second question, student will select the top 3 factors that influence their learning engagement.

Qualitative studies were also carried out at the end of the semester, to gather key concerns or ideas that the participating students can contribute. This allows us to gain more understanding and insight of the central phenomenon in engaging students purposefully. Participants include 10 students randomly selected from each diploma to participate in a focus group discussion with each representative lecturer from each course. A focus group will allow students to feel more at ease and willing to share realistic thoughts as the lecturer is going to play a minor figure during the focus group discussion. The questions are: 1. Can you share what are your experiences during in-class activities, out-of-class activities and interactive activities? 2. What activities help you make better connections to the course materials? Why? 3. Which instructional activities had made a positive impact to improve your engagement level during the learning process? Elaborate why. 4. Do you agree that student who is highly engage in his/her learning achieve better performance? 5. Any Suggestions on how engagement level can be increased to enhance learning experience to create positive impact on your learning. 6. Any other comments.

The Data collected was aligned with the unique characteristics of students from digital media design domain. Triangulation process was applied to enhance the validity and reliability of the findings.

Results

Data collected from the 150 second-year students are are illustrated in Figure 1- In-Class Activities, Figure 2 – Out of Class Activities, Figure 3 – Interactive Activities and Figure 4- Factors that engaged your learning.

Figure 1: In-Class Activities

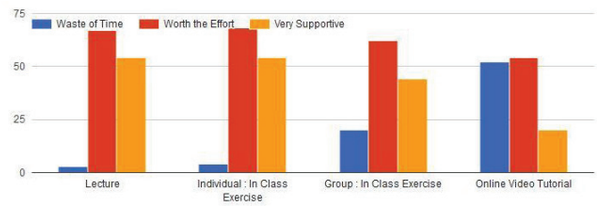

Figure 1: In-Class Activities

As shown in Figure 1 almost all students feel that lecture impact their learning positively. However, lecture should be designed to engage and interact with student in a fun and entertaining way to retain their attention span longer. Student suggests "Integrate things that are more current, or that would appeal to our generation," "make slides interesting it helps to attract and keep my attention on the lecture for a longer period", "include more visuals, videos that will be more interesting and exciting." Student finds lecture important in learning and gaining new knowledge, making learning interesting help them to stay focus and engaged throughout the delivery.

Most students believe that individual and group class exercise positively impacted their learning. Student

comments reveal that individual exercise help to reinforce learning while group exercise help students to learn from one another. Other comments such as "makes everyone enjoy learning even if one doesn't like the certain topic", "enable me to do it right away after learning, so that I will not forget what we are doing", "With a wider variety of activities to choose from it stimulates me to put more effort into expanding my horizon on learning", "able to learn from my mistakes" and "makes you understand everything on the spot and also if we have doubts we could also clarify" suggests that the students find the activities fun, helpful and enjoyable. The activities also allowed the students to learn effectively and clarify their thinking, it also challenges the students and makes them feel competent.

Student perceptions of in-class exercise also support the finding of Mearns et al. (2007) that if the teacher is perceived to be approachable, well prepared and sensitive to student needs, students are committed to working harder, get more out of the session and are more willing to express their own opinion. Komarraju and Karau (2008) mentioned if students perceived an in-class activity was valuable, then thinking and desire for improvement increased.

It is noteworthy that half of the students believe watching online video tutorial during class is a waste of time. Student's comments that the video is available at all times and this activity could be done during their free time. They prefer to use class time to learn from the lecturers or to have discussions.

Figure 2: Out-of-Class Activities

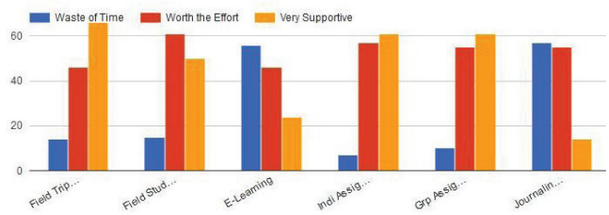

Figure 2: Out-of-Class Activities

Students find out-of-class activities (Figure 2) such as educational trip, field study, and assignments to have a positive impact on their learning. Comments such as "seeing how thing works in the industry is engaging and fun than just being in the lab", "helps me to learn new things and discover new stuff which can help me in my assignments", "this opens up our eyes and we'll know how the things that we learn could be applied to real world situations" and "learn new things and explore new learning way" suggested that students stay engaged if there is relevancy, educational trip or field study provides an opportunity for students to see how their learning can be applied to real-life situations as compared to just classroom bounded activities.

During the focus group questionnaire, students also state that they appreciate out-of-class activities because they can (1) learn from the professionals in the relevant industry; (2) Have more opportunities for discussions with each other and other people; (3) build relationship with the lecturers.

Educational trip and field study also resulted in an authentic intellectual engagement, it allows lecturers to explore and learn alongside the students to build learning experiences and knowledge together and develop meaningful relationships and respect. Taylor, L. & Parsons, J. (2011) stated students want stronger relationships with teachers, with each other, and with their communities and want their teachers to know how they learn.

Students also highlighted that they want their assignment to be relevant to the industry, authentic and meaningful. The assignment needs to be thoughtfully designed so that students will feel that it is worthy of their time. This allows the students to stay motivated and engaged. As Claxton (2007) also further suggests (1) relevancy: the topic connects with students' interests and concerns; (2) reality: solving problems or making progress genuinely matters to someone.

A noticeable high number of students find activities such as e-learning and journaling waste of time. Students reveal that these activities lack social interaction and unlike individual assignment, they are not challenged to tackle a real-world problem. This reflects the characteristic of Net Generation learners who value social interaction. They find that learning from people within their communities, subject experts enhance their knowledge and feel more authentic.

Figure 3: Interactive Activities

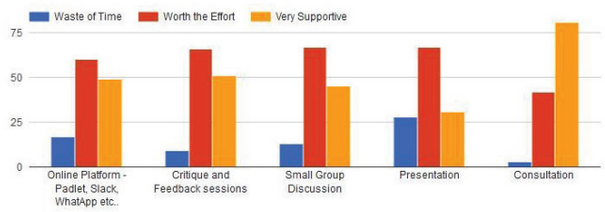

Figure 3: Interactive Activities

Figure 3 revealed that students feel connected to and interested in learning if the lesson entertains them, challenges them or helps them to learn what can be done better. More than half of the students like the learning to be interactive, that is fun and engaging. Lecturers should be encouraged to use a variety of online platforms such as Padlet, Kahoot, and Slack to engage the students. Comments such as "doing something active will keep me awake," "I feel like I can learn faster by playing games rather than doing boring stuff" and "Using slack on the phone allow for more honest private feedbacks and opinions. And students will be able to say what they want" suggested that students appreciated such learning activities.

Small group discussion allows collaborative learning to take place. Students responded that they enjoyed learning through discussion with friends; they find friends often are able to explain the content. Small group discussion creates opportunities to clarify and reinforce learning with each other. Many students also responded

that discussing in a small group is less intimidating as compare to working alone. It was also noticed that small group discussion often increases the willingness to participate in whole-class discussion. Increased class participation encourage discussion that help students analyse an argument, reflect and reinforce their learning. Windham (2005) mentioned that today's students ask for the opportunity to explore and to find solutions and answer themselves. Critique and feedback sessions and one-to-one consultation allow the student and lecturer to discuss idea together, this encourages more interaction and exploration as compare to just lecturer telling students what the answers and outcomes should be. Students also mentioned that in such activity, they feel less fear to ask the lecturer when they are in doubt. While for others, such activity enables discussion and gain advice and knowledge from the lecturer.

This finding supports Zepke and Leach (2010) discussion that there is a need to create educational experiences for students that are enriching, challenging and extend their academic abilities. The varieties of the activities helped the students to stay focused and engaged the students as the activities involved them.

Figure 4: Factors that engaged your learning

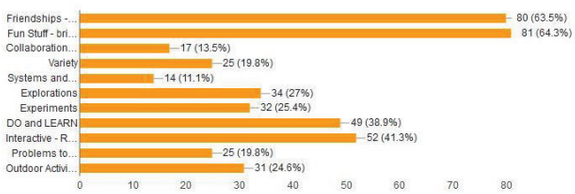

Figure 4: Factors that engaged your learning

Lastly students were asked to choose their top 3 factors and provide reasons to why these keep them engaged during In-Class Activities, Out-of-Class Activities and Interactive Activities. The top 5 responses were categories as follow, Friendship & Fun; Do-Learn-Interact; Explore & Experiment; Varied Problems; and Collaborative Systems.

Friendship & Fun category reflects the highest intensity of need to satisfy their relational and emotional state of mind with comments such as, "with friends it makes stressful times easier", "a friend will encourage you so you will not give up", "more friends will learn more things". With friends there are fun factor in class with responses such as, "friends are not only fun to be with, they help clear your doubt when you are lost", "talk with friends about funs stuff keeps us awake", "it is fun to have friend around to share what we learn and help each other".

A substantial group of students selected Do-learn-Interact. These students prefer practical hands-on with real-time feedback on what they have done. Some of their responses were, "while practicing a craft it provides a better experience compared to lectures", "it makes one understand immediately and when in doubt one can ask", "doing and learning is entertaining" and "when I learn something new, I need to practice it once to remember it."

Explore & Experiment categorizes a group of students who urge to try the unknown to better equip themselves for the future. Their responses were as such, "to explore and find out more knowledge about work and life", "exploration brings new answers", "it makes me think differently with new information", "new explorations bring about learning in a new way" and "exploration gives a free reign for the mind to focus on new ideas". All the above statements were evidently showing students minds are engaged in learning through experimentation and explorations.

Varied Problems and Collaborative Systems are the minorities where these students prefer learning through a variety of problems through team effort in a logical and systematic fashion and deem efficient. Their responses were that, "collaboration help each other do things faster", "collaboration exposes me to the varied style of works", "seeing stuff from a different perspective through collaboration can be fulfilling", "a variety of activities stimulates me to put more effort into expanding my horizon of knowledge" and "I enjoy putting different things together and finding common ground between the various group to achieve a goal". In the ever-changing digital media domain, it is important to develop conceptual and problem solving creative individuals.

Discussion

Figure 5: Conceptual Model

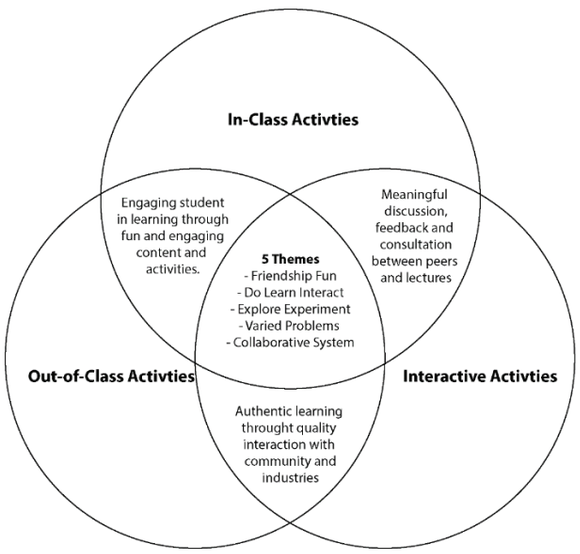

Figure 5: Conceptual Model

The conceptual model above summarizes our key concept in fostering student engagement. Student motivation is largely rooted in subjective experience identified in the 5 themes that increased their willingness to engage in In-Class Activities, Out-of-Class Activities and Interactive Activities.

Students responded on why they perceive these 5 themes aids learning positively. Majority of the students enjoy fun activities, and engaging content that entertains them and friendships are important aspects of a student's experience in school. According to Senior and Howard

(2014), existing friendships between students on a course and in the wider student community were a resource in which the students developed their understanding of theoretical concepts through discussion, explanation, and application to "real life" contexts. Peer and peer interaction, therefore, may have increased their engagement and opportunities to gain different perspective that facilitate a more fun and better learning experience.

Many students enjoy the learning by doing approach used in In-class exercises as knowledge is retained longer and it facilitates easy understanding of knowledge components with applications. While student may not enjoy out-of-class assignments, they understand that engaging in such challenges allow them to learn through problem-solving, engaging in critical thinking and most importantly make meaningful connections to the content learned in various way in and out of class. Interaction with lecturers and peers such as critique and feedback sessions help them acquire new information, new skills and expand on what they already know most importantly guide them towards the achievement of the intended learning outcomes. This is especially crucial for design courses as the nature of all design problems and processes are unique and different, student finds meaningful discussion between peers and lecturers, feedback and consultation with lecturers as highly beneficial and stimulating in their learning. These Interactive activities promote analysis, synthesis, and evaluation of class content between lecture and students.

Many student welcome out-of-classes activities as they see this as an opportunity for authentic learning through quality interaction with community and industries. In the process, students learn to explore, investigate, connect information and draw conclusion. It encourages the student to explore and experiment, drive their curiosity to challenge themselves to seek for answer. This self-directed learning allows students to learn beyond the classroom, developed self-learning and problem-solving skills that equipped them with life-long competency necessary for the real world.

A minority of the students appreciate opportunities to tackle varied problem through collaborative work. Student believed this broaden their exposure, stimulate their creativity and participation in collaborative problem solving with students from different academic discipline and/or different cultural background give them new perspectives.

Conclusions

The result of this research suggests that a learner-centered approach optimize students' learning. Make their learning more impactful and enjoyable. Incorporating Friendship & Fun, Do-Learn-Interact, Explore & Experiment, Varied Problems and Collaborative System into in-class activities, out of class activities and interactive activities help student connect to the course materials and enhance their learning experience to better engaged and involved them in the learning process. Engaging students in various active learning instructional activities, students will be better engaged, and better learning occurred. The students will also take responsibility for their own learning, and their performance is likely to increase.

Through these active learning strategies, we can aim to produce better conceptual and problem solving creative individual in SIDM. Positively impact students' perception of learning by adopting student-centered pedagogy to enhance their educational experiences. Student learning increased when student is encouraged to take responsibility for their learning and reflect on their learning. Integrate out-of-class activities into passive tradition classroom bounded learning by designing instructional approaches that facilitate student learning and self-assessment of their understanding outside of class as a significant amount of learning happens beyond the classroom. Encourage peer to peer and lecturer to student interaction to engage, enrich and extend their learning abilities.

The Net Generation is interactive and social learners. Students want to experience work that is meaningful, solve real problems, learn from people within their communities, and subject experts. Engage in dialogue and know that their learning contributes to making a difference in the world. (Dunleavy, J., Milton, P. & Crawford, C., 2010). The findings of this paper suggest that a learner-centered approach optimize students' ability to construct their own learning and knowledge acquisition thus it could be widely applied to students from a different discipline within SIDM.

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USING SELF-ASSESSMENT AND PEER FEEDBACK TO EVALUATE QUALITY OF INDIVIDUAL WORK IN A PROBLEM-BASED LEARNING SUBJECT: AN EXPLORATORY STUDY

Wee May Lin

Temasek Polytechnic, School of Engineering, Singapore

kohml@tp.edu.sg

Abstract

In recent years, there has been a general shift in the educational landscape, particularly for our local tertiary institutions, to adopt more student self-directed activities to help their graduates acquire skills of a lifelong learner. A lifelong learner is able to reflect on his actions, consider gaps in his knowledge and skills, and then identify ways to close these gaps. These gaps could either be discovered through self-assessment using a rubric or highlighted by others through a peer feedback process.

In April 2018, the author attempted the use of these two processes within a Problem-based Learning (PBL) subject at a stage in the curriculum delivery where students were still new to the subject content. This stage is termed the Discovery stage in the PBL framework adopted by the school. At this point, students are expected to research information on new technical concepts independently, organise and present the information in the form of 'teaching notes' (termed as Discovery notes in framework context) for their peers before embarking on the peer-teaching session. During the peer-teaching session, the student-tutor imparts his newfound knowledge to his other peers using his Discovery notes as an aid. In the past, students only receive direct feedback on their notes from the facilitator prior to the peer-teaching session. In this study, the feedback is 'given' by the students themselves through the self-assessment and peer feedback processes.

This paper seeks to gather students' perceptions of the benefits of the intervention, both from the perspective of authors as they develop the notes as well as from the perspective of peer reviewers when they read and give feedback on other students' notes. The findings from this study report the benefits and weaknesses of the intervention. In the conclusion section, some recommendations to maximize the benefits and limit the weaknesses of the intervention are presented.

Keywords: *Self-assessment, peer-assessment, peer review, peer feedback, problem-based learning*

Introduction

Many educational institutions recognise the importance of producing graduates to be lifelong learners so as to enable them to achieve a higher level of personal success and to survive in this highly competitive and globalised world. Lifelong learners must be self-motivated, resilient and possess positive open mindsets to constantly seek for feedback to improve their performance. As a result, emphasis in tertiary education is now gradually moving from teaching to learning and from teacher-directed to student self-directed (Boud, 1995; Boud & Feletti, 1997; Knowles, 1984). This leads to a mounting interest amongst educators to create opportunities for students to assess their own work and performance (self-assessment) and that of other students (peer- assessment) instead of solely depending on teachers to give feedback. Self-assessment and peer-assessment aid in developing lifelong learning skills. Hanrahan and Isaacs (2001) postulated that both self and peer-assessment skills are needed to help students develop lifelong learning skills. While self-assessment helps students to set goals and self-reflect on their performance, peer-assessment encourages students to work constructively and collaboratively. In this paper, 'peer-assessment' is being used for the sole purpose of providing formative feedback on each other's work and no summative grade is associated with the process. Henceforth, in order to better reflect the formative intent of the feedback process, the term 'peer feedback' is used rather than peer-assessment.

In this study, self-assessment and peer feedback processes were introduced into a Problem-based learning subject called Microcontroller Technology. The subject focuses on microcontroller-based hardware interfacing and programming and is offered to second-year students in the Diploma in Electronics.

Background

In this subject, students work in groups to produce a set of program codes that is capable of controlling digital electronic devices through a microcontroller. All groups, comprising four students each, are given different problem scenarios of different functional

requirements to work on at the onset of the semester. Each group works collaboratively through a series of stages in the PBL process (Figure 1) to produce a working solution that meets the required functional specifications. By the end of the semester, each group presents and demonstrates the functionality of their solution. The facilitator conducts an interview with every member to ascertain the level of his/her project involvement and the competency level of practical skills the student has achieved through the project. In addition, an end-of-semester written examination is put in place to assess the technical theoretical knowledge.

The list of learning issues (need-to-know content) to be covered is the same for all groups as the problem scenarios given to the students are intentionally designed around these issues. Within the group, the list is further distributed so that each member will be assigned to at least one issue to research on. The student organises the information found and presents it in the form of Discovery notes. The notes are used to aid peer learning. Group members can read the notes before the peer-teaching session and make reference to it when the peer-tutor shares, elaborates and teaches the new content to the group. Good quality notes mean that members will be able to understand the content quickly and thereby be able to apply the knowledge to the project more effectively during the Problem-solving stage. Discovery notes are graded and worth 10% of the entire subject mark.

In the past, feedback on the Discovery notes was provided by the facilitator only. Although the marking rubric was given, students did not consciously refer to it as they worked on the notes. Students relied heavily on facilitator's feedback and approval to determine the quality of their work. They worked towards meeting the facilitator's expectations rather than meeting the learning needs of their group members. If their peers had difficulty understanding the content 'taught' (usually when the notes were not pitched at their level of understanding), they would not be able to contribute as quickly or as effectively to the group project development as much as they wanted to.

In April 2018, self-assessment and peer feedback processes were introduced into a class of 24 students taking Microcontroller Technology at the Discovery stage where student were beginning to develop their notes for peer-teaching stage (Figure 1). Students self-assessed their performance as they developed their own notes. Peers in the same group then gave feedback on the first drafts produced by the other members so that the latter could revise their notes and produce a better second version of the Discovery notes for peer-teaching and for final grading by the facilitator. By the end of the peer-teaching session, it was anticipated that the entire project group would have good awareness of everybody else's topics and therefore are more prepared to collaborate and apply these knowledge to develop the solution.

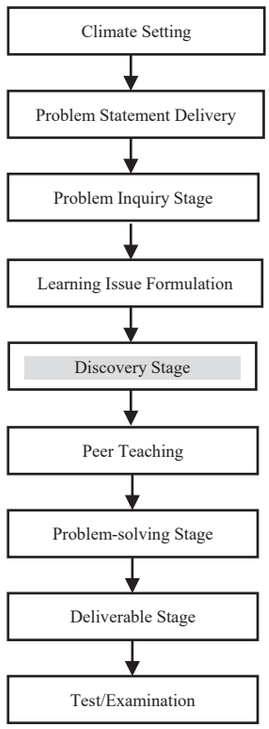

Figure 1. The Problem-Based Learning Delivery Model (Temasek Polytechnic, 2010)

Participants

Participants were 24 second-year polytechnic students from the Diploma in Electronics taking a five credit-unit engineering subject which adopts the PBL pedagogy. This is their first experience with PBL. Prior to this subject, these students have had acquired knowledge in digital and analog electronics as well as C programming skills which form the fundamental knowledge and skills required for this subject.

Students are required to work in groups of four on a project. They were allowed to choose who they wanted to team up with.

Rubric/Criteria

Taking into consideration of the fact that the students were performing self-assessment for the first time, a detailed marking rubric with nine criteria was designed and provided to the students (Figure 2). The aim was to guide students on how they should organise the information so that the peers could understand the content better. Descriptions of standards and specific expectations of what the facilitator is looking for under each level of performance are explicitly made known to students so as to allay their anxiety and also to make this process more targeted and purposeful for them.

	Criterion	A Excellent	B Good	C Room for improvement
Content (4%)	Relevance	I have chosen content that **almost entirely** matches the actual devices and programming language used in this project. (eg PIC18, 7-segment or other device of my learning issue (LI), C language, etc…)	I have chosen content that is **matches most** of the actual devices and programming language used in this project. (eg PIC18, 7-segment or other device of my learning issue (LI), C language, etc…)	I have chosen content that is about **half-matched** to the devices and programming language used in this project. (eg PIC18, 7-segment or other device of my learning issue (LI), C language, etc…)
	Accuracy	I am able to relate, interpret and apply **85-100%** of the content acquired to my LI.	I am able to relate, interpret and apply **70-85%** of the content acquired to my LI.	I can relate, interpret and apply about **half (50-65%)** of content acquired my LI.
	Appropriate examples/ illustrations used	About **85-100%** examples/illustrations I used are applicable to my LI and support my explanation	About **70-85%** of the examples/illustrations I used are applicable to my LI and support my explanation.	I have **limited** examples/illustrations I used are applicable to my LI and support my explanation
	Complete-ness	**All** items in Discovery checklist for my LI are completed to a satisfactory level.	**Most (70-85%)** of the items in Discovery checklist for my LI are completed to a satisfactory level.	**Almost half (50-65%)** of the items in Discovery checklist for my LI are completed to a satisfactory level.

Figure 2. Partial snapshot of the Rubric

The criteria assessed are:

- Content (4%)
  - Relevance, Accuracy, Appropriate example or illustration used, Completeness
- Effort (4%)
  - Range of sources used, Concision, Organisation, Pitch
- Originality (2%)
  - Acknowledgement of sources used

Summary of Work Done

Figure 3 shows the flow of work done by a student from the point when s/he embarks on the research to the point where s/he peer-teaches.

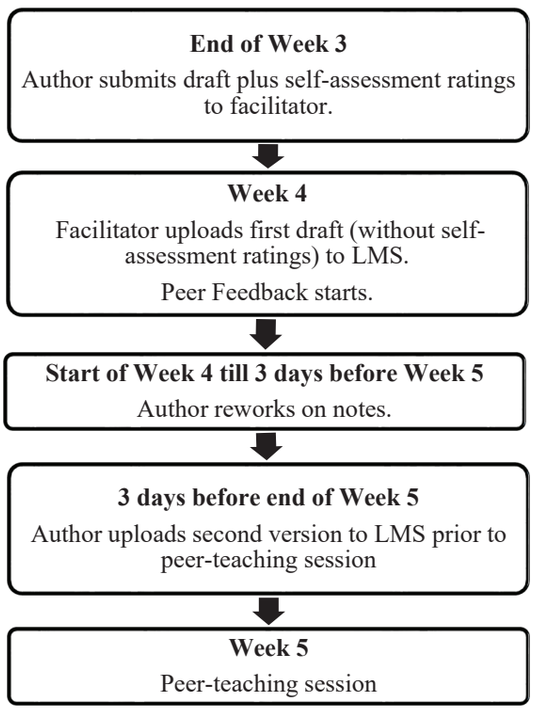

Figure 3. Workflow for students in this study

On Week 2, after the Learning Issues formulation stage, students were briefed on the purpose of self-assessment. They were informed that the self-assessment grade will have no impact on the final grade. Rubric for the Discovery notes was shown before students embarked on their research. In addition, they were given a checklist (Figure 4) containing questions that they needed to address in their notes. The facilitator then showed students three samples of past students' work (poor, average and good quality) on the projector and matched them against the rubric so that students could have an idea what the facilitator was expecting from them. Students were given the opportunity to clarify about the details in the rubric. They were then asked to submit the first draft with accompanying self-assessment ratings to the facilitator by end of Week 3.

At beginning of Week 4, the first draft (without the self-assessment ratings) was uploaded to LMS and group members were asked to give their non-anonymous feedback on the quality of the draft by referring to the same rubric. The peers were asked to identify 'what each member has done well' and 'what each member can improve on'. They were given slightly more than a week to input their comments online in Google Doc. Everyone in the group was able to read the feedback anytime during the week. Students were asked to look at the feedback, review, re-submit and upload the second version of their Discovery notes to the LMS 3 days before class on Week 5 for grading as well as for the other peers to read before the peer-teaching session on Week 5.

7-segment Display Peer Tutor: _____		**Information**
	1	Difference between a common anode (CA) and common cathode (CC) 7-segment display
	2	Identify the type of display (CA or CC) on the lab target board / project board
	3	Displaying a pattern or number on the 7-segment (using C program statements)
	4	Count down from 9 to 0 on the 7-segment (using C program statements)
	5	Identify the need for SL1 and SL2 on the project board (refer to schematic on LMS)
	6	Displaying a 2-digit number on the project board (refer to schematic on LMS)

Figure 4. Partial snapshot of Checklist

Data Collection Methods

To gather students' experiences on self-assessment and peer feedback processes, an online non-anonymous survey comprising seven open-ended questions was first administered prior to peer-teaching session. After the

peer-teaching session was completed, a focus group interview involving five students, randomly chosen from each of the five groups, was conducted a week later to elicit their responses on the usefulness of the notes in relation to their learning. Although there were six groups formed, only five students turned up for the interview. Participants were informed that their identity would be kept confidential and that their responses would have no impact on their subject grade.

The seven questions asked in the survey were:

- How do you think the rubric/criteria have aided you in the process of writing your Discovery notes?
- What do you think were the pros and cons of self-assessing your own Discovery notes?
- What were your thoughts as you self-assessed your work? Why? (e.g. was it difficult/alright and why)
- What do you think were the pros and cons of receiving peer feedback on your Discovery notes?
- What do you think were the pros and cons of assessing somebody else's work?
- What were your thoughts as you peer-assessed your peer's work? Why? (e.g. was it difficult/alright and why)
- Other than marks, what changes would you suggest to help you achieve a better quality of your work prior to grading, given the constraints that you have about two weeks to complete the assignment?

Results and Discussion

Responses received from both the online survey and interview regarding students' experiences are categorised in the following themes.

Using rubric

All except one found the rubric detailed and useful. The criteria and what different levels of performance might look like on each criterion help them to "know what is needed in my Discovery notes", "allow me to check what is missing from my notes" and "guide me to work closely with the tasks given". Students learned how good quality work looks like, how to evaluate their work against these qualities, how to retreat from their work to assess their own efforts and how to generate feedback for themselves about where they need to make improvements (Reif, 1990; Wolf, 1989). These are qualities of self-directed learners, not passive learners.

Self-assessment helps students to set their goals and monitor their performance as they journey through the process (Boud, 1995) and make adaptations based on their analysis (Labuhn et al., 2010). One student shared that "I am now able to know how I could get a higher grade". Another student commented that "I had to review my work one time more. I realised that I was not achieving satisfactory level for all the criteria".

Self-assessing own work

While the rubric seems helpful in terms of providing a quality check reference when writing their notes, however, several felt giving a grade to one's personal work was something that they were not used to despite the fact that the grades have no effect on the summative mark. While one felt it would seem too boastful to give himself a good grade, a couple of responses indicated that the grades shown might not be reflective of the quality of their effort put in as they were afraid of being judged as lousy in the eyes of others (even though they were told their peers will not see their self-assessed grade). However, Boud and Falchikov (1989)'s review of various quantitative studies on student self-assessment suggested that "there is no consistent tendency to over- or underestimate performance". However, they suggested that one of the possible reasons for poor self-assessment ability could stem from students' weak understanding of the assessment criteria used for measuring their performance.

A large number of students commented that they were unsure if they were on the right track, both in terms of whether they were meeting the actual expectations of the facilitator and whether the technical content that they put in was accurate, relevant and complete. Many students still expect facilitators to give feedback, citing that teachers' feedback are more accurate and helpful since teachers are expert both in subject content and writing skills.

Receiving feedback from others about their work

In general, students felt that this process somewhat gave them an indication as to whether their group members generally like their notes. Seeing from another person's perspective helps to identify areas where they might have overlooked. They liked the idea of getting multiple inputs from different members as different people could be looking at different things in the notes. The process also helps them gain better understanding of the criteria used for the summative assessment of their work as seen from the reader's perspective (Wood & Kurzel, 2008). When it came to the portion on suggestions on areas for improvements, most of the students' comments focused on criteria that are not related to the content per se (i.e. accuracy and relevance of content were not frequently mentioned). Some felt that some comments "tended to be less critical to the point of irrelevance" or were not specific to help them narrow down to what and how they could improve. Perhaps, students should have been taught how to give constructive and specific feedback in order to make this feedback process more effective and beneficial.

Giving feedback on others' work

Almost citing the same reasons as above, students felt 'incompetent' to give feedback on their peers' work for two reasons; largely due to the lack of technical knowledge on peers' learning issues and to a moderate

extent, their concern about 'face-saving'. As the content is new to them too, students did not know how else to help their peers to improve except to provide general comments on format and pitch. When students are faced with the task of criticising their peers' ability to write, they are sometimes more likely to withhold the advice to save face or to help their peers save face. Even if they do give some advice, they attempt to 'tone down' their comments so that they do not appear overly critical. Though there are advantages to keep the reviewers anonymous so that students are more willing to make more critical and constructive comments (Howard et al., 2010), however, identifying them forces the students to learn to give each other constructive and honest feedback responsibly when working as a team (Gulikers et al., 2009). Constructive and honest feedback helps the team to move in the same direction and to clearly communicate what they should be working towards for the benefit of the team.

In addition to giving feedback online, participants who were involved in the interview shared that they also gave face-to-face feedback to their peers. Face-to-face feedback facilitates immediate clarification and helps the authors locate the gaps in their notes quickly. Participants at the interview shared that it was not difficult for them to give honest feedback largely because most of them have known each other for a year and a certain level of trust was already present amongst them. Furthermore, they were given the choice to select their group mates. This made the task of giving honest feedback less daunting. However, they were wary to phrase the feedback in a more polite and constructive way in order to preserve their friendship. Surprisingly, when asked if they would prefer to replace online peer feedback totally with face-to-face, the participants preferred the former. They felt that online version gave them more time to think through and phrase their feedback carefully. This approach is more crucial if they are giving feedback to people whom they are not familiar with.

Understanding others' work

Interestingly, more than 75% of the students found reading others' work beneficial. The process not only helps the reviewer self-assess his own work by judging the work of others, he also gains insight into his own performance and learn good practices which the authors have used (Topping, 1996). In addition, reviewing others' work and having to give constructive feedback meant that they need to analyse the work critically so that the feedback can be relevant. In so doing, students develop their reading and analytical skills.

Participants who were involved in the interview generally agreed that the Discovery notes were sufficient as a start to lead them into the peer-teaching session but not adequate to see how the information can be applied to the given problem scenario. They felt the knowledge gaps were somewhat filled in during the face-to-face peer-teaching session where there were opportunities for them to seek clarifications from the peer-tutor. The interview participants added that it was tedious to describe the applications of technical concepts in greater details in text. They felt the peer-teaching session was useful and more efficient as they could explain and draw at the same time. This approach suits many of them as they tend to learn better with sketches and drawings.

Conclusion and Recommendations

In view of the fact that Problem-based Learning by itself was not something that students could buy-in and adapt readily, this intervention represented a bold attempt to further challenge students to become independent and intra-dependent PBL learners. Most students found their experience in this intervention refreshing. They saw the value of peer feedback and the usefulness of ongoing self-assessment and self-monitoring of one's performance during the development of the Discovery notes. Being constructive and specific but yet exercise sensitivity towards their peers was one thing that they learned to take note of when giving peer feedback.

There were a few observations and learning points derived from the findings. Recommendations on how the processes could be further improved are included in this section.

- Despite the fact that students knew they were not given any mark for self-assessment during the briefing, it was apparent that they took the process seriously. Students were using the rubric information as a tool to guide them to achieve a desired goal (Chappuis & Stiggins, 2002).

- Although the facilitator gave a briefing in relation to the use and interpretation of the rubric on the onset and make the criteria explicit by including very clear and detailed descriptors, it appeared that students might not have understood the criteria deeply. Misinterpretation of these criteria could arise as students might have pre-conceived prior experiences which shaped their expectations. Perhaps, some time should be set aside in class to get students to 'assess' the exemplars by themselves using the rubric and then justify their 'grade' in class so that everyone has a common understanding of what the facilitator is expecting. Besides, the facilitator can use this opportunity to clarify any misinterpretation students might have.

- Students found the checklist useful as it helped them to narrow the scope of their research areas. The checklist seems to complement the rubric well in this study, particularly in the context of PBL, as the students were new to the subject content.

- Despite that, several students encountered some difficulties evaluating the relevance and accuracy

of the content that they found on the internet. Besides the short amount of time that they had for research, students probably lacked the ability to critically evaluate the quality of information that they found. Hence, it might therefore be necessary to teach or demonstrate how good research skills look like before students embark on the research activity.

- Students in the same project group found it difficult to give comments on the 'relevance and accuracy' of their peers' work since they themselves are not familiar with their peers' learning issues. To mitigate the above in relation to 'relevance and accuracy' of the technical content, the first round of peer feedback could involve members from other groups who are working on the same learning issue. These students could give each other feedback based on the criteria relating to relevance and accuracy of content.

  The second round of peer feedback involves the author's own group members. Their responsibility could largely focus on content organisation and pitching which gear towards helping them read and understanding more easily.

- For peers to be able to give honest feedback, there must be a certain level of familiarity and trust amongst each other. Hence, it is suggested that some team-building activities could be introduced into a class if the students do not know each other well. A trusting and friendly environment can support the peer feedback process better.

- Students are generally willing to give constructive feedback to their peers but could lack the ability to do it effectively. The ability to give constructive feedback to peers and subordinates in a workplace is a professional skill that is highly valued by employer. Hence, the students would need to be given more practice to hone this skill well by intentionally providing these opportunities in other subjects.

In conclusion, apart from just fine-tuning the mechanics of incorporating these processes into the Discovery stage, implications on equipping students with process skills such as giving constructive feedback and research skills should also be considered by the subject team so as to better enhance the effectiveness of the implementation.

Acknowledgement

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HOW DO WE MAKE STUDENTS LEARN ENGINEERING? THE IMPORTANCE OF ORGANIZATION OF CLASSES BY CAPACITY ACCORDING TO THE CHARACTERISTICS OF STUDENTS

Takahiro Niwa*[a], Yoshimichi Nakamura[a], Akio Kikuchi[a], Takahiro Wakasa[a]

[a] Department of Liberal Arts and Engineering Sciences, Institute of Technology, Hachinohe College (Hachinohe KOSEN), JAPAN

* niwa-g@hachinohe.kosen-ac.jp

Abstract

Nowadays, Japanese population, especially children who is below 15 years old, is decreasing. This has two meanings. One is that many educational institutions has difficulties to collect the students. Another meaning is that KOSEN has to accept the students who are not very interesting about engineering. In particular, some students enter KOSEN without sufficient knowledge for mathematics or physics to learn engineering. Therefore, in every year, there are students who have difficulties learning in college and have to repeat a school year or drop out. Moreover, each student in one class have very big gap of learning skills, teachers often have difficulties to teach.

We consider that one of reason about these problems are organization of classes for mathematics and physics. In our KOSEN, organization of classes of mathematics and physics place for just each specialized course, is not considering the characteristics of students. However, it is too difficult to identify each ability in all students. So, in order to discuss the importance of organization of classes by capacity according to the characteristics of students clearly and quantitatively, we analyse correlations of students' score of between each liberal arts subject in lower graders in our college.

As this analysis, we find that students have the higher score of the logical writing in Japanese and English, the higher score correlation between the subjects of several mathematics subject. These mathematics subjects need abilities of theoretical and logical thinking rather than the other one This result is two meanings. The one is that their logical writing skill relate to mathematics strongly. Another one is that if their mathematical subjects' scores are low, it is thought that it is relatively easy to cultivate their mathematical abilities. In order to cultivate their knowledge for mathematics or physics to learn engineering, we will need to organize classes focusing on the structure of mathematical expressions.

Keywords: *Organization of classes, Liberal Arts Education, Mathematics & Physics Education*

Introduction

KOSEN is one kind of technical college in Japan, thus junior high school student who want to learn in KOSEN was very interested in Mathematics and Physics. However, in present days, KOSEN has to accept various student, including students who are not very interested in mathematics and physics because we have to maintain admission quota. Out KOSEN has four courses in one department (Industrial Systems Engineering); Mechanical system design course (hereafter M-course), Electrical and computer engineering course (E-course), Material and Bio engineering course (C-course), Civil Engineering and Architectural design course (Z-Course). However, student who insufficient knowledge for mathematics or physics to learn engineering enters any course. This fact brings some serious problems. The biggest one is “polarized academic performance”. Figure 1 shows that score of a midterm exam about physics in a course in our college (average score is 68 points). A Histogram is not shown gaussian distribution but also almost flat in all score range. This is an evidence for “polarized academic performance” we think. We also found that the tendency is shown in mathematics too.

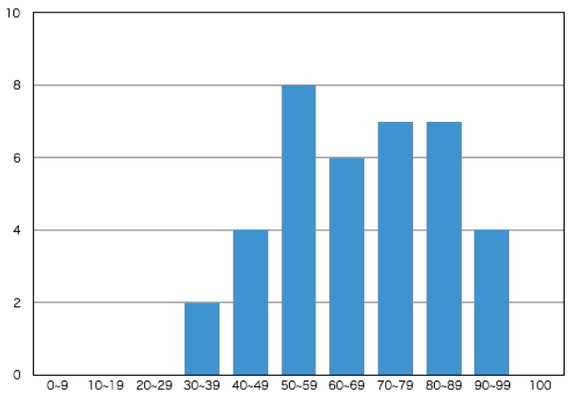

Figure 1. The Histogram of scores of a midterm exam about physics in a course in our college. The horizontal axis and vertical axis correspond to score distribution and number of students, respectively.

"Polarized academic performance" brings several difficulties both of teachers and students. Who should the teacher target and teach? – If we teach for high-performing student, many low-performing students cannot understand. If we teach for average-scored student, many students feel boring about class because they are not majority.
We consider the difficulties of classes are caused by organization of classes in physics and mathematics.

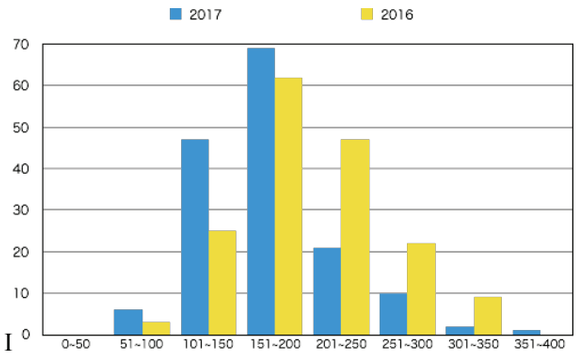

Figure 2. The Histogram of scores of National Achievement Test. The horizontal axis and vertical axis correspond to score distribution and number of students, respectively.

In our KOSEN, organization of classes of mathematics and physics place for just each specialized course, is not considering the characteristics of students, thus we do not consider that how do students obtain their knowledges about physics, mathematics and engineering when we organized the classes.

Therefore, we discuss the importance of organization of classes by capacity according to the characteristics of students clearly and quantitatively, we analyse correlations of students' score of between each liberal arts subject in lower graders in our college.

Samples and analysing methods

In order to discuss how do students obtain the knowledge about physics and mathematics, we choose performance of 3rd-graders of 2017 academic year as the sample. The main reason is that in the case of Japanese KOSEN, students finish most fundamental subjects up to the 3rd grade including physics and mathematics. Another reason is that we have their scores of National Achievement Test. Their scores more decrease than that of 3rd-graders of 2016 academic year. In particular, average of low-performing student decreases (Figure 2). From this result, we consider that this is not only we cease "doping" for National Achievement Test (Niwa & Nakamura, 2017), but also because of the diversification of the way that students acquire knowledge each course.

In analysis, we classify the fundamental subjects (Physics, Mathematics, Japanese, and English) that the student has taken for each related subject and calculate the average score of each fundamental subject. Based on

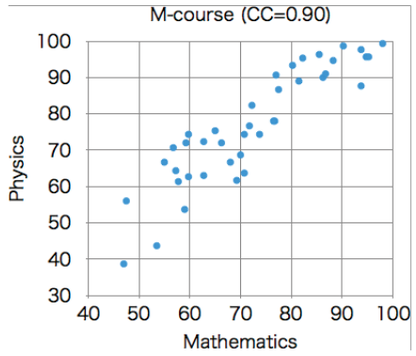

Figure 3. correlation diagrams between score of physics and that of mathematics (M-cource)

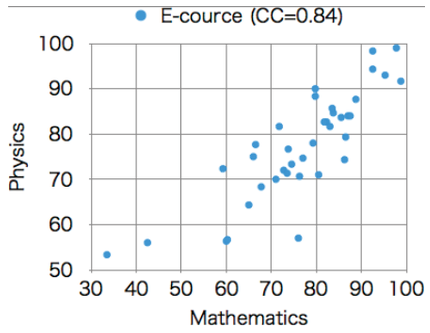

Figure 4. Correlation diagrams between score of physics and that of mathematics (E-cource)

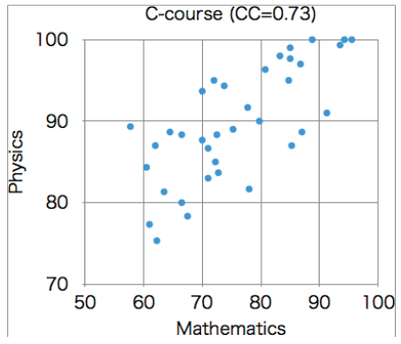

Figure 5. Correlation diagrams between score of physics and that of mathematics (C-cource)

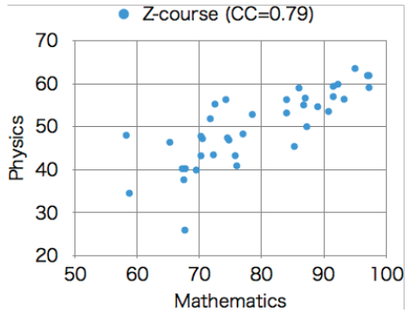

Figure 6. Correlation diagrams between score of physics and that of mathematics (z-cource)

these average scores, we draw correlation diagram between mathematics and physics each course at first. In the next step, we calculate correlation coefficient of scores between all fundamental subjects to investigate the knowledge-based relationships between all subjects.

Results

Figure 3~6 show correlation diagrams between score of physics and that of mathematics each course in our college. Score correlation between mathematics and physics of M-course (correlation coefficient; CC = 0.90) and E-course (CC = 0.84) are very strong. However, C-course (CC = 0.73) value indicates the weakest correlation. CC value of Z-course is just in the middle. On the other hand, in the C-course, the score range was the smallest in both mathematics and physics, in contrast, the score range of M-course was the biggest in both mathematics and physics. Table 1~4 show correlation coefficient table between all fundamental subjects. In these table, correlation coefficient larger than 0.7 highlight as yellow and it larger than 0.8 highlights as red, respectively. In table 1, we show results of M-course. M-course has the largest number of yellow and red highlights. Mathematics 1 and physics 1 (M1-P1) and 2 English subjects (EG1-EG2 and EG2-EC1) show the strongest relationships. English and physics have also strong relationships too. Table 2 shows results of E-course. From table 2, we find the connection between subjects in some mathematics subjects and physics exercise are the strongest. EG1-EG2 and EG2- EC1 have also strong relationships we find. Table 3 shows results of C-course. This table has only 4 yellow highlights which indicate that score range was the smallest in both mathematics and physics in spite of the knowledge-based connection between subjects are very weak. In table 4, we show results of Z-course. Table 4 has 2 red highlights and 4 yellow highlights. This is just in the middle between E-course and C-course. We summarized results in table 1~4 as table 5.

Table 5. Correlation coefficient between score of physics and that of mathematics each course

Course	M	E	C	Z
Correlation coefficient	0.90	0.84	0.73	0.79
# of subjects CC >= 0.7	14	10	4	4
# of subjects CC >= 0.8	3	4	0	2

Discussion

From figure 3~6, table 1~4, and table 5, we find interesting tendency; if correlation coefficient between mathematics and physics leading from table 3~6 is large, then total number of yellow and red highlights in table 1~4 has large numbers. To explain about this tendency, we generate hypothesis about “memorize”.

Table 1. Score correlation coefficient between all fundamental subjects in 3rd grade of M-course. The first letter of the heading indicates the abbreviation of the subject name (M, P, J, and E are corresponding to Mathematics, Physics, Japanese and English, respectively), and in the case where there is the second letter, the item’s details are shown (E, G, W, C are corresponding to Exercise, Grammar, Writing, Conversation).

	M2	M3	ME	PE	JG	JW	EG1	EG2	EC1	EC2	P1	P2
M1	0.67	0.64	0.77	0.51	0.39	0.35	0.67	0.61	0.60	0.57	0.80	0.76
M2		0.59	0.74	0.47	0.29	0.39	0.61	0.46	0.64	0.52	0.69	0.75
M3			0.77	0.51	0.30	0.36	0.58	0.49	0.53	0.52	0.63	0.63
ME				0.54	0.32	0.24	0.60	0.57	0.55	0.54	0.76	0.67
PE					0.26	0.26	0.49	0.57	0.35	0.40	0.60	0.40
JG						0.44	0.43	0.33	0.59	0.47	0.38	0.39
JW							0.38	0.18	0.42	0.32	0.25	0.39
EG1								0.80	0.82	0.71	0.70	0.70
EG2									0.65	0.74	0.71	0.54
EC1										0.74	0.67	0.71
EC2											0.65	0.49
P1												0.65

Table 2. Score correlation coefficient between all fundamental subjects in 3rd grade of E-course. For more details of headings are same as Table 2.

	M2	M3	ME	PE	JG	JW	EG1	EG2	EC1	EC2	P1	P2
M1	0.74	0.80	0.80	0.80	0.43	0.34	0.69	0.62	0.68	0.49	0.77	0.66
M2		0.70	0.65	0.57	0.17	0.43	0.47	0.44	0.44	0.34	0.56	0.61
M3			0.79	0.76	0.31	0.30	0.40	0.44	0.47	0.33	0.67	0.63
ME				0.81	0.38	0.28	0.56	0.59	0.60	0.54	0.69	0.62
PE					0.29	0.10	0.36	0.48	0.45	0.34	0.65	0.55
JG						0.20	0.45	0.36	0.45	0.30	0.35	0.22
JW							0.22	-0.02	0.14	-0.02	0.14	0.36
EG1								0.73	0.78	0.64	0.61	0.41
EG2									0.61	0.73	0.56	0.31
EC1										0.76	0.59	0.42
EC2											0.50	0.30
P1												0.76

Table 3. Score correlation coefficient between all fundamental subjects in 3rd grade of C-course. For more details of headings are same as Table 2.

	M2	M3	ME	PE	JG	JW	EG1	EG2	EC1	EC2	P1	P2
M1	0.62	0.36	0.76	0.48	0.14	0.30	0.58	0.52	0.57	0.55	0.69	0.62
M2		0.27	0.76	0.41	-0.32	0.50	0.46	0.70	0.55	0.46	0.58	0.54
M3			0.28	-0.00	0.02	-0.01	0.21	0.14	0.34	0.30	0.22	0.14
ME				0.62	0.02	0.29	0.54	0.54	0.47	0.39	0.66	0.62
PE					-0.05	0.24	0.31	0.37	0.29	0.28	0.50	0.47
JG						-0.43	-0.00	-0.33	-0.16	-0.06	0.02	-0.06
JW							0.37	0.48	0.21	0.24	0.33	0.32
EG1								0.60	0.55	0.56	0.53	0.47
EG2									0.60	0.60	0.38	0.55
EC1										0.63	0.65	0.65
EC2											0.47	0.34
P1												0.75

When many students have to memorize something, they memorize about it related to something else. We consider that the results in case of M-course and E-course shows it. Because many subjects indicate strong relationship seen in Table 1 and 2. On the other hand, although students in C-course has narrow score range, and average score is high, results of C-course do not show it like M and E-course. We consider that this indicates differences about memorize-style. If student has strong relationships between score of mathematics and physics, they show that they can memorize various things in association. In contrast, students with low correlation between mathematical and physical scores may not have memory association and they may just remember it as a simple task. We define that this memorizing type is "scanner-type memorize". In order to explain differences of memorize-style, we need to characterization of each course. Student belongs to M or E-course are required to utilize sophisticated mathematics usually. However, C-course students are not requiring it well. Because they are required to memorize chemical terms and biological terminology rather than utilizing mathematics. We are not planning on superiority or inferiority of the two memory styles. However, if a student has a scanner type memory style, it may be disadvantageous in logical thinking. At least, if student has "scanner-type memorize", then class organization for fundamental subjects especially mathematics and physics needs to consider memorize-style for each student.

In order to verify the hypothesis on memory from another aspect, we investigate relationships between logical writing in Japanese and other subjects. We reclassify the students not by course but by sorting in logical writing in Japanese and extracting the top 40 and bottom 40 people at first. In second step, we recalculate correlation coefficient between all subject based on new classification (Table 6 and 7). From these results, we obtain a new finding. Although it is not as obvious as the result by each course, it is found that the top 40 have a strong correlation between mathematics. On the other hand, in case of the bottom 40, we find strong correlations in physics subjects. Naturally logical thinking is necessary also in physics. But admitting bringing textbooks to the examination may have influenced the results in case of physics. At least, in order to cultivate students' logical thinking, we find logical writing is very effective. Kada and Niwa (2016) also pointed out that it is very effective to increase the interest in mathematics and physics by giving students a task that scientific thinking power is required during the classes of the Japanese.

As we have mentioned above, in order to organize of class for fundamental subjects especially mathematics and physics, it is not appropriate to simply classify by mathematical and physical scores. Naturally, it is not appropriate to classify by each course too. For appropriate class organization, we need to classify based on memorize-type each student including score of logical writing and English.

Table 4. Score correlation coefficient between all fundamental subjects in 3rd grade of C-course. For more details of headings are same as Table 2.

	M2	M3	ME	PE	JG	JW	EG1	EG2	EC1	EC2	P1	P2
M1	0.69	0.30	0.78	0.60	0.36	0.26	0.68	0.50	0.72	0.63	0.67	0.63
M2		0.28	0.58	0.54	0.15	0.06	0.57	0.34	0.59	0.46	0.43	0.50
M3			0.36	0.37	-0.20	0.17	0.34	0.39	0.21	0.18	0.32	0.42
ME				0.45	0.27	0.11	0.58	0.53	0.54	0.47	0.62	0.61
PE					0.34	0.62	0.57	0.53	0.67	0.50	0.45	0.56
JG						0.40		0.29	0.38	0.30	0.49	0.24
JW							0.41	0.39	0.43	0.28	0.28	0.25
EG1								0.80	0.84	0.62	0.55	0.62
EG2									0.69	0.52	0.51	0.56
EC1										0.75	0.55	0.64
EC2											0.45	0.48
P1												0.70

Table 6. Score correlation coefficient of the top 40 in logical writing. For more details of headings are same as Table 2.

	M2	M3	ME	PE	JG	JW	EG1	EG2	EC1	EC2	P1	P2
M1	0.71	0.46	0.85	0.60	0.10	-0.06	0.70	0.56	0.62	0.45	0.57	0.60
M2		0.44	0.73	0.45	-0.05	-0.02	0.50	0.40	0.64	0.52	0.50	0.64
M3			0.54	0.44	-0.19	0.14	0.36	0.43	0.34	0.40	0.69	0.64
ME				0.60	0.02	0.18	0.68	0.58	0.63	0.53	0.57	0.63
PE					0.26	0.22	0.55	0.60	0.62	0.54	0.67	0.74
JG						0.05	0.22	0.20	0.34	0.16	0.09	0.04
JW							0.23	0.28	0.16	0.20	0.27	0.25
EG1								0.80	0.78	0.66	0.63	0.60
EG2									0.74	0.69	0.57	0.62
EC1										0.85	0.56	0.67
EC2											0.57	0.56
P1												0.76

Table 7. Score correlation coefficient of the bottom 40 in logical writing. For more details of headings are same as Table 2.

	M2	M3	ME	PE	JG	JW	EG1	EG2	EC1	EC2	P1	P2
M1	0.69	0.61	0.75	0.48	0.21	0.28	0.46	0.38	0.39	0.46	0.62	0.55
M2		0.40	0.61	0.29	0.02	0.34	0.39	0.39	0.17	0.31	0.48	0.59
M3			0.41	0.51	0.38	0.32	0.45	0.21	0.43	0.30	0.81	0.73
ME				0.54	0.27	0.23	0.33	0.32	0.28	0.34	0.53	0.55
PE					0.25	0.17	0.29	0.34	0.23	0.13	0.56	0.41
JG						-0.03	0.39	0.22	0.51	0.49	0.54	0.35
JW							0.29	0.08	0.18	0.15	0.24	0.28
EG1								0.70	0.75	0.75	0.56	0.40
EG2									0.53	0.71	0.35	0.17
EC1										0.76	0.44	0.44
EC2											0.42	0.22
P1												0.80

Conlusion

In this paper, we discussed about knowledge-based relation in fundamental subjects. Our conclusion as follows:

- In order to discuss how do students obtain the knowledge about physics and mathematics, we draw correlation diagram between mathematics and physics each course at first. In the next step, we calculate correlation coefficient of scores between all fundamental subjects to investigate the knowledge-based relationships between all subjects.
- Score correlation between mathematics and physics of M-course (correlation coefficient; CC = 0.90) and E-course (CC = 0.84) are very strong. However, C-course (CC = 0.73) value indicates the weakest correlation.
- We consider that this indicates differences about memorize-style. If student has strong relationships between score of mathematics and physics, they show that they can memorize various things in association. In contrast, students with low correlation between mathematical and physical scores may not have memory association and they may just remember it as a simple task. We define that this memorizing type is “scanner-type memorize”. If a student has a scanner type memory style, it may be disadvantageous in logical thinking. At least, if student has “scanner-type memorize”, then class organization for fundamental subjects especially mathematics and physics needs to consider memorize-style for each student.
- In order to verify the hypothesis on memory from another aspect, we investigate relationships between logical writing in Japanese and other subjects. As this result, although it is not as obvious as the result by each course, it is found that the top 40 have a strong correlation between mathematics.
- In order to organize of class for fundamental subjects especially mathematics and physics, it is not appropriate to simply classify by mathematical and physical scores. Naturally, it is not appropriate to classify by each course too. For appropriate class organization, we need to classify based on memorize-type each student including score of logical writing and English.

INVESTIGATION OF EDUCATIONAL EFFICACY OF ACTIVE LEARNING: ESTIMATION FROM BIOLOGICAL VIEWPOINT

Y. Ichikawa[a], K. Moriya[b], R. Komura[c], M. Morimoto[d], K. Yajima[e], and M. Nakagawa[f]

[a] General Education Department, National Institute of Technology (NIT), Tokyo College, Japan

[b] Department of Production Systems Engineering, NIT, Hakodate College, Japan

[c] Department of Electronics and Information Engineering, NIT, Ishikawa College, Japan

[d] Department of Natural Science, NIT, Akita College, Japan

[e] Department of General Engineering, NIT, Sendai College, Japan

[f] Faculty of Engineering, Nagaoka University of Technology, Japan

*yuko@tokyo-ct.ac.jp

Abstract:

We attempt to objectively visualize the effects of the educational efficacy of active learning (AL) by measuring students' physiological parameters during classes. We prepared four different types of 20-minute classes: (1) Information Technology and (2) Mathematics where three students in each class were engaged in (A) active learning or sat through (B) conventional lectures (CL). The students were split into two groups, where the first group was allocated to 1A and 2B classes, and the second group to 2A and 1B classes. For each class combination, the cerebral blood flow of one student was measured noninvasively with a NIRS (Near Infrared Spectroscopy) device, while the number of eye blinks and eye movements of two other students were tracked with a special type of glasses. Students were then asked to fill out a self-report questionnaire on their levels of satisfaction, concentration, and interest in the classes, as well as the extent of their self-thinking. Students engaged in AL reported higher scores for all items, especially for both concentration and satisfaction (p<0.05 respectively). The cerebral blood flow measurements (difference between oxygenated hemoglobin (Oxy-Hb) and deoxygenated hemoglobin (Deoxy-Hb)) revealed that brain activity increased during AL classes and decreased during CL, but this could be due to the heavy weight of the NIRS device on the students' heads. Data on eye blinks indicated that the level of concentration increased as the AL classes progressed. Overall, we observed a higher level of brain activity and concentration in students engaged in AL compared to those in CL. However, this is a pilot study with a small sample size, and individual variation may have affected the results. Further studies with larger sample sizes would be required to validate these results. In addition, it would be interesting to examine if there is any correlation between the observable changes in these data and the students' actual activities in the video recorded during classes, as well as the improvement in students' concentration and activation when ICT (information and communications technology) tools are used in classes.

Keywords: *Active learning, cerebral blood flow, number of blinks, concentration,*

Introduction

The National Institute of Technology (NIT) of Japan has stipulated the introduction of AL to ensure the quality of education, of which several initiatives called for each college to set up a new AL center equipped with ICT equipment to create the necessary environment, and for teachers to revise their lessons accordingly and attend workshops. The aim of incorporating AL is to get away from the mere imparting of information (considered as passive learning) and to provide a program where students can proactively participate in classrooms instead. This has resulted in a drastic departure from the former conventional classroom activities and the colleges had to come up with a new system to evaluate students and the classes. However, most of these evaluations are subjective, such as learning portfolios for students to assess their learning progress and reflection cards or questionnaires filled by students, as well as teachers' feedback.

On the other hand, the commonly recognized objective indicators used to evaluate the educational efficacy are the level of academic achievement and the increase in students' study time.

In this study, we will compare the biological data of students in AL classes against those in conventional lecture (CL) classes in an attempt to visualize the efficacy of AL using objective indicators of cerebral blood flow and eye blinks. We will also propose a new method based on our results to evaluate the educational efficacy.

Experimental Methods

2.1 Procedure

We conducted four different types of 20-minute classes as follows:

1A: Information technology class using AL and several quizzes.
1B: Information technology class in CL (see Figure 1).
2A: Mathematics class using AL where group work is required (see Figure 2).
2B: Mathematics class in CL.

Six students were split in two groups of three. The first group took 1A and 2B classes, while the second group took 1B and 2A classes. This arrangement was to ensure that each student would take one AL class and one CL class of different subject to prevent carryover effects. For each class combination, the cerebral blood flow of one student was measured while the number of eye blinks of the remaining two students were tracked.



Figure 1: Students in 1B class.



Figure 2: Students in 2A class.

2.1 Cerebral Blood Flow

The activity level in the prefrontal cortex was observed by measuring the difference between Oxy-Hb and Deoxy-Hb with a NIRS device using non-invasive optical topography (WOT-100, Hitachi High Technologies Ltd.) at a sampling frequency of 5 Hz. An increase in Oxy-Hb and decrease in Deoxy-Hb would indicate that the corresponding region of the prefrontal cortex is activated compared with the previous condition. Conversely, a decrease in Oxy- Hb and increase in Deoxy-Hb would signify inactivity in the prefrontal cortex. We believe that the bigger the difference between the Oxy-Hb and Deoxy-Hb, the more the student's brain is activated.

2.2 Eye Blinks

The number of eye blinks and eye movements were tracked with a special type of glasses (JINS MEME, n.d.). The glasses also capture data on the strength of eye blinks and head and movements, but we are only looking at the number of blinks for this study as we believe that people will blink lesser when they are concentrating on the task at hand.

2.3 The questionnaire

We conducted a 5-point Likert-scale questionnaire on the students (see Table 1). Students were asked to evaluate the items on five levels: 5 – Extremely well, 4 – Very well, 3 – Somewhat well, 2 – Slightly well, 1 – Not at all well.

Table 2: Items in the questionnaire

Questionnaire
1. How interested were you in the class?
2. How much did you concentrate on the class?
3. How deeply did you think about the class?
4. How satisfied are you with the class?
5. Any comment about the class?

Results and Discussion

In this study, we investigated the biological indicators of students during classes and found that changes in the students' cerebral blood flows mainly occurred around CH8 and CH14 (Moriya *et al*. 2017) of the right and left prefrontal cortices, respectively (see Figure 4). The chart on the left is the cerebral blood flow changes of a student in the AL class (1B) and the one on the right is that of the same student in the CL class (2A). The charts clearly showed a larger increase in Oxy-Hb and a larger decrease in Deoxy-Hb when the student was attending the AL class compared to the CL class.

Figure 3 shows the number of eye blinks by two students. The red line is the number of eye blinks in the AL class and the blue line is the number of eye blinks in the CL class. The number of eye blinks in the charts are the average number of eye blinks for every five minutes. The charts indicated that the number of eye blinks decreased as the AL classes progressed (red lines) but

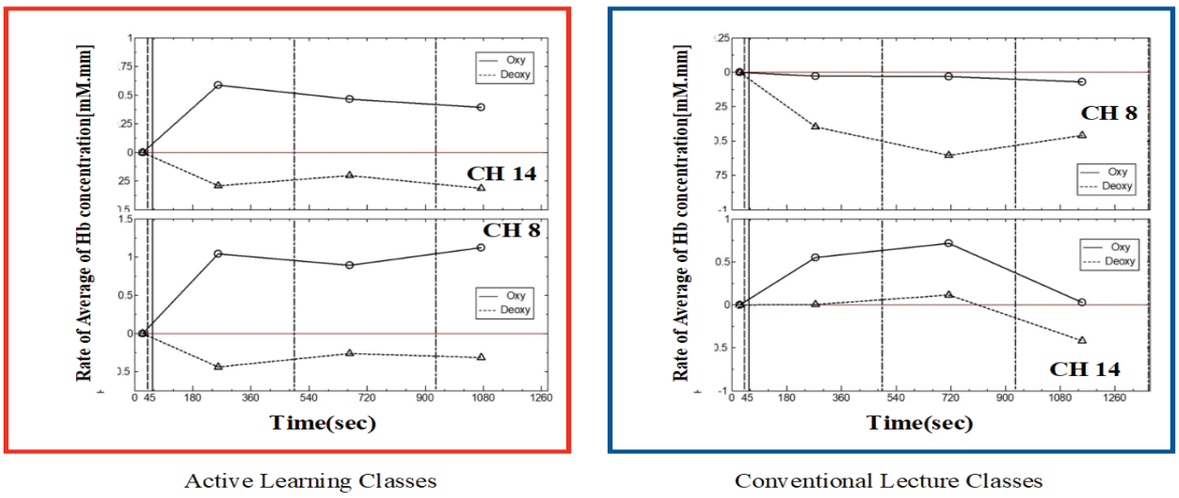

Figure 5: An example of changes in the cerebral blood flow in the CH8 and CH14 regions of a student as the class progressed.

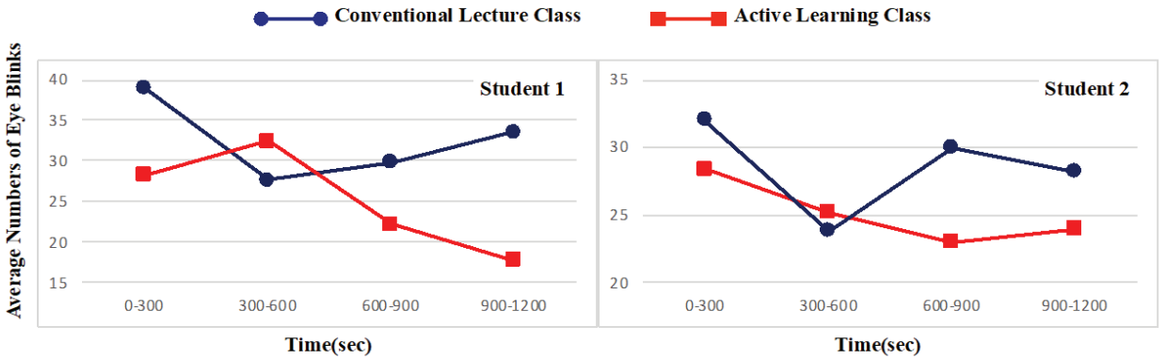

Figure 4: The numbers of eye blinks of two students. Each data point is the average number of eye blinks for every five minutes.

Table 3: Result of the questionnare. Each row shows the results for each class and each column for the items.

Items	*1*	*2*	*3*	*4*	*Average*
1A	5.0	4.3	3.7	4.7	4.43
1B	3.7	3.7	4.0	3.7	3.78
2A	4.0	4.3	4.3	4.7	4.33
2B	3.5	2.3	2.5	3.0	2.83
Average	4.01	3.7	3.6	4.0	3.84
p-value	0.06	0.02	0.17	0.0006	

increased in CL classes (blue lines) instead.

Figure 5 shows the average scores of the items in the questionnaire. Students consistently gave higher scores for AL classes than CL classes. The average scores for

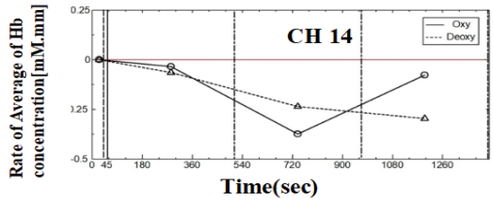

Figure 3: Unexpected change in cerebral blood flow of one student

all items are shown in Table 3. A *t*-test revealed that the *p*-values between AL and CL are 0.06, 0.02, 0.17, and ≤0.001 respectively for items 1 to 4 in the questionnaire, which seems to hint that students find it easier to concentrate and had a higher level of interest in the lesson during AL classes.

Interestingly, while we had originally assumed that students would think more deeply about the lesson in AL classes, the self-report questionnaire seems to indicate otherwise (see questionnaire item 3, p-value = 0.17, Table 3). Granted that the difference is not statistically significant, we believe that the slightly lower score is because the information technology classes (1A and 1B) were conducted to merely impart information to the students whereas the mathematics classes required students to think deeply to understand new facts. Having said that, our results showed that students who attended the information technology classes that employed AL demonstrated a higher level of brain activity and concentration.

The mean score obtained from all students on the questionnaire for class 2B is the lowest. We suspected that the contents of the mathematics class were too difficult for them to understand, and the objective biological data and the subjective answers obtained from the questionnaires verified our suspicions.

We would also like to highlight an interesting yet unexpected result that we observed in our study concerning one student's cerebral blood flow in class 2A (see Figure 5). Both his Oxy-Hb and Deoxy-Hb levels started to decrease as the class commenced. He indicated in the questionnaire that the NIRS device was too heavy and annoying. He could not really open his eyes and even had stiff shoulders, and thus was unable to really concentrate on the class. We believe that the unexpected dips in both his Oxy-Hb and Deoxy-Hb levels were due to the heavy weight of the device.

Conclusions

In this study, we investigated students' brain activation by measuring their biological responses. Due to a limited number of measurement devices, we could only perform measurements on six students only. However, our results demonstrated that the brains of students exhibited a higher level of activation in the AL classes than the CL classes. Moreover, the heavy NIRS device that students were asked to wear on their heads may have affected the results. On the other hand, students are under much lesser strain wearing the eyeglasses measuring eye blinks, so it was possible for us to measure their number of eye blinks throughout the entire 90-minute long classes.

Due to our small sample size, we decided to calculate the corrected effect sizes (Hedge's g) and obtained 0.93, 0.62, 1.41, and 1.86 respectively for items 1 to 4 in the questionnaire. While these effect sizes are considerably large, there may be a large amount of bias due to the extremely small sample size. We will need to conduct further studies with bigger sample sizes to verify these results.

While we also analyzed the cerebral blood flow and the number of eye blinks, it would be interesting to examine if there is any correlation between the observable changes in these data and the students' actual activities in the video recorded during classes, and to find out which class activity is more effective in activating the students' brains. We believe that measuring the cerebral blood flow and eye blinks and correlating these data with observational data acquired from videotaping the students in classes would help us to select the ICT tools that would boost students' level of concentration and brain activation, and thereby the educational efficacy.

This is a small pilot study but we intend to verify the efficacy of AL with bigger sample sizes in future studies and discover class activities that would be more efficient in enhancing the students' level of concentration and brain activation. Our eventual goal is to propose a new way to evaluate AL's educational efficacy using biological data as objective indicators.

Acknowledgements

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SCIENCE LABORATORY ACTIVITIES FOR ENGLISH LANGUAGE LEARNERS

M. Hara*, a

[a] National Institute of Technology, Wakayama College, Assistant Professor, Wakayama, Japan

*hara@wakayama-nct.ac.jp

Abstract

English education at NIT has more potential for investigating an efficient and practical way for young engineers to acquire the language skills. This paper aims to examine the comprehensive teaching methodology which is the science laboratory activities for engineering students of English language learners. To share the evaluation of students and discuss the ways of improvement are also the purposes of this paper. Author conducted three science laboratory activities from November 2017 to June 2018. The levels and courses of the students vary: 1) first-year students of electrical engineering courses, 15-16 years old, 2) first-year students of material science course, 15-17 years old, and 3) fifth-year students of material and mechanical engineering courses, 19-22 years old. Each class had 23-41 students. First, students were divided into six different groups and each group was assigned to conduct an experiment. For example, a group investigated a subject to visualize Gyro Effect using balloons and coins. Students should understand the experiment flow from English instructions. Second, students discussed the background and hypothesis of the experiment among themselves. Then, they conducted the actual experiments using basic materials, scribbling notes on a sheet of paper and taking pictures for reporting. Next, they wrote a lab report in English by analysing what they had observed in the experiment. According to the lab report, students made a speech manuscript and Power Point presentation all in English. Finally, each group made a presentation about their experiments and share results in front of their classmates. More than 65% of students made a positive evaluation while about 30% found it difficult yet better than using textbooks. Even though the activity needs to adjust contents of experiments depending their courses and levels, it was a versatile method for every level and major.

Keywords: *English education, English teaching methodology, English language learners, science laboratory, National Institute of Technology*

Introduction

The English education at the National Institute of Technology (hereafter called NIT) has more flexibility compared to general high schools in Japan. It is because students of NIT do not need to study for the entrance exam to enter university since its basic curriculum is for five years unlike high schools that has three years. Some students proceed to university to add two more years to acquire a bachelor degree, others start working right after graduation. Either way, they need more practical English skills than just techniques to pass the examination.

Some studies have shown the importance of motivation for English language learners. For instance, Johnson and Johnson (2010) analysed that engineering students tend to study English because of extrinsic motivation such as for their credit or career rather than intrinsic motivation associated with enjoyment to learn new things or fulfilment to speak other languages. Kimura, Nakata, and Okumura (2001) compared engineering students to English major students in Japan and they discovered that students have more pragmatic reasons to study English than English major students. Iwamoto (2018) conducted a survey for engineering majors of Toyo University to examine whether there are differences between their motivation types depending on their English proficiency. She argues that even among engineering students, those who have high proficiency in English enjoy learning English. In other words, motivation is the key to improve their language proficiency. Iwamoto also suggests that it is important to promote extrinsic motivation by using materials to make students understand “how engineers can use English in their professional lives” (Iwamoto, 2018: 11).

There are many teaching methods introduced by scholars who have been investigating how to solve the problems in teaching second language learners. For example, Larsen-Freeman and Anderson (2011) introduced 11 English language teaching approaches namely 1) grammar-translation, 2) the direct method, 3) the audio-lingual methods, 4) the silent way, 5) desuggestopedia, 6) community language learning, 7) total physical response, 8) communicative language teaching, 9) content-based instruction, 10) task-based language teaching, and 11) a politically-oriented participatory approach.

As of now, the NIT, Wakayama college uses high school level English textbooks approved by the Ministry of Education, Culture, Sports, Science and Technology for the first- and second-year students. Professors mostly use these textbooks based on the teaching methods of 1) grammar-translation, 2) the direct method, sometimes 3) the audio-lingual methods. However, professors have freedom to adjust their syllabus and to add extra activities in their classes to help students motivated to use English rather than study English. As the previous work admitted, in order for engineering students to promote motivation, connecting English learning to their professional lives is important.

Therefore, this study investigates the effective way to promote engineering students' motivation for English learning by using the content-based instruction as well as the task-based language teaching. To increase the intrinsic motivation, English teaching methodology should be related to what engineering students are familiar with and fun of thus the contents are about science experiments and the tasks are to make presentation using a computer and software. This paper analyses the evaluation of students to verify students' response for this module.

Methods and Pedagogy

I conducted science laboratory activities for three times between November 2017 to June 2018. The level and course of the students varied as Table 1 shows. It was a compulsory course for Class A & B while Class C was a part of elective course.

Table 1. Participants information

	Class A	*Class B*	*Class C*
Year	First-year	First-year	Fifth-year
Age	15-16 y/o	15-17 y/o	19-22 y/o
Major	Electrical engineering	Material science	Mechanical engineering and Material science
Class size	40 students	41 students	23 students
Date of activity	November to December, 2017	November to December, 2017	May to June, 2018

First, students were divided into six different groups with 3 to 7 students depending on the class size. I advised students to move their desks and chairs to start a group work easily. I asked them to decide the roles of each member of the group such as a leader/facilitator, time keeper, reporter, and presenter/s. Each group was assigned to conduct a different experiment and they should first understand the instruction written in English. I assigned six experiments as Table 2 chosen from the experiments introduced in the textbook, whose main authors are professors of NIT, called "Exploring SciTech English" published by Kairyudo.

Table 2. Types of experiments

Name of the experiment	*Purpose of the experiment*	*Materials used*
Gyro Effect	To examine Gyro effect and to think about when we can feel it	Balloons and coins
Magnus Effect	To understand Magnus effect which is useful to make breaking balls	A vinyl tube and some clay to make a ball
Vibration control	To test the best way for vibration control to know what kind of construction equips with earthquake suppression	A sheet of paper, a cardboard, glue, paper clips, a pencil, and a cutter knife
Jet engine	To describe how jet engine works	A long thread, a balloon, a straw, and sticky tape
Paper plane	To observe how a plane can be in the air for a long time	Some sheets of paper and clips
Super-cooling	To demonstrate the work of artificial cloud by freezing water with salt	Aluminium foils, a plastic container, ice (100g), a plastic bag, salt (20g), water, and a hammer

Second, I explained about the lab report which students were required to submit. Among three classes, only students in Class C were used to write a lab report already because they were already the fifth-year students thus I needed to explain deeply about what and how to write it for Class A and B. After being explained, students discussed about the background and hypothesis of the experiment in the group and write a first half of the lab report. They also listed up what materials they needed for the experiment.

Then, each group conducted an actual experiment using basic materials that the instructor prepared based on the list made by students. While conducting an experiment, it was suggested to scribble notes on a sheet of paper and take pictures for reporting. All six experiments were done inside a classroom at the same time.

Next, they wrote the second half of their lab report in English by analysing what they had observed in the experiment. According to the lab report, students made a speech manuscript and Power Point presentation all in English. Since the first-year students were not used to make a presentation, the instructor taught them the basic usage of the software in a computer room.

Finally, each group made a presentation to share their experiments and findings in front of classmates in English. It was not only an instructor but also students themselves who evaluated their classmates' presentations using a judging sheet. The points of evaluation were contents, clearness, attitude including eye contact and gesture, effectiveness of PPT, and teamwork. A group that got the highest score were awarded in class.

Table 3. Schedule of the activity

	Goal	*Class style*
Week 1 (90mins)	- to understand the flow of the entire activity - to figure out the instruction of experiment - to discuss the background, hypothesis, and necessary materials of the experiment	Lecture & Group work
Week 2 (90mins)	- to conduct an experiment per group	Group work
Week 3 (90mins)	- to discuss the results of experiments - to write a lab report in English and to make a manuscript of presentation	Group work
Week 4 (90mins)	- to make presentation about the experiments in English using a software	Presentation preparation
Week 5 (90mins)	- to give a presentation in English	Presentation

Results and Discussion

Students evaluated the module in a comment sheet after the whole activity and the results of analysis are below (Table 4). More than 65% of all three classes made a positive evaluation. More first-year students than fifth-year students valued "cooperation" in this activity by conducting experiments and making presentation together with their classmates. It can be said first-year students have less opportunities to join the group-oriented activities in their junior school education compare to fifth-year students who have had experienced group activities and laboratory works during their NIT education. Rather, fifth-year students found this activity enjoyable because they used English to express their professional knowledge.

On the other hand, about 35% of first-year students and 22% of fifth-year students found the activity difficult. Yet, there are overlaps between positive and negative comments. For example, one said "At first, I thought it would be too difficult to do this activity but we made it. Teamwork made it easy." (Class A). Others also said "I now understood it is difficult to express what we want to say in English through this activity." (Class B) or "I was very nervous to give a presentation in English but I was relieved to hear audience clapping their hands to us." (Class B).

Table 4. Reflection of students

	Class A	*Class B*	*Class C*
Positive comments (%)	26 (65%)	34 (85%)	21 (91%)
Enjoyment	14 (35%)	19 (46%)	16 (70%)
Cooperation	10 (25%)	14 (34%)	3 (13%)
Fulfilment	5 (16%)	5 (12%)	6 (26%)
Others	4 (10%)	6 (15%)	0 (0%)
Negative comments (%)	18 (45%)	18 (44%)	12 (52%)
Difficult	14 (35%)	14 (34%)	5 (22%)
Nervous	1 (3%)	3 (7%)	2 (9%)
Regretting	1 (3%)	0 (0%)	4 (17%)
Others	1 (3%)	1 (2%)	1 (4%)

Conclusions

To raise both intrinsic and extrinsic motivation, this natural science oriented English activity makes sense in three ways: 1) most of engineering students like and are used to conducting experiments thus, they do it out of curiosity; 2) it is practical for engineers to write a lab report and make a presentation in English; and 3) reflection from students shows that students feel fulfilment throughout the activity. Even though a lecture needs to adjust contents of experiments depending on their courses and levels, it would be a versatile method for every level and major of NIT.

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A PILOT STUDY OF MASSIVE OPEN ONLINE COURSES (MOOCS) FOR ENGINEERING STUDENTS IN HONG KONG

K. M. WONG*, K. H. HUNG and W. H. LO

Hong Kong Institute of Vocational Education,
Vocational Training Council, Hong Kong, China

*km_wong@vtc.edu.hk

Abstract

The advancement of the internet has enabled the rapid developments of massive open online courses (MOOCs) in education. MOOCs allow a new form of student-centred learning where learners can interact with the course materials at a place, time and pace convenient to them. In MOOC platforms, every action of the learners including learning progress, assessment results, and interactions with the course facilitator and peer learners are all recorded providing comprehensive data on learning behaviour, which can be used to improve the learning materials, as well as to enhance the learning experience of the learners. This pilot study focuses on the development of a mini-version of MOOC on mathematics for Higher Diploma students in the Engineering Discipline of Hong Kong Institute of Vocational Education. The mini-MOOC is designed as a pre-class self-learning tool with the following two objectives: 1) to refresh and to strengthen the mathematic foundations of the students before embarking on the study of the module of engineering mathematics; and 2) to provide information to the teachers on the students' mathematics competencies so that the teachers can make necessary adjustments to their teaching before the classes. The mini-MOOC covers common types of mathematics functions in engineering applications including linear, quadratic, polynomial, exponential, trigonometric forms, etc. It provides a quick revision on their properties followed with tests to refresh and reinforce their understanding, and then followed by examples showing their applications in solving engineering problems, so as to arouse the students' interest and preparing them to pursue further in their study of the module. At the same time, the results of the tests provide information to the teachers on the students' mathematic competencies. In this paper, the development of the mini-MOOC is discussed and the use of pre-tests and post-tests for measurement of student learning is also explored.

Keywords: *Massive Open Online Courses, MOOC, online education, engineering education, vocational education, mathematics, Hong Kong.*

Introduction

The advancement of information technology has enabled fast developments in all aspects of modern life. The high-speed broadband internet service is now available in almost all households in modern cities. In the field of education, the wide coverage of internet allows the rapid developments of massive open online courses (MOOCs).

Unlike the traditional face-to-face classroom teaching where the location, time, and teaching pace are normally fixed, MOOCs allow a new form of student-centred learning where learners can interact with the course materials at a place, time and pace convenient to them. Once the learners logon to a MOOC, they can watch the learning videos, read the learning materials, do the online quizzes, or join a discussion with the peer learners, and all sorts of learning activities created by the MOOC facilitator. If there is an internet-connected device, which can be a personal computer, a tablet, or a mobile smart phone, there is no restriction on the learning through MOOCs. Therefore, MOOCs provide freedom of learning to the learners.

In MOOC server platforms, the actions of the learners are all recorded, such as file opening of learning materials, duration of watching learning videos, logon time and duration, competition of online assessments with their results, and interactions with the course facilitator and peer learners. The records could be later used for MOOC development. The records provide comprehensive information on learning behaviour, which can be analysed by learning analytics. The records allow data for measurements of the impacts of the MOOCs on the students' learning. The results and findings could then be used to improve the learning materials, as well as to enhance the learning experience of the learners.

This pilot study focuses on the development of a mini-version of MOOC on mathematics for Higher Diploma students in the Engineering Discipline of Hong Kong Institute of Vocational Education (IVE). For Hong Kong Diploma of Secondary Education (HKDSE) graduates, the general entrance requirements to Higher Diploma is five HKDSE subjects at Level 2 or above,

including English Language and Chinese Language. As Mathematics is a necessary skill in engineering, most Higher Diploma programmes offered by the Engineering Discipline require Mathematics be included in the five HKDSE subjects. The mini-MOOC is designed as a pre-class self-learning tool with the following two objectives: 1) to refresh and to strengthen the mathematic foundations of the students before embarking on the study of the module of engineering mathematics; and 2) to provide information to the teachers on the students' mathematics competencies so that the teachers can make necessary adjustments to their teaching before the classes.

The mini-MOOC covers common types of mathematics functions in engineering applications including linear, quadratic, polynomial, exponential, logarithmic, and trigonometrical functions. It provides a quick revision on their important properties to refresh and reinforce their understanding. Examples showing their applications in solving engineering problems are illustrated, so as to arouse the students' interest and prepare them to pursue further in their study of the module. A short test is introduced after each sub-topic to test the students' understanding. At the same time, the results of the tests provide information to the teachers on the students' mathematic competencies. In this paper, the development of the mini-MOOC is discussed and the use of pre-tests and post-tests for measurement of student learning is also explored.

Literature Review

MOOCs seem to become a new fashion in the context of Technology Enhanced Learning. MOOCs allow a new form of student-centered learning and are becoming a widely-discussed new phenomenon in education such as the models of staff/student and student/student interactions (Martin, 2012). Furthermore, actions of learners and interactions can all be recorded for quality assurance related to the current online education practices in tracking and supporting personalized feedback (Jung, 2011).

There are significant areas of opportunity related to the evaluation of MOOCs, however standards regarding their pedagogical quality have yet to be agreed upon. Bernal et al. (2013) recommend that MOOCs should apply the same quality standards used in formal open and distance courses. In assessing the educational quality of distance education and open learning resources, researchers generally used indicators related to pedagogical, functional and technological factors. For Barbera, Gros, and Kirschner (2012), time is a critical factor that has also been used as a quality measure, since it is related to the amount and the sequence in which people learn through the accumulation of experiences. In collaborative learning environments, the implementation of strategies that promote participants' self-regulation is recommended (Franco-Casamitjana, Barbera, & Romero, 2013).

Daniel (2012) suggests that MOOCs could be evaluated by learners and educators, with the aim of producing league tables that rank courses. He suggests that poorly performing courses would either disappear due to lack of demand, or would undertake efforts to improve quality. Another route forward is to equate quality with participation measures (Dillenbourg et al., 2013). The primary focus would be on assessments of the learning outcomes of individual participants, thereby placing the learner at the center of measures of quality. This is in keeping with the growing focus in the research on developing multiple measures of learner behavior, motivations and engagement, through the employment of various learning and data analytic techniques. Since MOOCs shift agency towards the learner, there is a need to foreground learner perspectives, using various measures of learner perceptions, behaviors and actions, and experiences as the foundation for assessing quality.

Furthermore, the idea of KPIs can also be applied to evaluate the success rate of a MOOC. In some cases, the Kirkpatrick (1976) model was adopted as an appropriate approach to the evaluation of training in organizations consisting four levels of training outcomes: reaction, learning, behavior, and results (Bates, 2004). Reaction was originally used to describe how much participants liked a particular training program and the term evolves along with time to assess trainees' affective responses to the quality (e.g., satisfaction with instructor) or the relevance of training (e.g., work-related utility). Learning measures are quantifiable indicators of the learning that has taken place during the course of the training typologies. Behavior outcomes address either the extent to which knowledge and skills gained in training are applied on the job or result in exceptional job-related performance. Results are intended to provide some measure of the impact that training has had on broader organizational goals and objectives.

MOOC Development in Vocational Training Council

Development of MOOCs is one of the current initiatives of the Vocational Training Council (VTC). Around ten MOOCs were developed across multiple disciplines (http://mooc.vtc.edu.hk). The Department of Construction plays a leading role in developing MOOCs in VTC. In the field of construction, the MOOCs developed by the Department include "Unauthorised Building Works", "Principles of Measurement" and "Building Pathology-Aluminium Window Inspection". The MOOCs are not only open to current students and alumni, but also to staff for continual professional development.

This MOOC project is built on the successful applications of the previous MOOCs developed by the Department of Construction. The "Unauthorised Building Works" (UBWs) MOOC addressed the common phenomena in Hong Kong, which created serious safety and health hazards to occupants and public such as the collapse of tenement block at 45J Ma Tau Wai Road in 2010, and Fa Yuen Street fire in 2011. Such UBW-related accidents claimed many lives and injuries in the past. The MOOC aimed to enable learners to grasp

the legal meaning of UBWs by going through the Buildings Ordinance and Minor Works Control System, and to explore common UBWs in Hong Kong and their impacts on building structures. The "Principles of Measurement" MOOC provided basic understanding about the important role of Quantity Surveyor in many infrastructures such as Mass Transit Railway, Express Rail Link, and tall buildings in Hong Kong. The aims of the MOOC were to equip learners with essential knowledge of quantity surveying practice in building measurement, get them familiar with the measurements in reference to the Hong Kong Standard Method of Measurement of Building Works Fourth Edition (HKSMM4), to explain the importance of industry-wide used uniform and standard method for measuring the quantities of materials in building works, to realize the numerous means of measuring techniques, and to illustrate the working procedure.

More MOOCs are under development in all eight disciplines in VTC, namely Engineering Discipline, Applied Science Discipline, Business Administration Discipline, Childcare, Elderly and Community Services Discipline, Design Discipline, Hotel, Service and Tourism Studies Discipline, Information Technology Discipline, and International Cuisine / Chinese Cuisine Discipline. At the time of this submission, the MOOC described in this paper is being developed under the initiative for the Engineering Discipline. These MOOCs will be launched in Academic Year 2018/19, which starts in September 2018.

All the MOOCs in VTC are developed using edX, which is an MOOC provider founded by Harvard University and Massachusetts Institute of Technology in 2012. It hosts online university-level courses in a wide range of disciplines to learners around the globe. EdX is a non-profit organization and runs on the free open edX open-source software platform. While the platform is open source, these MOOCs can be free-of-charge or charged, at the discretion of the course developers. In 2017, edX has approximately 1,800 courses and has 14 million users worldwide (Shah, 2018). EdX also conducts research into learning behaviours based on how learners use its platform.

MOOC Platform

VTC adopts dual platforms for the MOOC development, as shown in Figure 1. The development platform is for the course developers, whereas the production platform is for the users or the learners. The course developers create the MOOC in the development platform. The available functions in the platform include uploading learning videos, adding multi-language transcripts, creating discussion forum among peer learners, and setting up quizzes and grade books. All the trial runs are done in the development platform. The development platform is further subdivided into two sites – the studio site and the browsing site. In the studio site is to where the course developers do the uploading and updating. After the updates, the developers can see the outcomes of the MOOC in the browsing site.

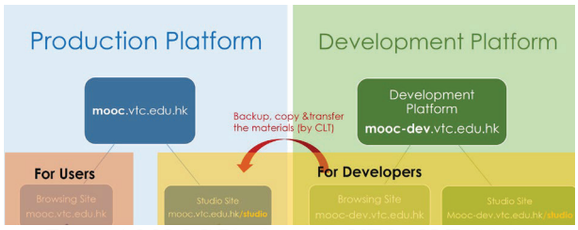

Figure 1 MOOC Platforms in VTC (CLT, 2018)

Once the MOOC production is completed and obtained approval from the internal quality assurance process, the MOOC on the development platform is then copied to the production platform for the users. The copying function is not real-time and only activated by the Centre for Learning and Teaching (CLT), which serves as a quality assurance agent and a gate-keeper for the MOOC development.

The production platform is for the learners and daily operations by the developers. Similar to the development platform, the production platform also entails the studio site and the browsing site. The studio is for the developers for the final checking on the course contents and daily operations of the MOOCs. The browsing site is the final output for all VTC learners, where they logon and access to the course contents.

MOOC Design

The outline of the mini-MOOC for the engineering mathematics and the nominal time for completing the tasks are given in Table 1. The mini-MOOC begins with an introduction video. There are then six learning videos in the mini-MOOC. Each of those learning videos lasts just 3 minutes, such that the duration is well within the attention span of the learners.

Table 1 Outline of the mini-MOOC

No	Learning Task	Time
1	Introduction video	2 mins
2	Pre-test	30 mins
3	Video 1: Key concepts in functions	3 mins
4	Post-test 1	5 mins
5	Video 2: Linear functions	3 mins
6	Post-test 2	5 mins
7	Video 3: Quadratic functions	3 mins
8	Post-test 3	5 mins
9	Video 4: Polynomial functions	3 mins
10	Post-test 4	5 mins
11	Video 5: Exponential functions	3 mins
12	Post-test 5	5 mins
13	Video 6: Trigonometric functions	3 mins
14	Post-test 6	5 mins
15	Student satisfaction survey	5 mins

In the introduction video, the course facilitator also the first author welcomes the learners and set the scene

for the MOOC learning. Figure 2 gives the screen capture of the opening of the introduction video, which gives the objectives and outline of the mini-MOOC. A refreshing background in green with random mathematical expressions is chosen to help setting the scene for the subsequent learning.



Figure 2 Introduction video of the mini-MOOC

A pre-test and post-test approach, which is well accepted method for measuring effects in education intervention, is adopted in this mini-MOOC design. One pre-test and six post-tests are used to measure the degree of change occurring as a result of the MOOC learning.

The pre-test has around 60 multiple-choice questions, which covers all the scope of all six post-tests. In other words, the post-tests are subsets of the pre-test test. The pre-test is essential to benchmark the different mathematical competencies of the individual Higher Diploma students before MOOC learning. In the pre-test, the questions are direct without the need of complex calculations, the learners are expected to finish the test within 30 minutes.

As shown in Table 1, the pre-test is placed right after the introduction video. After each learning video for a sub-topic such as linear functions, the learners must complete the post-test for that sub-topic. With the similar difficulty to the pre-test questions, each of the six post-tests has around ten multiple-choice questions. The learners are expected to finish it within five minutes. The rationale of using six post-tests instead of using one post-test at the end of the MOOC is that this approach allows a more accurate measurement of the effectiveness of individual learning videos by minimizing the time between watching the video and the completion of the test. In addition, the approach allows greater flexibility for the learners, who can watch one learning video and do the corresponding post-test within ten minutes and start another set at their convenience.

The results of the pre-test and the post-tests provide useful information to the teachers on the students' mathematic competencies and the analysis of the effectiveness of the mini-MOOC for the projective objectives. The results will be available after the implementation of the mini-MOOC by end of 2018.

At the end of the mini-MOOC, a student satisfaction survey is provided to gather feedback about the user experience of the mini-MOOC. The information is important in quality assurance and future development.

MOOC Administration

While this pilot study aims to develop the mini-MOOC on mathematics eventually to all Higher Diploma students in the Engineering Discipline of IVE, the mini-MOOC will be open to the students in phases. In the production stage, the mini-MOOC is first tested by trial runs by sample staff who have experience in teaching engineering mathematic modules in Higher Diploma curriculums. Once the mini-MOOC is enhanced with the feedback from the sample staff, it will be ready for the Higher Diploma students. The release of the mini-MOOC will be in three stages. In the first stage, the mini-MOOC will be released to the students studying Higher Diploma in Civil Engineering, who are expected to have a stronger mathematical background. As the mini-MOOC is designed as a pre-class self-learning tool, it will be made available for the students in the first month of the Academic Year 2018/19. The first semester of the Academic Year starts in September 2018, around 200 civil engineering students will take the first mathematic module called "Engineering Mathematics". The pre-test results are first collected once the students joined the mini-MOOC. The pre-test can provide information to the teachers on the students' mathematics competencies so that the teachers can make necessary adjustments to their teaching before the classes.

In the second stage, the mini-MOOC will then be released to the students studying other Higher Diploma programmes in the Department of Construction. In the final stage, it will be released to all Higher Diploma programmes in the Engineering Discipline. The experience in the MOOC developed will be shared to VTC staff through sharing sessions.

Conclusions

A mini-MOOC for foundation mathematics is developed for Higher Diploma engineering students in Hong Kong under the MOOC development initiative in VTC. The successful application of the mini-MOOC will generate valuable information and experience, which not only help students' active learning in MOOC platforms, but also are important milestones for further development of more advanced topics in engineering mathematics.

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STUDENTS' PARTICIPATION IN DEGREE PROGRAM-LEVEL QUALITY ASSURANCE ACTIVITIES

J. Roslöf

Faculty of Engineering and Business, Turku University of Applied Sciences, Turku, Finland

janne.roslof@turkuamk.fi

Abstract

Active Involvement of students in the program-level quality assurance (QA) and improvement processes is a significant part of the continuous development cycle in higher education. When evaluating the degree program's effectiveness and efficiency in reaching its intended goals, it is important that also the students participate in the continuous development work in different ways. Universities typically use several methods to include students in their QA processes. Also Turku University of Applied Sciences (TUAS) has many tools enabling the students' voices to be heard. In this paper, student involvement in the TUAS quality assurance and improvement activities is described in general. In addition, the recent experiences on student feedback and efforts in order to facilitate the positive feedback culture are reported.

Keywords: *continuous development, feedback, higher education, improvement, students, quality assurance*

Introduction

Active involvement of students in the program-level quality assurance (QA) and improvement processes is a significant part of the continuous development cycle in higher education. In Europe, the so called Bologna Process has put increasing weight on the engagement of students in the QA in higher education (Alaniska et al., 2006). When evaluating the program's effectiveness and efficiency in reaching its intended goals, it is important that also the students participate in the continuous development work in different ways.

Universities typically use several methods to include students in their QA processes. Students provide feedback on the courses they have taken, contribute to the development of teaching and learning in their subject area, or participate in different decision making processes (Alaniska et al., 2006). Also TUAS utilizes multiple tools enabling the students' voices to be heard. There are student representatives in the university board and in most of QA-related working groups, as well as in the industrial advisory boards. The student representatives nominated by the Student Union also mediate development initiatives and possible identified problems to the degree program management. In addition, a university-level student feedback survey is organized annually, the program leaders and tutor teachers have regular development discussions with their groups, and it is possible to give feedback on every course separately. The received feedback is processed systematically, and the students are informed on the implemented corrective actions based on their initiatives.

However, many faculty members describe the student feedback culture at TUAS as critically-oriented. That is, a significant part of the feedback is considered to focus on sharing negative experiences and complaints often without constructive initiatives on how the reported issues could be improved. Naturally, it is important that all the identified topics requiring corrective actions are filed, but the strength of positive feedback should not be forgotten either. In this paper, student involvement in the TUAS quality assurance and improvement activities is described in general. In addition, recent experiences on student engagement and feedback in the Information and Communication Technology (ICT) Unit of TUAS and efforts in order to facilitate the positive feedback culture and attempts to benefit from the reinforcing effect of it are reported and discussed in particular.

Students' roles in quality assurance

Alaniska and Eriksson (2006) have discussed students' roles in the academic community. In order to achieve optimal results in there should be a collaborative culture of learning present in the higher education institutions (HEIs). The closer the students are involved in a department's activities the more open dialogue and better result for improvement. The students' involvement in QA activities can be divided in four categories (Alaniska & Eriksson, 2006):

1) Student as an information provider: Giving feedback in different forms is the most common way of engaging students in QA. A typical procedure is to ask feedback for every completed course or collect data every semester, for example. There is a multitude of ways to collect student feedback and both quantitative and qualitative methods are used.

2) Student as an actor: Students have potential to have a more active role than just the role of a source of data. The students can participate in designing the feedback questionnaires in cooperation with the academic staff and join the analysis of the collected data

as well. Students can also organize workshops concerning different improvement topics where the issues can be discussed together with the staff members in a comfortable environment.

3) Student as an expert: One of the focal points of QA in education should be the quality of learning – not teaching. The students are experts in their learning; they are able to reflect how (and if) they have reached the intended learning outcomes and how teaching has guided them in this process. Utilizing the students' expertise can be implemented by inviting them to join different working groups, meetings and seminars. Considering students as experts demands positive attitude both from the staff and from the students.

4) Student as a partner: The partnership between students and staff refers to an authentic and constructive dialogue enabling reflective feedback. The common responsibility and ownership about the activities and their further development is recognized, and there is an easy-going atmosphere and culture in the department. Continuous cooperation and co-organization takes place leading to open and authentic QA and improvement.

Successful student involvement can contribute to several parts and processes of the institution. Typical effects include curricular improvements, course content updates and further development of learning and teaching methods leading to improved student experience and, most importantly, enhanced achievement of the learning objectives. In other words, the students give diagnostic feedback to the faculty for improving their teaching. Furthermore, the activities provide a measure of teaching effectiveness for personnel decisions, the students themselves gain information for the selection of courses and instructors, and the outcomes may support research on learning and teaching. The student involvement can also play an important role in a national or international QA exercise such as a formal audit or accreditation process. Yet, also criticism and controversies exist in the discussion on student engagement in QA. Do the student' evaluations on different teaching instruments and course contents including complex and multidimensional aspects really measure effective teaching and learning? (Marsh, 2007; Aškerc & Braček Lalić, 2016)

Wyns et al. (2015) present a case study report from Belgium: The student involvement at KU Leuven has long traditions. Every faculty has its own student organization and student representatives are appointed annually through elections. In addition to improving QA, student participation has been shown to positively influence the students' skills in communication, critical analysis and leadership. Students also become aware of their own institution by participating in different QA and decision-making processes.

Student involvement at TUAS

In accordance to the European traditions and higher education quality paradigms, TUAS aims at engaging the students in several different ways. The goal is to create and further facilitate a collaborative culture of partnership in learning between the students, faculty and other staff members.

Formally, the students are represented by the Student Union of TUAS. The union is an independent association-format organization that selects its own key persons and committee members via annual elections. The Student Union has also employed personnel who takes care of the administrative issues as well as participates in driving the students' interests both within the different bodies of TUAS as well as in other local and national networks. The most important actors on a

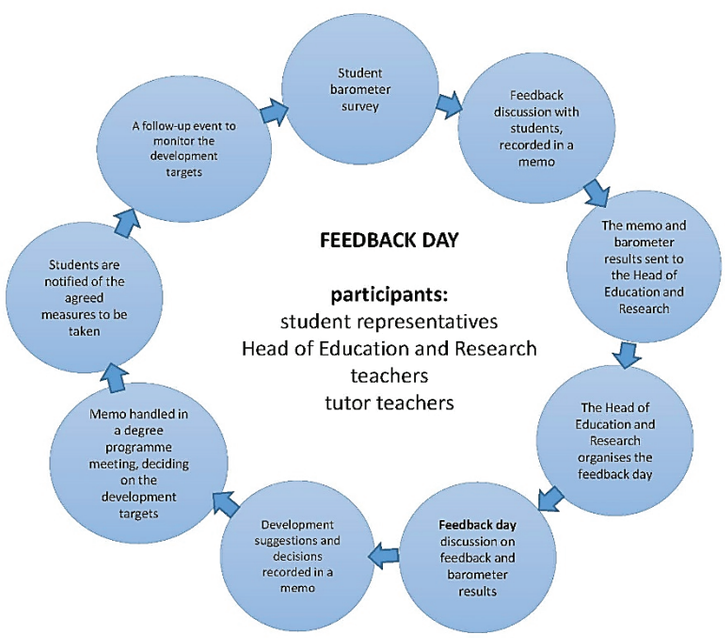

Figure 1. Illustration of the TUAS Feedback day process (TUAS, 2018)



Figure 2. Students and staff at the Feedback Day event of TUAS ICT Unit in April 2018.

departmental/program-level are the so called Executive Board Student Representatives who are nominated annually for each department. These representatives have a key role in mediating different topics between the institution and their students. The representatives participate in different working groups and, for example, they are members of the Industrial Advisory Committees. The official representatives may have a team of other active students supporting their work. For instance, in the ICT Unit of TUAS each student group (of about 30 students) has 2-3 student coordinators who are supposed to lead the student involvement activities within their group.

Traditional course feedback can be given for every course implementation. The teachers are responsible for the course feedback process concerning their own courses. It is possible to utilize a standard feedback form of the student information system, or the teachers can choose other means to collect their feedback.

An important university-wide tool for feedback collection is the annual Student Barometer. The Barometer is a large-scale web-based survey that is implemented in the beginning of each calendar year. The survey questionnaire contains a large number of questions (usually round 50) but some of the questions are presented only to limited student groups, such as the first-year students. Most of the questions are general quantitative scale-formulated questions but there are also some open-ended free-text parts that are expected to provide more detailed and elaborated viewpoints. The survey is kept rather stable in order to maintain comparability between the different years. Yet, there can be specific annual themes focusing on different development areas.

In the ICT Unit of TUAS, the Student Barometer process is supported by a development discussion with each student group. These discussions are held between the group responsible students, the group's tutor teacher and the respective program leader. Sometimes also the union's student representative and the study counsellor take part. The group's student coordinators are expected to discuss possible feedback, questions and improvement initiatives with their group members before the discussion and then bring these topics to the common table. Many questions get answered already during the development discussion but sometimes the issues require further investigations and corrective actions. A summary memo is written after every meeting and the memos are published and shared openly. The series of discussions are timed so that all the memos are available at the same time when the annual Student Barometer results are received.

The Student Barometer results are analyzed together with the development discussion summaries both by the program teams (staff) and the students. Usually, the union's student representative leads the analysis process and aims at defining the most important development initiatives based of the annual feedback. This is a demanding task since there is lots of data and it is not uncommon that there are both positive and negative comments on the same topics. The feedback summaries categorized by degree programs and student cohorts are presented in an open event called the *Feedback Day*. This "day" is a 2-3 hour event organized by the faculty together with the students. The event is usually opened by presenting the TUAS QA practices and the different opportunities available for the students to participate in the development activities. Thereafter, the feedback summaries are discussed by the students, and they have the possibility to add new viewpoints to the topics and comment the analysis prepared by the student representative and his/her team. Sometimes the dialogue gets lively. Also the staff members may comment the students' argumentation yet the intention of the event is not to start any defensive debates from the faculty's side. Finally, an open memo summarizing the feedback analysis and the results of the discussion and presenting the most important development initiatives and proposed corrective actions is prepared and published.

The results are analyzed and discussed in the degree program teams. The cycle is completed by organizing another event usually in the middle of the new autumn semester. This event is called the *Feedback on Feedback* meeting and it is organized by the department. The aim of the meeting is to bring back the previous-year's feedback to the table and provide the department's response to it. The decided corrective actions based on the feedback are presented. Also the topics that will not

lead to any actions are presented and explained. Some of the minor corrective actions are typically implemented immediately whereas others are included into the operational plan of the department or escalated forward to different university-level bodies. This concludes the development cycle and it is time to start a new round in the continuous development process. The tutor teachers start to coach their groups together with the student representative towards a new development discussion round and the Student Barometer in the beginning of the next calendar year. This "TUAS Development Day" process is illustrated in Figure 1. (Turku University of Applied Sciences, 2018)

Reflections on QA activities and student feedback

Based on my 15-year experience on educational administration, it is easy to agree that students' engagement in the QA activities is vital for making positive development happen and for fostering a fruitful culture of learning in general. However, also criticism and concerns connected to the student participation and the return on investment on it exist. The critical voices may reflect a still developing maturity of the institutions' or departments' processes and atmosphere but, if nothing else, it is important to consider these viewpoints as well in the continuous development work.

Little and Williams (2010) agree that the students are expected to play an active role in the educational process: Optimally, this means that the students and staff work in partnership to improve learning. The student representation system is not dominated by negative comments on specific issues but, instead, there is a shared and forward-looking sense of shared responsibility. However, they argue that the recent developments including the expansion and differentiation of higher education, increased accountability for public spending, and tuition fees have formed the students' role towards a consumer profile. Possible over-emphasis of the student as a consumer/customer may lead to increasing one-directional transactions between the higher education provider and the learner. If the students start behaving as passive recipients of educational services, it will limit their possibilities to inform and enhance their learning experience. The student engagement may also start to act in opposition to the present quality measures (Pickup, 2017).

There are no recent studies on this perspective available at TUAS but there are regularly doubts within the faculty especially concerning the usefulness of the student engagement in relation to the time and efforts invested in the activities. A common discussion topic in the teachers' coffee room is that the response rate is rather low in most of the feedback channels. This makes it easy to question the relevance of the results and gives room for defensive explanations concerning the received feedback. It is sometimes claimed that the feedback is dominated by students with negative experiences and, as the general response rate is low, most of the students are considered to be actually fairly satisfied.

TUAS Student Barometer 2018 overview

The Student Barometer 2017 was replied by only 138 students of the degree programs hosted by the TUAS's ICT Unit resulting in a response rate of roughly 14% only. Similar figures had been typical also during the earlier few years. I was decided to put extra effort in getting the students more interested in answering the 2018 survey. The student representative promoted the survey via her channels, and the tutor teachers kept the students informed about the approaching opportunity to participate. When the survey was activated, many tutors also took their groups to a computer classroom and informed them directly on how to reply to the Barometer (voluntarily, of course).

These efforts clearly affected the students' activity. The Student Barometer 2018 got 307 answers submitted by the ICT students. That is, the number of replies was more than doubled from the year before. The response rate of 31% was not sky-high either but much more representative than the traditional figures. Yet, most of the respondents were first-year and second-year students which should be kept in mind when interpreting the results. 212 responses (69%) originated from these younger students whereas 51 third-year (17%) and only 39 fourth-year (or older) (13%) students replied.

When the students were asked how satisfied they were on their studies at TUAS in general, the average was 3.7 (scale: 5 = Very satisfied, 1 = Very unsatisfied) that can be considered as a good result and slightly above TUAS average. Less than 30 respondents (<10%) answered that they were unsatisfied or very unsatisfied. So, the overall feedback was fairly positive.

Positive feedback was also given in the open-ended question asking *on which issues TUAS has been successful*. This optional question was replied by 227 respondents. Most of the positive comments dealt with the facilities and learning environment which received more than 50 replies. Many students (>20) also mentioned the curricula and course contents, teachers and staff members' expertise, versatile learning methods, and project-based courses. However, only a small number of these free text replies contained more detailed explanations behind the statement that could have helped to understand the reasons for positive experiences. Most of the answers contained just a few words like: *Good facilities* or *Quality of teaching*. The claims that the student feedback focused only on negative issues seemed in any case be a myth according to the Barometer results.

Yet the Barometer results also contained critical replies. 237 students replied to the question *on which issues TUAS could improve*. Several respondents (>30) wished for more contact teaching hours. More than 20 mentions received also the TUAS information systems, classroom schedules and, somewhat surprisingly, also the facilities. There were clearly more answers containing detailed elaborations motivating the proposed development areas but still most the replies were short and so generally expressed that it was very difficult to define any improvement actions based on them: *Teaching of some courses*, *The quality of teaching*, or *Some teachers do not give enough feedback*. Also the

replies that included more detailed discussion on the background of the negative experience rarely contained any further initiatives on how the situation could be improved.

A positive feedback initiative

One of the TUAS Staff Survey 2017 results indicated that the teachers wished for more positive feedback on their efforts. Many staff members had experienced that success in research activities, such as new funding decisions and publications, received more (and more often) positive acknowledgement than teaching work that, on the other hand, was rather often discussed reflecting the critical voices of student feedback. The experience of receiving feedback is, naturally, a complex topic that cannot be solved by a single action. Yet, a pilot of a positive feedback campaign was decided to be implemented in the ICT Unit during spring 2018 based on these survey results together with the teachers' remarks concerning the negative-oriented focus of the discussed student feedback.

The Student Union's student representatives took the challenge to select one staff member that had made an especially positive contribution each month between December '17 and May '18. That is, in total six staff members were supposed to be nominated during the half-year-long pilot period. The department promised to award these staff members with a small token of appreciation. The students' responsibility was to organize the nomination process in some democratic way, and to announce the nominees two times during the pilot period – the first three in the beginning of April and the next three in the beginning of June 2018. The nominees were supposed to be ICT Unit's own staff members, one person could be selected only once during the pilot, and the students should publish a short but clear motivation explaining the selection of each person. In addition to the improvement of positive teacher feedback visibility, the other important internal QA-related goal was to facilitate the focus and discussion to recognition of positive contributions within the student community.

The pilot was implemented as planned. The nominations of three staff members were published in the department's development day mid-April and the other three in a staff meeting mid-June. The students had made their selections according to the instructions yet the motivations seemed to be, also in this case, rather generally formulated, "*…facilitates group spirit, provides illustrative examples etc.*"

The nominated staff members were clearly happy about the received acknowledgement. Also the students seemed to have spent time and effort on the selection process even though it remained unclear how wide audience they had been able to include into the process. It is possible that the younger students had been more active also this time than their older fellows. Five out of the six nominees were teachers that were involved in several courses during the first two academic years.

However, there were also some staff members who seemed not to feel comfortable with the process. Perhaps they were afraid of that the nominees could not have been the "right" ones? Or maybe these hesitations reflected defenses connected to thoughts of not being among the nominees?

Discussion and conclusions

In this paper, the different roles of and forms of student engagement in QA processes in higher education were reported. The student involvement practices of Turku University of Applied Sciences were presented and discussed. In addition, recent experiences on student feedback collection and analysis including critical viewpoints were reflected.

Involving students in multiple ways and roles in QA and decision making processes is a significant part of creating and further developing a culture of learning partnership between all the members of the academic community. Student engagement shall not be seen as a continuous development tool only. It is also an important tool for the students to get familiar with their environment, to gain responsibility and respect of the community, and to learn important working life skills.

Also TUAS uses several different ways to involve its students into QA activities and other processes. These practices are well aligned with Finnish and European traditions and trends. Yet there is room for improvement. There is more potential to benefit from these activities and the resulting data than is currently feasible. Even though the group development discussions and interactive feedback events provide value-adding content to the versatile but rather one-directional and general Student Barometer data, a significant part of the current feedback does not provide clear enough information for deeper analysis and development. Additional attention should be paid to guide the students to provide feedback that also explains the backgrounds of the experiences and, more often, elaborates possible improvement initiatives. This could lead to even better return on investment in this work.

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IMPROVEMENT OF STUDENT'S PATENT ACQUISITION COMPETENCY AND INTELLECTUAL PROPERTY RIGHTS EDUCATION

Senshu Yoshii*

National Institution of Technology, Miyakonojo College, General Education Division, Japan

*senshu@cc.miyakonojo-nct.ac.jp

Abstract

Many Southeast Asian nations advocate strengthening patent protection as part of economic policy today. The educational institutions of each country follow this policy of strengthening patent protection, and students are taught in engineering education to acquire abilities necessary for product development.

However, many universities are confused in the enforcement of intellectual property rights education. What kind of intellectual property rights curriculum should we establish? How should we find teachers? In the first place, how should we teach intellectual property rights as a subject?

In higher education in Japan, intellectual property education is divided into two aspects: "the understanding of the intellectual property system" and "ability to invent." The former is carried out by specialists in law, such as a patent attorney or a jurist who knows the intellectual property system well; while the latter is given by professors having experience of product development. The knowledge of law teachers about product development is imperfect, and they have been thought to provide problematic instruction in product development. However, many students invent many new products with the guidance of the law teacher every year at the specific National Institutes of Technology (NIT), and several students acquire patent rights.

In this article, I will discuss various educational methods based on the cases of National Institute of Technology, Miyakonojo College, to show how to make students' ideas into patent rights. It is thought that a theory of alternative dispute resolution in civil affairs disputes can contribute to improving the situation in patent acquisition for such a student. Mainly, this will be discussed as I refer to a principle of legal theory—Felstiner's "naming–blaming–claiming" model—in relation to a civil affairs dispute about the competency required of a student for the patent and the acquisition.

Keywords: *Intellectual Property Rights, Idea, Innovation, Patent, Competency, Legal Science*

Introduction

In Asian countries including Japan, intellectual property education is taking an essential role in engineering education now.

In Japan, the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) updated the course of study in elementary and junior high schools in 1998 and in high schools in 1999. Both of them were upgraded under the education program named as "manufacturing education: *MonozukuriKyoiku.*" Each educational institution has worked on each subject in the education about intellectual property rights in school education positively by the revision of these guidelines.

The Japanese government has been trying to realize a nation based on the creativity of science and technology. This policy views ethics as human resources supporting Japanese technology in the revision of the course of study of the higher education system, and it becomes essential to bring up creation-related rich, high-quality human resources—so to speak, a senior engineer having knowledge of intellectual property rights.

As a matter of course, the Japanese government revised a similar curriculum in higher education. Each university planned to carry out interdisciplinary engineering education that was to become the foundation for manufacturing and reorganized large-scale departments to produce engineers in the compound-specialty domain. Furthermore, the incorporation of the national universities, which the Japanese government carried out in 2004, helped to set up an organization and a budget so that each university freely and voluntarily became part of it. Each university applies high standards of merit and adopts an aggressive approach leading to the activation of the field of study and improvement in the education of science and technology.

Intellectual Property Policy in Japan

The Japanese government proposed the "Nation Declaration Policy by Intellectual Property" in 2002.

Prime Minister Junichiro Koizumi made a policy speech on the strategic use of intellectual property at the Diet on February 4, 2002. He announced that Japan was to become an "intellectual property country," endeavoring to make intellectual property a key driving force behind national prosperity.

The first point to be discussed was the Japanese IP policy. The term “intellectual property right” (IPR) is defined in the IPR Basic Act, in Article 2-2 as follows:

> *"intellectual property right" as used in this Act shall mean a patent right, a utility model right, a plant breeder's right, a design right, a copyright, a trademark right, a right that is stipulated by laws and regulations on other intellectual property or right pertaining to an interest that is protected by acts.*

The guidelines of the Strategic Formulation on the Intellectual Property of July 2002 led to the enactment of the IPR Basic Act in December that year. Since 2003, the IPR Strategic Program has been published. The issues regarding IPR education at National Institute of Technology (NIT) colleges and in higher education were first mentioned in this publication (Table 1). How has IPR education been introduced to NIT colleges?

Table 1. Strategic Policies of “IPR Country” in Japan

1998	Patent Office published “the Standard Textbook for Studying Industrial Property Rights” and started the “School Assistant Programs for IPR Education.”
2001	METI established "IPR Curriculum."
2002	PM Koizumi’s speech: "Intellectual Property Country" (February); Intellectual Property Strategy Formulation Guideline (July); Intellectual Property Basic Act (November)
2003	Intellectual Property Strategic Program 2003 announcement
2011	MEXT added IPR education to industrial, commercial, and agricultural high schools.

Outline of IPR Education in Japan

IPR education, the Japanese scholars, as well as students had to say enough educational content and are also provided (INPIT 2010). As highlighted in Yoshii (2012) in particular, systematization of intellectual property teaching through college tuition is insufficient from the subjective standpoint of supervising teachers, but an expanded curriculum has not been sufficiently built up. Compared with the educational institutions in Taiwan and Singapore that actively use the curriculum and problem-solving techniques, at present, we have not been keeping pace with them in this domain. To ensure promotion of internationalization of colleges in the future, the time has come for us to modify the curriculum, to set the global standard for intellectual property education and to understand the current state of intellectual property in the ASEAN countries.

Most NIT students cannot fully understand the IPR legal system due to its complexity. Consequently, IPR has been taught as a special subject and only a few NIT colleges have offered it.

It is currently difficult to conduct the IPR Strategic Program due to overlaps and discontinuities in the roles of various offices in the Japanese government. It is commonly thought that the Ministry of Economy, Trade and Industry (METI) handles administrative duties and policymaking. METI controls its sub-organizations and administers the Japanese patent policy formulated by them. For example, the Patent Office, one of METI’s sub-organizations, is an administrative office for patents, design registration, and trademarks. The National Center for Industrial Property Information and Training (INPIT), another METI sub-organization, was formed to run the J-Plat Pat, Intellectual Property Rights Digital Library.

In 1998, aware of the importance of IP education, the Patent Office published the “Standard Textbook for Studying IPR” and began to support school programs for IPR education. Based on this textbook, the Patent Office and IPDL produced the “Standard Curriculum for IPR” and launched the “School Assistant Program for IPR Education.”

Although METI and its sub-organizations have contributed greatly to the dissemination of IPR knowledge, it has not been able to provide enough opportunities to students to study IPR at school. Because the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has ultimate authority over educational divisions, METI could not spread IPR education among schools. Until 2002, the Japanese education system did not feature IPR in its curricula, and MEXT had no plans to train secondary education teachers in the subject. Only a few teachers have been aware of the importance of IPR, and they have taught this subject without licenses. In fact, there are only nine lines that mention IPR among the 230 pages of the most-used Japanese social science textbook for secondary-education students.

Since IP’s role in higher education is at an early stage, there are several issues concerning the start of new education in this field. Osaka Kyoiku University launched a program called the Education System for Teachers to Teach IPR in 2005. The Patent Office and Yamaguchi University also conducted a study titled "Research Project on IP Education at the University" in 2006.

Professors can teach students high-technology skills and awareness through their own initiative. However, there are not enough lectures on "creating new ideas," such as developing mind maps, quality control circles, etc.

MEXT established the 5th Science and Technology Basic Plan, approved in a cabinet meeting on January 22, 2016. This plan stipulated the following:

> *ii) Upbringing, achievement promotion of a variety of human resources through technology innovation.*
> *Besides, technical support for the Program Manager to implement a plan, manage research, and ensure progress on the project on, a research administrator (URA: University Research Administrator) to control of the whole*

research activities with a superintendent-in-charge, a research facility, various human resources such as technology transfer, human resources, and university management resources are necessary to promote creation of high intellect and social implementation in a university and a public research organization. Also, human resources specializing in management of human resources, technology, and intellectual property to take on the corporate strategy of new business development and changes in the business model are demanded to promote the standard implementation of the intellectual resources quickly and effectively in companies. While such human resources make use of the specialty that each person has, it is essential to create the environment that can show ability in the right person for the right place. However, the qualitative-quantitative mismatch of human resources between a university and the industry may occur, and the human resources are getting such jobs are short; and also, there are problems such as each person's ability to cope with a rapid social change occurs.

In this plan, MEXT predicts the drying up of human resources with the ability for intellectual property operation. For this reason, personnel training in IPR that can provide global leadership is urgent for Japan. However, it can hardly be said that intellectual property education is being imparted in an environment where it is regarded as necessary in the Japanese higher education system. In many educational institutions, lectures for the IPR class are often taken by teachers lacking expertise in the subject.

IPR Education at NITs

How has IPR education been conducted in higher education in Japan, especially in NITs? According to NIT's syllabus, only 8 of the 61 schools (13%) teach IPR subjects. However, the number of NIT colleges joining the School Assistant Program for IPR Education is 15. About half of those schools have no lecture titled IP, rather teaching IPR in lectures with different names or through club activities. Surveying the actual situation from a different standpoint, lectures in NIT colleges are separated into two types: product-based teaching (PBT) and classroom-based teaching (CBT). While PBT consists of product development, CBT involves instruction in the IPR legal system and the patent application process. In NIT colleges, many of the IPR lectures given are PBT (Table 2).

Most NIT colleges have taught IPR using the "Standard Textbook for Studying Industrial Property Rights" with the "IPR Curriculum." By using this textbook, most students can understand the concepts of IPR within just twenty-five hourly lessons. Additionally, this textbook is provided free-of-charge by INPIT, so students taking PBT lectures can use free textbooks.

An exceptional example of IPR education among the standard technical NIT colleges is the NIT, Miyakonojo College. At this college, a professor delivers intellectual property rights education about practices, which is rare in Japan. In addition to explaining the legal system, the professor trains his students in "the thought process that leads to the invention," using mind mapping and the KJ method.

Table 2. Details of IP education lectures in NIT colleges

Year	Product-based teaching	Classroom-based teaching
2006	10	3
2007	10	3
2008	10	3
2009	10	3
2010	12	3

Source: INPIT (2007:2008:2009:2010:2011)

Education through both PBT and CBT provides opportunities for students to understand IPR. Nowadays, there are many IPR education lectures at NIT colleges. In 2007, INPIT studied when the teachers had begun to study IPR. The results are shown in Table 3. It must be noted that many of the teachers at NIT colleges have no experience of, or license in, IPR education.

Table 3. Stage at which teachers studied IPR in Japan

	High School	NIT	Total	%
At school	7	4	11	10%
Employment in enterprise	15	9	24	20%
Employment in NIT	31	6	37	32%
On this Program	32	2	34	30%
Aftertime	9	0	9	8%
Total	94	21	115	100%

Source: INPIT (2007: 23)

There is a further point that needs to be clarified. The IPR curriculum established by INPIT lacks some elements: while it provides an effective means for students to understand IPR legal systems within a short time, it offers no guidance on "creating new ideas."

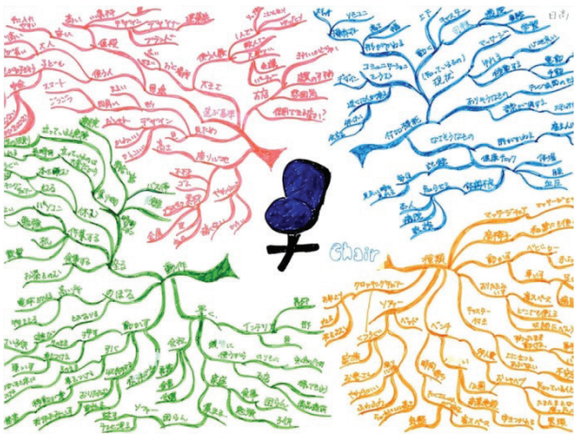
A Case of NIT, Miyakonojo College

NIT, Miyakonojo College (NITM) is one of a few Japanese higher education institutions having a curriculum in IPR from 1985. They have an IPR class for senior students, attended by approximately 60 students every year.

Teacher guidance policies are apparent, and they are thoroughly helped through the patent law system and how to put out ideas. As an example of the former, they were prepared for the national examination on intellectual property management skills; and as an example of the latter, they were thoroughly trained in the mind map creation method and the KJ method. Besides,

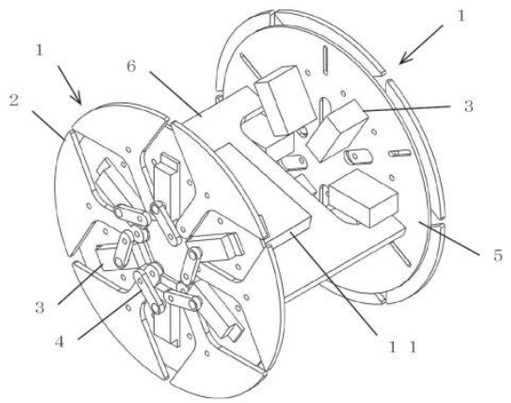
all students are obliged to exhibit in the patent contest organized by the Patent Office.

Figure 1. Student's mind map

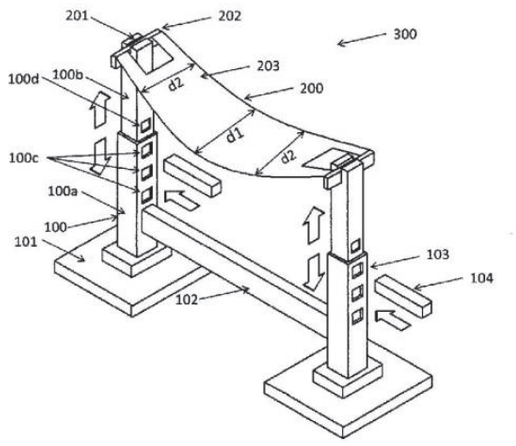


Analyzing Chair product

Figure 2. Student's Patents



(Japanese Unexamined Patent Application Publication No. 2016-193694)



(Japanese Patent No. 3036462)

Remarkably, this class has been conducted by faculty majoring in law. Up to now, three teachers have helped students acquire ten patents in the patent contest. To put it briefly, senior students in NITM need knowledge of IPR rather than manufacturing skills.

The patents obtained by students are by no means sophisticated, and only a few have been commercialized. However, the Japan Patent Office grants licenses to students after recognizing originality. Our students are smart enough that they will be able to acquire patents with minimal effort. The intellectual property faculty of NITM believes that what is necessary for students with basic knowledge of engineering is not further knowledge of engineering but knowledge of intellectual property and the practical aspects of acquiring patents.

Teaching guidance by such law teachers is low in teachers' evaluation from specialized departments. But as N. Luhmann (2012) states, the information initiative lies not on the originator but on the recipient. It is the patent office, not the teacher, who evaluates the students' inventions, and eventually granted patents, recognizing the novelty and creativity of their invention. Although the inventions acquired by students may be peculiar to them, experiencing the process of obtaining licenses helps them to grow as next-generation inventors, to create innovative inventions, and to change the world. Even for Thomas Edison, inventor among inventors, the first invention was "a device that automatically transmits telegrams to get rid of work."

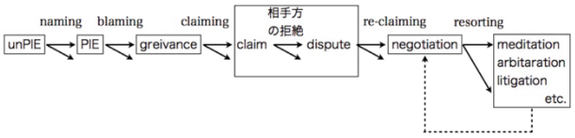
Naming-Blaming-claiming

Such IPR education in NITM can be conceptualized based on a conflict model by Felstiner and others. Discussion by Felstiner and his colleagues focuses on the stage where conflict development does not result in litigation, and discusses factors that cannot be appealed in court. According to that theory, they state the importance of exploring why the legal system does not function effectively in the real world as follows (Felstiner 1980) :

> *But disputes are not things: they are social constructs. Their shapes reflect whatever definition the observer gives to the concept. Moreover, a significant portion of any dispute exists only in the minds of the disputants.*
> *These ideas, though certainly not novel, are important because they draw attention to a neglected topic in the sociology of law—the emergence and transformation of disputes—the way in which experiences become grievances, grievances become disputes, and disputes take various shapes, follow particular dispute processing paths, and lead to new forms of understanding. Studying the emergence and transformation of disputes means studying a social process as it occurs. It means studying the conditions under which injuries are perceived or go unnoticed and how people respond to the experience of injustice and conflict.*

Furthermore, Felstiner analyzes the process until these conflicts reach the court as being into three stages.

Chart 1. Naming–blaming–claiming model



naming — A state where people can perceive infringing acts.

blaming — A state where the victim can be conscious of who the victim is suffering for.

claiming — A state where people can inform the specified counterparty of the fact of infringement and seek relief against it.

Their assertions that showed that no conflict reached these stages and did not develop into a trial are supported by legal sociologists all over the world. This model is also useful in patent rights, and it is also helpful to show why students' inventions do not achieve patent acquisition.

Through the concept of Felstiner et al., it becomes clear that there are many ideas buried in the world that are never realized as inventions. What we can actually see is only the idea filed with the Patent Office; and many ideas have disappeared namelessly in this way.

Students have sufficient capability regarding inventions, but they are burying ideas for patent acquisition. It is unfortunate that the small numbers of patent applications by students is seen as a problem of students' ability. If the teacher believes in the student's potential and if the idea does not lead to patent acquisition, it is thought necessary to discuss the factors according to the stages developed by Felstiner et al.

Chart 2. IPR naming–blaming–claiming model

IPR naming — A state where you can realize that the idea is worthy of the invention.

IPR blaming — A state that can claim to be a patent on what we invented.

IPR claiming — A state that claims to be an invention and is able to file a patent application.

Analyzing the reason why students do not file a patent in this way, as a process in three stages, and providing instruction accordingly leads to nurturing engineers who voluntarily create inventions. The case of NITM is that in the student's patent application it is not engineering literacy but IPR competency that has a significant effect. A faculty advising on IPR should instruct the students, paying attention to the question, "why do students file a patent for that idea?"

Conclusions

In Japan, IPR in higher education is currently focused on providing students engineering knowledge through engineering faculty members. Unfortunately, this was not the result of adequate consideration, and was born out of a struggle due to budget reduction from MEXT and the lack of teachers. As shown in this paper, effective IPR education is no longer to give students knowledge of engineering but to enable competencies to develop ideas and to make presentations in contests and the like.

It is only a small attempt of one Japanese school that forms the grounds from this conclusion. As a matter of course, by an environmental difference and a national difference, the conclusion is more likely to change. Perhaps the reader might take this as an opportunity to test the same in each school.

Acknowledgements

We gratefully acknowledge the support of INPIT 2017-2018.

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FACTORY CLASSROOM: AN EDUCATIONAL TOOL FOR NURTURING SCIENTIFIC FACT FOR FOOD TECHNOLOGY

Pimpen Pornchaloempong[a], Kitdakorn Klomkarn*[,b] and Pitikhate Sooraksa[b]

[a] Department of Food Engineering, Faculty of Engineering
[b] Department of Computer Engineering, Faculty of Engineering,
King Mongkut's Institute of Technology Ladkrabang, THAILAND

*kitdakorn.kl@kmitl.ac.th, pitikhate.so@kmitl.ac.th

Abstract

This paper presents an onsite learning with training method for undergraduate and graduate students majoring in food engineering and the small and medium entrepreneurs in food industry. A multi-disciplinary laboratory fusing with a multi-function mini-factory, called "Factory Classroom," was established by academic staffs from food, agriculture, industrial and computer departments of faculty of engineering at KMITL. In our factory, prototypes of food machine were designed by ours researchers. Some industrial food machines was supported by the leaders of food machine manufacturing companies in Thailand and Japan. To foster learning, the students are assigned to conduct experiments. They designed their own products produced by machines in the factory. The first objective is that students' products are served various campus activities. The second objective is to provide a scientific training programs in food product design and technology transfer using the machines for SMEs, called friendly SME services. Ultimately, to nurture professionals, the factory classroom aims to be a role model for serving the food industries and SMEs of Thailand. It is our obligation to design quality products, develop the future food, and implement smart food machines as integration of learning-by-doing and teaching-by-real-world examples. In the first phase of Factory Classroom, the main food processing methods are drying, freezing and thermal processing which aims for developing prototypes nutritious and high value beverage, and ready-to-eat products.
In academic year August 2016- April 2017, Factory Classroom launched more than 20 pilot food products developed by graduate students granted by Thailand Research Fund (TRF). Each product assigned from the entrepreneurs who had their own market. The prototype of drying machine has been designed by graduate students under intensive supervising by staffs from many departments. The work was supported by Thailand Research Fund and National Research Council of Thailand.

Keywords: *21st century learning, teaching entrepreneurships, multiple department collaboration, flipped classroom.*

Introduction

Thailand is one of the largest agricultural and food product country. The food industry is a very important contributor to Thailand's economy and has obtained the country sobriquet as "Kitchen of the World." Meat and seafood preparations are valued around $6.0 billion (Thailand, 2018). In addition rice, cassava, sugar and canned pineapple from Thailand are the top ten of world export (Thailand, 2016). All food processing industries have been grown rapidly over decades to serve the world market demand. In the year 2016, Thai government had vision THAILAND 4.0 to transform old economy into a value-based economy that is driven by innovation, technology and creativity. Instead of producing simple commodities food products, the high value creation food products must be taken place. In this economic model, the smart farming should be spread over Thailand. Small and medium enterprises in food industries must transform into smart entrepreneurial ones with high creativity and potentials. To produce quality smart manpower for next generation of food industrialization with the 21st century skills and creative research outcomes contributing to value based economy, the engineering education in the Thai universities must be reformed.

From Flipped Classroom to Factory Classroom

Factory Classroom is a research unit of faculty of engineering established for training research students, commercial services with industrial cooperation.

To achieve the aims of THAILAND 4.0 for high-valve food products, brands of products should be defined. With this reason, the best material, selecting

from organic or high quality control farm are the priority in consideration. In addition, taste of the best preservation for products are mainly concerned.

To fulfil the mission, three teaching teams from four departments and an industrial board were created. The first teaching team were recruited from department of agricultural engineering responsible to design and implement smart farms, and check quality of materials from the farms.

The second team comprises professors from food and computer engineering departments. This team is the main members of Factory Classroom operating in the laboratory and also in the factory. In this team, the good manufacturing practice (GMP) experts from the food industry are employed to supervise the students and a highly experienced former CEO was invited as an honorary advisor. The last team is a modern marketing one working for feasibility study before launching the products. Job descriptions also include creative packing design and branding of the product.

The three teams are work together with external modern marketers to ensure delivery of real products for the market place. After finishing feasibility study and functional product implementation, the packaging designers from the faculty of architecture are responsible to finalize the prototypes and the products.

Factory Classroom as a Learning Plant

The factory classroom plant shown in Fig. 1 is a workplace consisting of a co-working space for teaching, a business office, a food laboratory and a main factory.

In the learning plant, the processing function is to achieve shelf life extension, preserve food quality with optimal temperature and moisture contents and modern design packaging. The Factory Classroom consists of four process units which are collaborated with the food industrial manufacturers and outside funding and granting agencies. For more detail, the four process units are as follows

1.**Freezing Process**: Freezer is a major food preservation, cooling food maintains temperature below freezing point of water to slow the microbiological activities that cause deterioration in foods. An industrial size freezer was donated by PATKOL shown in Fig. 2, a public company in Thailand that is one of leaders in food processing engineering in Thailand.

2.**Drying Process**: A smart drying machine was designed and built for the process of heat and mass transfer from external heating medium into food. Referred to the machine shown in Fig. 3, smart sensor and intelligence control for programmable condition were designed by Ph.D students under supervising by professors in food and computer departments under the grant supporting from the TRF.



Figure 1 In spatial views, Factory Classroom consists of two main spacing utilities: The first floor is a factory and the second floor is a classroom.



Figure 2 The freezer used to teach and train students for freezing processes.



Figure 3 A smart medium-temperature machine for fruit drying processes.

3.**Freeze-drying Process**: Freeze drying unit is an effective way for drying by removing water form products after frozen under vacuum. Unlike dehydration by the most drying processes which evaporate water using heat, the process involves freezing the materials or products, lowering pressure by vacuum, then removing the ice by sublimation. This process is suitable for preserving on characteristic of initial form or conditioning materials. The freeze dryer obtained an award form national innovation agency of Thailand and National Research Council award, the machine shown in Fig. 4 was designed and constructed by the ITC company (Thailand). The CEO of the company, the best alumni and a role model for our students in Factory Classroom, devoted this machine.



Figure 4 The ITC Kyo-D freeze-drying machine is used by students for learning the process.

4.**Evaporating process:** A multi-propose evaporator is a machine employed to evaporate water from liquid foods to make concentrated liquid products. The machine shown in Fig. 5 was donated under international industrial collaboration between the Faculty of Engineering, KMITL, and Nishida Food Machinery company, Japan.



Figure 5 The multi-purpose evaporator is donated by Nishida Food Machinery company, Fukuoka, Japan.

Students in Factory Classroom

After the students enroll in a graduate program in food engineering, which includes of course work, seminar and thesis. To fulfil graduate requirement, master degree students must publish at least one paper in a conference proceeding and the doctoral degree ones require publication in international journals.
In order to meet program requirement and to satisfy the essential 21st century skills for the professional and career development, the students need to adopt and enhance the following skills:

- Decision making
- Problem solving
- Communicating orally, and
- Creativity.

The project based on real products are assigned for full time students who are employed as food developers in Factory Classroom. The prototype product owners are SMEs supporting financially under grants from the TRF. After finishing feasibility study by the marketing team of Factory Classroom, students have been jointed working closely with SMEs who have own their market positions



Figure 6 Students and SMEs work together to develop commercial products.

To teach decision making skill, each student plays role as a key developer of the product, planning on a laboratory scale to pilot scale experiments as shown in Fig. 7, and the set up are all designed under limitation of time and budget by the student under supervising by the teaching team of Factory Classroom.



Figure 7 Students use a UHT machine made in the USA to produce fruit drink products.

The problem solving skill is trained on how to control raw material, looking for process methods using scientific assumptions.

Every week, all students must join a seminar with the teaching team and international research students who visit under co-researching programs with the Factory Classroom students.A progress report of each student must be in English to practice both in oral and written communication skills. The presentations are commented and corrected by the teaching teams.

Finally, after carrying out the pilot scale, having a product prototype that is a part of the student's thesis. To enhance creativity, each student works among designers of the marketing team from packaging design to product positing addressed by the product owner as shown in Fig. 8.



Figure 8 Each student has a chance to work with the product designer, the owner, and the marketing team under real situations.

Results

An example of student research output in creating from laboratory scale to prototype a product is the black sesame which is a functional food, premium product thermally optimizing processed by Factory Classroom. The product prototype obtained an award from the Thailand Research Fund, which was a part of the student master thesis.

Another example for the output of the teaching team and student is a project entitled as 'Penta golden fruits' products. As the name "penta" implied, five tropical fruits including mango, mangosteen, durian, coconut and pineapple are selected to create high values. To illustrate, mango products are assigned at the first phase of the research, five SMEs with their own ideas for the ready-to-eat products have been selected and invited to work with Factory Classroom. The research procedure starts from a feasibility study, collects mangoes from smart farms with quality assurance, processes in the laboratory, designs packaging, until finish the prototypes of five products. Eventually, topping mango was selected to be one of the best products in the year 2018 and got the SME award from Thailand Research Fund.

Acknowledgements

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GROUPWORK ABOUT RESPONSE TO FICTIONAL SECURITY INCIDENT IN INFORMATION SECURITY EDUCATION

R. Komura *,a

[a] Department of Electronics and Information Engineering, National Institute of Technology, Ishikawa College, Japan

* komura@ishikawa-nct.ac.jp

Abstract

The information security become an important factor on ICT (Information and Communication Technology) to use and keep computer system. But the number of engineers having the skills of information security is shortage and the nurture of human resource is desired on the industrial societies in the world. There is same situation in Japan and NIT (National Institute of Technology, Japan) goes ahead with the plan for nurturing human resource in the education. The K-SEC (Kosen Security Educational Community) project start to grow the skills of information security. This paper shows the design and practice of information security education with active learning method in K-SEC project. A skill for information security response is one of the most important skills in modern society. And we also think the moral for information security is one of important factors in the education on information science and students think about moral on information science in this groupwork. Groupwork in this paper is design for students to play four kinds of posts, which are division manager, department manager, employee and a part time worker, in a company and think how to prevent incidents as each post. In the groupworks we set a information security incident caused by a part time worker's careless operation. And students think each post should prepare for prevent the incident. The group work is consisting of 3 steps, first step is consideration of points of cause of the incident on each post, second step is making proposals of auctions to prevent the incident and third step is the presentation of proposals of actions in each post. In each step, student think about themes using whiteboard and tags and contents in the group work is inputted to e-learning system to share the contents with other groups. In the presentation, suggestions of most of students are appropriate proposals in the real company and our groupwork achieved success to train the skills and morals on information security.

Keywords: *information security education, grope work, LMS, K-SEC, moral on information*

Introduction

The developments of ICT (Information and Communication Technology) is in progress and the information security become an important factor to keep ICT systems. But the number of engineers having the skills of information security is insufficient and the nurture of human resource is desired on the industrial societies in the world. There is same situation in Japan and NIT (National Institute of Technology, Japan) starts an education project for nurturing human resource. The project is called the K-SEC (Kosen Security Educational Community) (figure 1). K-SEC was organized in 2015. The number of the campus of NIT joining K-SEC is increasing (Kochi Kosen (2018)). Our campuses also join the K-SEC and develop the contents for information security educations. The skills which should be grown in the education of information security is not only ability on ICT but also the proportional senses on using and/or designing the ICT systems. For example, some rules designed for protecting important information is not usability for users. The system with less usability is not able to be excellent system. Because of these backgrounds, we need to design and make the educational contents for growing ICT skills and proportional senses by groupwork.

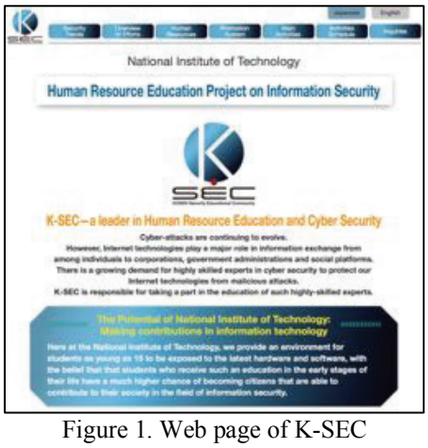

Figure 1. Web page of K-SEC (https://csinfo2018.kochi-ct.ac.jp/en/index.html)

Materials and Methods or pedagogy

The educational contents for information security developed by the K-SEC consists of three levels. The contents for 1st level are for all students in NIT to learn common knowledge of ICT and information security, and the content for 2nd level is for the student in each department to learn the factors of the information security on their fields of study. The content for 3rd level is for student learning information science to learn and get the skill for the information security to become a capable engineer and/or scientist like as a white hacker. The teaching style on the contents developed in the K-SEC is classroom learning style, self-learning style, active-learning style and practical training style. In this paper, we use the contents about the moral on the information security for the self-learning and carry out grope work to learn proportional senses on ICT system and information security.

The grope work is planned as flip teaching and is carried out in the event for nurturing human resource in Kosen on 30th August, 2017. In the event, students selected from all Japanese Kosen assembled in NIT, Ishikawa Campus. The contents of the event are this grope work and hackathon to create questions for CTF(Capture The Flag). This paper explains about the grope work.

We think engineer related to the information security should have sense about morals and balance between availability and limitation on the rule of corporation. We design a groupwork to make rules of corporation which has information security incident. In groupwork, students make rules for each post. The grope work consists of two stages. One is previous learning using internet and the other is face-to-face class. The course for the previous learning is set up on the Blackboard, which is the one of the LMSs which we can used. The contents of the course are about morals on using information and we input basic knowledges into students. These contents are developed by K-SEC and available at all campus of NIT. Then the students who already learn basic knowledges gathered at Ishikawa Campus and start face to face class. The theme of class is grope work to make the rule of corporation against incident on information security. Students are separated to 7gropes and the number of students at each grope are 5 students.

Each grope discusses about the rules on corporation on information security. The themes on grope work are PC, smart phone, SNS, cloud service and e-mail. The processes of grope work are following:

1. Ice Break
2. Explain about incident on information security at the corporation.
3. Digging up the problems on the rules at each post.
4. Sharing the problems with other gropes using ICT
5. Making new rules against the problem
6. Sharing new rules with other gropes using ICT

At first, we explain the story about the information security incidents in the corporation. In the story, a part-timer leaks an information about a behavior of information system in a division in the corporation as problem to the SNS and a director of the headquarters, who find the information on SNS, forces to stop the system, but the behavior is by design.

In the process of digging up the problem, students discuss the problem on each post in the corporation. The posts in the discussions are the director of the headquarters, he director of the division, the regular employee of the division and a part-timer of the division. Students discuss about the incident ant find the problems at each post. After the discussion, they summarize the problems and input the contents about problems into LMS. Then we disclosure the contents to all students and share the problems discussed in each group.

In the process of making new rules, Students consider problems they found and propose the rule against the problems for each post in the corporation. After the consideration, they organize the rule at each post and input the rule into LMS. Then we summarize the rule that students consider and present the rule in real corporation and

Self-evaluations were carried out before and after the event. These results of evaluations were used for estimation of effects of event.



Figure 2. Web page of K-SEC



Figure 3. Web page of K-SEC



Figure 4. Web page of K-SEC

Results and Discussion

The event is held on 30th and 31th August 2017, at NIT, Ishikawa campus. 35 students come to the campus. A half number of students belong to Ishikawa campus and another half is come from other campus or Kosen.

Figure 2 shows the slide for this groupwork and title of groupwork is “the discussion about rules for the information security by students in KOSEN”. We explain the story about information security incidents using this slide. 5 students work in one table and discuss about information security incidents using white board at each group (Figure 3). Results of discussion by students are inputted to LMS (Microsoft Forms) as shown in Figure 4.

Figure 5 shows results of problems dug up at each post and inputted to LMS by students. In this process, it is can be said that students analyze the story and find proper problems at each post in the corporation. Figure 6 shows results of rules made and inputted to LMS by students. Students analyze problems properly and make rules to prevent incidents while keeping usability. These results are very close to model answers which we assumed and it is identified that students have senses to treat information properly.

Self-evaluations and peer-evaluation was carried out during the event. In evaluation, best score is 5 and worst score is 1. The points for evaluation are teamwork, independently, logical mind, problem solving ability, moral and communication skill. In the radar chart, scores after the event on all points of evaluation in self-evaluations is larger than that before the event. This result means that student can be grow problem solving ability and other skills and can feel the growth of skills.

Conclusions

The grope work is planned as flip teaching and is carried out in the event for nurturing human resource on information security in Kosen. In the grope work, students analyze the security incident in a corporation and find the problem at each post. After that they make new rule against problem in information security with availability. Additionally it is confirmed by self-evaluations that the other skill of student grow.

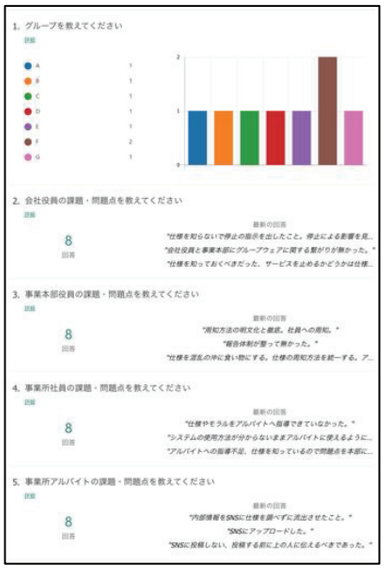

Figure 5. Web page of K-SEC



Figure 6. Web page of K-SEC

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REPORT ON DESIGNING AND BUILDING MANUAL-CONTROLLED ROBOTS AND SHARING OF THE LECTURE CONTENTS

T. Shirai*,[a], M. Kito [a], Y.Sawaki [a], T. Fujimatsu [a], H. Ezaki [b] and J. Yoshida [c]

[a] N. I. T., Suzuka College/Dep. of Mechanical Engineering, Mie, Japan
[b] N. I. T., Suzuka College/Dep. of Materials Science and Eng., Mie, Japan
[c] N. I. T., Suzuka College/Principal, Mie, Japan

*shirai@mech.suzuka-ct.ac.jp

Abstract

This paper reports a practical course performed in "Comprehensive Practice" for the third grade mechanical engineering students at National Institute of Technology (NIT, KOSEN), Suzuka College. In the practical course, each team of five to six students in a class builds their small manual-controlled robot over one year. The robots made of aluminium consist of four motors and different kinds of gears. A total of 40 small cardboard boxes are placed at Area-A. The robots compete on how many boxes they can transport from Area-A to Area-B. After discussing their ideas, designing roughly and then in detail with 3D-CAD: SolidWorks, students machine parts and assemble robots with provided materials following the prescribed rules. They cannot move on to the next step unless their ideas and designs are confirmed. The competition is held at the end of the academic year. The results of the competition as well as idea award, design award and technique award are reflected in the grade evaluation. As lectures progress, each team becomes more united and tackle their problems together. We conducted questionnaires for students twice to measure the effectiveness of this course. In the questionnaires, the students evaluated the difficulty of the task on a five point scale. While 3 out of 44 students marked 1 or 5 in the questionnaire and 20 students marked 3 (appropriate). The lecture contents, including the competition rules, a list of provided materials, an example drawing of a gearbox, a lecture schedule, a questionnaire form, a weekly report form, a format of the final report, a grading standard, ballot papers for each award, and a video of the competitions, are released on LMS (Blackboard) introduced by KOSEN in Japan. Kitakyushu College has also held a competition for the fourth grade students under the same rules using the shared lecture contents since 2016. In February 2018, two teams from our college participated in the competition held in Kitakyushu College.

Keywords: *Creative engineering, designing and building robots, teamwork, questionnaires, shearing lecture contents, LMS, joint competition*

Introduction

National Institute of Technology (NIT, KOSEN) in Japan is a higher education institute established to cultivate engineers through lecture and practice. In recent years, the number of PBL (Problem/Project Based Learning) and Active learning to encourage the creativity of students is increasing (Kanematsu et. al., 2013; Shibasato et. al., 2012; Yajima, Okumura, Sugaya, Takeichi, & Sato, 2016). Active learning is compatible with a robot education (Niimi, 2016).

A practical course: UNSOYASAN has been carried in "Comprehensive Practice" for the third grade mechanical engineering students at NIT, Suzuka College, since April 2006. The lecture contents are released on LMS (Learning Management System, Moodle) to students. In 2015 the lecture contents were released on LMS (Blackboard) which is available to staffs and students in KOSEN. NIT, Kitakyushu College started a practical course under the same rules based on the lecture contents. The paper presents the details of the practical course which has been carried for more than 10 years. The results of questionnaires for students, the lecture contents released on LMS and the results of the competition with Kitakyushu College are also reported.

Competition rules

In the practical work, each team of five to six students in a class of about 40 students builds their robot. Students are allowed to use a 7.2 V battery for radio control cars and two D batteries for powering thier robots. The maximum size and weight of robots is 400 mm × 400 mm and 4 kgf, respectively. There is no height limit.

Figure 1 shows the layout of the game field. The game field is rectangular plane of 2 m × 3 m with borders of 60 mm in height on each side. A robot is placed in the start zone. After starting a game, the robot moves to Area-A where maximum 40 small cardboard

boxes are piled and carries as many boxes as possible within 3 minutes to Area-B which consists of two areas: Area-B1 and Area-B2. There is a barrier of 60 mm in height installed between the field and Area-B2. Thus, teams can score points either by crossing over the 60 mm barrier or by pushing the cardboard boxes to Area-B1 though it takes time. There is a step of 10 mm × 10 mm square rod between Area-B1 and Area-B2. The robot has to cross over the step in order to move from Area-B1 to Area-B2. The score points for Area-B2 is greater than those for Area-B1. Teams obtain a score of 1 point for a box in Area-B1 and 2 points in Area-B2. Thus, the maximum score will be 80 points. The size of the cardboard box is about 103 mm × 94 mm × 38 mm, the weight is 30.6 gf. The way of piling boxes in the Area-A is unrestrained. Teams can use a heavy cardboard box besides the mentioned boxes. The heavy box sizes the same, but weighs 650 gf. Teams obtain a score of 10 points, when the robot carried the heavy box to Area-B1 and 20 points to Area-B2.

Competitions are conducted twice for each team. Teams are ranked in order of their obtained scores. The results of the competitions are reflected in grades. Besides the results of the competitions, idea award, design award and technique award in each team chosen by students are reflected in grades. Only one robot manipulator is allowed, though the robot is allowed to be separated after starting the game. Teams can also obtain scores when boxes are above Area-B, even if the boxes are contact with the robot at the end of the game. The boxes which fell outside of the field cannot be counted.

Provided materials

Students can use two kinds of motors: 7.2V DC motor (RS-540SH manufactured by Mabuchi motor co., 200 gf · cm, 14,000 rpm) and 3V geared motor (worm gear box manufactured by Tamiya inc.). A total of 4 motors are given. Spur gears made of polyacetal (module 1, number of teeth 20/40/60/80/120), Metal spur gears (module 1, 16 teeth), Worm gears and worm wheels (reduction ratio 40:1), Miter gears (number of teeth 30, made from polyacetal), Casters (Wheel diameter φ 25), Bearings (BC6-12ZZ, inner diameter φ 6, outer diameter φ 12, thickness t = 3 mm). Aluminium circular pipes (outer diameter φ 16 and φ 12, t = 1 mm), aluminium round bars (φ 10 and φ 8), aluminium rectangular rods (cross sectional shape 35 mm × 5 mm), aluminium square pipes (10 mm × 10 mm, t = 1 and 20 mm × 20 mm, t = 1.5), Chamber materials (20 mm × 20 mm, t = 1.5), boards (t = 1), PVC round bars (φ 50, φ 80) are also provided. Screws M3, M4 are available. Students are allowed to buy other materials except too expensive ones.

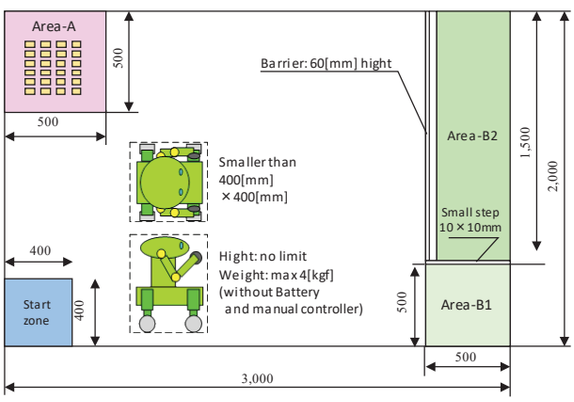


Figure 1 Layout of the game field

Lecture contents

Table 1 shows the practical course schedule. Each lecture takes 180 minutes and 28 lectures are held in a year. In the first two weeks of the course, an orientation and a home electronics disassembly practice are conducted. In the orientation, the rules, descriptions of provided materials and the schedule are explained and various robots built in the previous years are also introduced to students by competition videos. In addition to the robots which record high scores and realized stable motion, those score low but have uniqueness, those were unable to achieve their motions as expected, those broke apart during the game, are shown to students through the videos. At the beginning of the course, we warn students that physical phenomena easily betray their expectations. We let them know that they need various ingenuity to realize even a simple idea like lifting a box over to a height of 60 mm with a belt conveyor. Figure 2 shows a class scene of the home electronics disassembly practice. The home

Table 1 Lecture plan

No. of lecture	Lecture contents
1	Explanation of the competition, Home electronics disassembly practice in team
2	
3	Idea and concept development for designing a robot
4	Idea competition in the team
5	
6	Practical training (NC milling machine and 5 axis machining center)
7	
8	
9	Assembly drawing of the team robot using 3D CAD
10	
11	* Drawing check
12	Part drawings of the team robot
13	
14	* Drawing check
15	
16	
17	Machining of parts
18	
19	
20	*Driving function check
21	Machining of parts
22	Assembling and adjusting the team robot
23	
24	
25	Connectiong wires, function check
26	Final adjustment
27	Competition
28	Report writing

electronics disassembly practice aims at generating students' interests in the structure and operation principles of various products, developing understanding that a device which even seems simple also consists of many parts and acquiring skills to use tools correctly as well as encouraging good teamwork in group members by carrying out a task together. The home electronics used in the disassembly practice are provided free of charge from our staffs and they are completely disassembled and then recycled or disposed. Reassembling them is not a matter of concern in the disassembly practice. We believe it is important to disassemble them completely. Practical training in operating NC milling machines and five-axis machining centres is conducted in four weeks. The competition is held at the 27th week. The final week of the academic year is scheduled for report writing. Through 20 lectures excluding a total of 8 lectures, students complete their robots from scratch. In the third lecture, each student not as a team submits their idea sheets. In the following week, each student presents their ideas using the submitted idea sheets to their group members to develop a new concept (Idea competition). Each team completes an idea sheet including the members' ideas and then works on designing a robot. Three lectures are assigned for designing assembly drawings. The team who passed the drawing check is allowed to move on to part drawings. Three lectures are also assigned for the part drawings. The team who passed the drawing check is allowed to machining parts using machine tools including lathe, milling machine, drilling machine.

Figure 3 shows work scenes in the Creation Center. Ten lectures are assigned to works on machining parts, assembling and adjusting robots. The schedule after designing assembly drawings is just a guideline. The drawing checks for assembly and part drawings and the driving function check in the 20th lecture are setted as milestones which also make students recognize the delay of the schedule. Although the competition is scheduled on the 27th lecture, the schedule tends to be delayed and in fact the competition is usually held in the final 28th lecture.

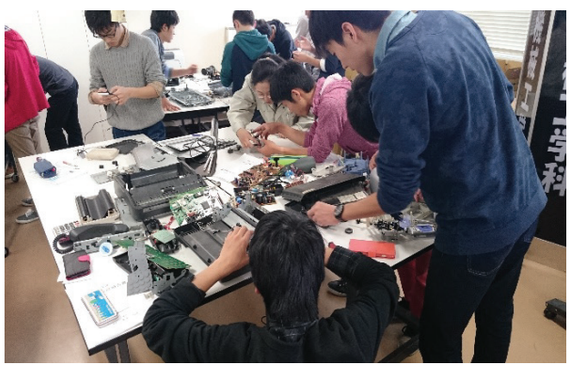


Figure 2 Home electronics disassembly practice

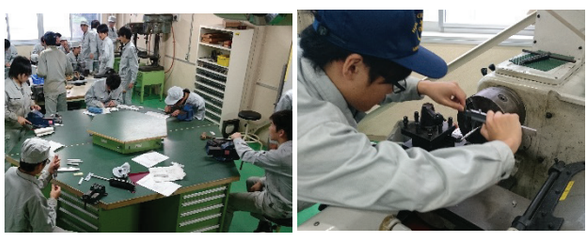
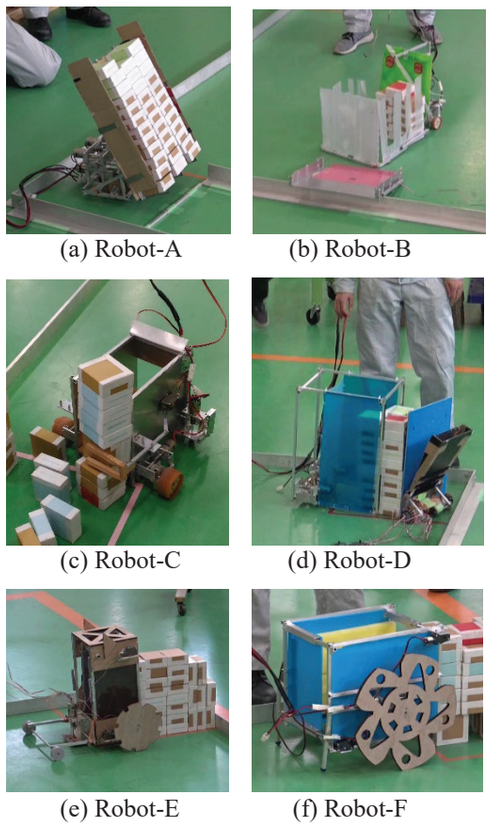


Figure 3 Machining work

Examples of robots

Samples of robots made by students are shown in Figure 4. Robot-A in Figure 4 (a) is the type of robot which carries boxes piled flatly in a wall shape at one time. Maintaining the whole boxes together requires high manipulating skills. Students practiced adequately for the competition. Robot-B in Figure 4 (b) is the separated type of robot. The robot puts a slope on the barrier of 60 mm at the boundary between the game field and Area-B2 before carrying boxes and then pushes boxes to Area-B2 through the slope. This type of robot scored high. Robot-C in Figure 4 (c) is the common type of robot which stores and carries boxes piled in tower shape. Robot-D in Figure 4 (d) is the type of robot which stores box towers in the same manner of Robot-A and Robot-C. Robot-D has the separated part which supports the box towers behind to prevent from felling. Robot-E in Figure 4 (e) and Robot-F in Figure 4 (f) are characterised by their tires. Robot-E has tires



(a) Robot-A (b) Robot-B

(c) Robot-C (d) Robot-D

(e) Robot-E (f) Robot-F

Figure 4 Various types of robot

with slits to cross over the small step with a height of 10 mm and a width of 10 mm between Area-B1 and Area-B2. Robot-F has tires with large slits to step over the barrier of a height of 60 mm between the game field and Area-B2. The important point to cross over the step or the barrier is that the phases of the left and right tires must coincide.

Lecture questionnaire and Discussion

Lecture questionnaires are conducted in the 14th lecture in October and the 28th lecture in February. Two kinds of anonymous questionnaires as listed in Table 2 and Table 3 are performed. In the self-evaluation questionnaire, students evaluate their own attitude towards the practical course by themselves. In the teammate questionnaire, they choose those who are contributing to designing and building their robot in the team. The self-evaluation questionnaire has ten questions. In the questionnaire, students evaluate on a five point scale. The mark 1 means "no", the mark 3 means "to some extent" and mark 5 means "yes". Note that it is desirable to evaluate as "to some extent (=3)" in Question 9 which askes the difficulty of the practical course, because when students feel the practical course is too easy (=1) or too hard (=5), they do not actively participate in the practical course. The results of the self-evaluation questionnaire for 3 years from 2015 to 2017 are shown in Table 4. Oct. and Feb. are the class average values, σ is the standard deviation, Average, Min and Max are the average, the minimum value, and the maximum value of each question for three years, respectively. Feb. – Oct. is the increase / decrease value of the average value of the first and the second self-evaluation questionnaire of the same year. Questions 1 to 3 ask students if they actively participate in the practical course. The results of Questions 1 to 3 indicate that students participated most actively in the practical course of the machining parts but less actively in the designing. There is not much difference between the results of Oct. and Feb. This is because only those who are good at 3D CAD tend to be involved in the designing, while in the case of machining parts which require manpower, everyone can equally contribute to work. The results in 2016 and in 2017 for Questions 4 to 5 which explore students' level of understanding in their robot structures show no significant increase in the average values of Oct. and Feb. unlike those in 2015. Since 2016 we have given tasks for all students to learn 3D CAD skills from the early stage. Thus, even if some students in the team design their robot, all students can contribute to draw parts. This results in discussion the robot structure in the team. The understanding of the robot structure in 2015 has significantly improved to the same level as in 2016 and 2017, through the machining process of robots. The similar trend of a difference by year can be seen also in Questions 6 which asks students their willingness and Questions 7 which asks them the importance of the practical course. The results of questionnaire show that it is important to prevent the learning motivation which has once risen at the stage of

Table 2 Self-evaluation questionnaire

	Question
Q1	Do you actively generate ideas when designing and building the robot?
Q2	Do you actively devise the mechanism and design of the robot?
Q3	Do you actively machine parts of the robot, assemble and adjust the robot?
Q4	Do you understand the structure and characteristics (advantages / disadvantages) of the robot, and can you explain it to others?
Q5	Do you research and tackle problems and uneasy points by yourself in regard to designing and building the robot?
Q6	Does your team have a friendly atmosphere to discuss causes and solutions when problems arise?
Q7	Do you actively participate in the lecture?
Q8	Is the lecture effective for you?
Q9	Is the lecture too easy for you?
Q10	Do you think that the evaluation method of grades is fair?

Table 3 Teammate evaluation questionnaire

	Question
Q1	Who actively generates ideas?
Q2	Who actively devises the mechanism of the robot, actively designs and draws it?
Q3	Who actively builds and assemples parts of the robot?
Q4	Who is the indispensable person for completing the robot?

Table 4 Results of questionnaire

	2017				2016				2015				Average	Min.	Max.	Max. – Min.	Feb. – Oct.		
	Oct.	σ	Feb.	σ	Oct.	σ	Feb.	σ	Oct.	σ	Feb.	σ					2017	2016	2015
Q1	3.6	0.98	3.7	0.89	3.9	1.00	3.9	1.09	3.8	1.00	3.9	1.08	3.78	3.6	3.9	0.3	0.1	△ 0.0	0.1
Q2	3.4	1.06	3.6	0.98	3.6	0.93	3.7	1.02	3.5	1.06	3.6	1.13	3.56	3.4	3.7	0.3	0.2	0.1	0.1
Q3	4.1	0.87	4.1	0.99	4.2	0.73	4.0	1.03	3.9	0.85	4.2	0.81	4.09	3.9	4.2	0.3	△ 0.0	△ 0.2	0.3
Q4	3.6	0.84	3.7	0.88	3.9	0.91	3.8	1.03	3.2	1.15	3.7	1.11	3.65	3.2	3.9	0.7	0.1	△ 0.1	0.4
Q5	3.7	0.91	3.8	0.92	3.6	0.93	3.5	1.07	3.2	1.04	3.6	1.11	3.59	3.2	3.8	0.5	0.0	△ 0.1	0.4
Q6	3.7	1.11	3.8	0.86	4.0	0.96	3.7	1.20	3.5	1.20	3.9	1.03	3.75	3.5	4.0	0.5	0.1	△ 0.3	0.5
Q7	4.1	0.80	4.1	1.02	4.3	0.68	4.2	1.02	4.0	0.89	4.1	0.87	4.13	4.0	4.3	0.4	0.0	△ 0.2	0.1
Q8	4.1	0.96	3.8	1.20	4.2	0.96	4.0	1.03	3.9	0.84	4.0	0.88	3.99	3.8	4.2	0.4	△ 0.3	△ 0.2	0.0
Q9	2.9	0.85	3.2	0.82	2.5	0.99	3.2	1.03	2.8	1.04	2.9	0.82	2.91	2.5	3.2	0.7	0.3	0.7	0.1
Q10	3.8	0.95	3.7	1.06	3.8	0.99	4.0	0.91	3.7	0.82	4.0	0.80	3.82	3.7	4.0	0.3	△ 0.1	0.2	0.3

giving ideas from decreasing at the stage of designing and drawing. The answers for Questions 9 which asks the difficulty of the practical course marked close to 3 as expected.

Grades are evaluated on a scale of 100 points. The breakdown is as follows. The evaluation of the reports submitted after each lecture is 60%, the evaluation of the final report is 25%, the evaluation of the robot is 5%, and the evaluation according to the contribution of each student is 15%. Question 10 asks students the fairness for the grade evaluation mentioned above. The reports submitted after each lecture are handwritten. The final report has to be typed and electronically submitted. Note that the final report deadline is scheduled after the Questionnaire in February. Students' evaluations improved up to 4.0 at the end of the academic year in 2015 and in 2016, however it decreased to 3.7 in 2017. No clear reason could be found.

The results of teammate evaluation indicate that some students can machine parts actively even though they are weak at generating ideas and designing. Some scored high marks for Question 4, who are good at scheduling and encouraging their teammate to keep a high level of motivation. Students can choose two people at maximum from their team in the teammate evaluation questionnaire. Naturally, they can choose themselves. Two students who won the most votes in the two questionnaires in October and in February, obtain additional points. It is difficult for teachers to accurately measure the degree of active participation of each student in practical course. In the course, the degree of active participation is evaluated from the reports submitted after each lecture and the final report as well as the results from the teammate evaluation questionnaire. Evaluating by teammates can lead to students' motivation for the practical course.

Lecture contents

The lecture contents (electronic files) have been released on LMS (Blackboard) to National Institute of Technology (KOSEN) since 2016 as shown in Figure 5. The lecture contents include a) lecture syllabus, b) handouts for students, c) an example drawing, d) an idea sheet, e) Self-evaluation questionnaire and teammate evaluation questionnaire, f) ballot papers for each award, g) the template of the final report (MS-Word), h) videos of the previous competitions, i) the template of the report for the home electronics disassembly practice.

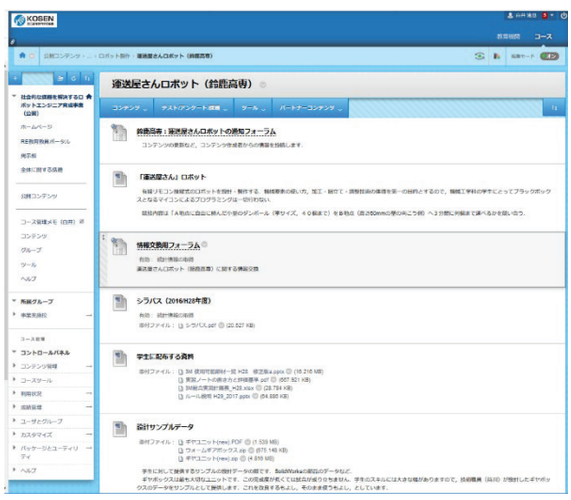


Figure 5 Lecture contents released on LMS

Kitakyushu College has also held the practical subject of "mechanical engineering experiment 1" (second semester, 4th grade students) under the same rules using the shared lecture contents since 2016. The similar practical course is planned to be held in 2018 as well. Although the course period is half of our "Comprehensive Practice", the number of lectures is the same because the lectures are held twice per week in Kitakyushu College. The practical course in Kitakyushu College targets the fourth grade students, while ours targets the third grade students.

The robots of our college were invited to the competition held on 23rd February 2018. Two robots shown in Figs.4 (a) and (b) which won the first and second place and four students (2 students for each robot) were participated in the competition. The top four out of seven teams of Kitakyushu College qualify for the final tournament. Four teams compete in the final tournament by two teams each. The two teams of Kitakyushu College who won and the two teams of Suzuka College compete in the semi-finals. The robot who won in the competition at the Suzuka College won the first place here as well. Few robots operated perfectly without breaking down during the game because the lecture of Kitakyushu College is the second year of implementation. In contrast, the robots of Suzuka College had held the competition earlier than the competition at Kitakyushu College and manipulators were familiar with the robot operation. This is one of the reasons for the victory of Suzuka College. The fact that students in KOSEN who are geographically apart had an opportunity of exchanging technical ideas through the same competition is a great achievement.

Conclusions

This paper reports the practical course which has been performed in "Comprehensive Practice" in Department of mechanical engineering, National Institute of Technology (NIT, KOSEN), Suzuka College since 2016. The third grade students were divided into eight teams in the practical course. Each team generated ideas, presented the ideas, designed and built a robot, adjusted it and held the competition. We conducted our own questionnaires. The analyzed results of questionnaires for three years were discussed. The paper also presented the lecture contents which have been computerized and released to all KOSEN colleges through LMS. NIT, Kitakyushu College held practical course under the same rules based on the lecture contents. Students in Suzuka College participated in the competition held in Kitakyushu College and exchanged technical ideas.

Acknowledgements

We would like to thank a number of people in the Department of Creative Engineering, National Institute of Technology, Kitakyushu College, who implemented practical work under the same rules based on our lecture contents and invited us to the competition. In particular we wish to thank Dr. Takashi Takimoto.

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COLOR BALL COMMUNICATION EXPERIMENT

N. Harada

National Institute of Technology, Tokuyama College
Computer Science and Electronic Engineering, Shunan, Japan

n-harada@tokuyama.ac.jp

Abstract

This paper suggests color ball communication intended for elementary school to college students. Recently, children tend not to play with real objects. The color ball communication can send 4000 kinds of Chinese characters by the permutations of 8 balls of 8 kinds of colors. Simultaneously, it may have students interested in LEDs, a photo sensor, a plastic optical fiber, a microcomputer board, and software for coding and decoding a message with GUI including an animation. The students inspired by an extension lecture demonstrating this material may enter the college and learn principles. The students can learn reasons why LEDs can emit light and why optical fibers can guide a light. They can also learn the method of multiplexing 4 color LED lights with modulating in orthogonal sequences, the way of analyzing the light intensities reflected by an object using a factor analysis, the way of comparing and recognizing signals. Furthermore, they can learn a forward error correcting code and comprehend the necessity of redundancy. They can learn all those experimentally. They can process the measurements on an Excel's spread sheet, and use the Python to derive eigen values and vectors. They can program an Arduino board to modulate LED lights in direct sequence spread spectrum and distinguish the color by comparing their factor vectors. The Processing software allows the personal computer interact to the microcomputer. It can show up the color ball animation and the corresponding characters. A Java application codes an input message to the color ball queues by means of the (6, 3) linear block coding. Students look for the noise source to improve the reliance. They inspect the optical arrangement, the transmitting and receiving circuit, and the mechanics for picking up at the fiber's end. They suggest the ways of raising the communication efficiency such as increasing colors or improving the coding method. They can enjoy devising some reaction like sounds to attract users.

Keywords: *Color Sensor, Direct Sequence Spread Spectrum, Eigen Values and Vectors, Factor Analysis, Forward Error Correcting Code, Plastic Optical Fiber*

Introduction

Factor analysis has been widely used in areas, such as biology, psychometrics personality theories, marketing, product management, operations research and finance. Explanations of the factor analysis in textbooks are so abstract, and that prevent beginners from understanding. Many students, hopefully including readers, want to understand the factor analysis. Let's conduct an experiment on the factor analysis.

Outline of the color ball communication

Figure 1 shows a snapshot of the students' experiment. This device can send a message by rolling color balls. This is intended for children to arise their interest in the communication technologies. Why have the color balls changed into the message? Each color plays the role of a signal. Figure 2 shows the color reader connected to a vinyl chloride pipe through a plastic optical fiber that guides lights on a round trip for illumination and reflection. Figure 3 shows the system's indication of a message, where each character appears after reading eight colors of the balls. Figure 4 shows the color coder, where a set of eight colors indicate a Kana or Chinese character, etc.



Figure 1. Students working on the color ball communication experiment.

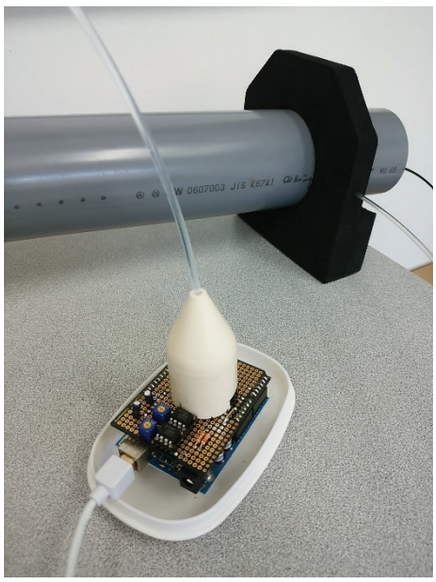

Figure 2. The color reader is connected to a vinyl chloride pipe through a plastic optical fiber that guides lights on a round trip for illumination and reflection.

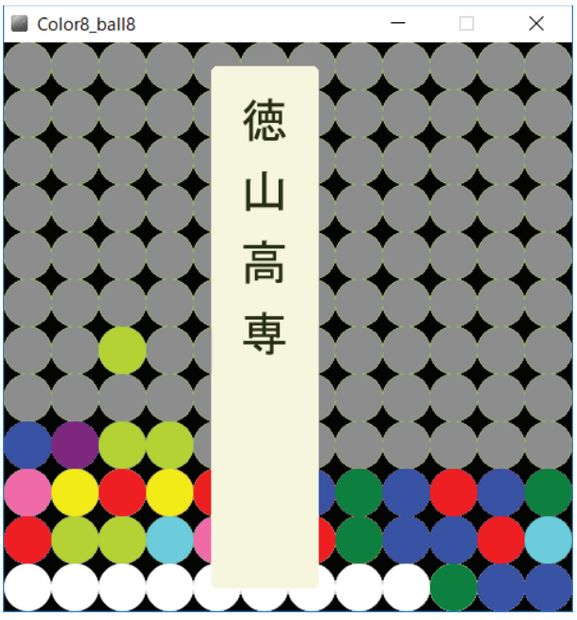

Figure 3. The system indicates a message, where each character appears after reading eight colors of the balls



Figure 4. The color encoder shows a set of eight colors for each Kana or Chinese character, etc.

Principles

How do machines recognize the color? The color should be decomposed into the elements and then be compared like the paper Chromatography shown in Figure 5. How should the ball's color be decomposed? The elements can be estimated by analyzing the reflected lights of four LEDs colored red, green, blue, and white. Figure 6 shows the photo of the device. How can each colored light be detected separately? It is done by the modulation of Direct Sequence Spread Spectrum, DSSS. Each colored LED flashes in a different pattern. Microcomputer memorizes the sum of the four reflected lights at each time step. Figure 7 shows the way of calculating the response of the green light only.



Figure 5. The paper Chromatography

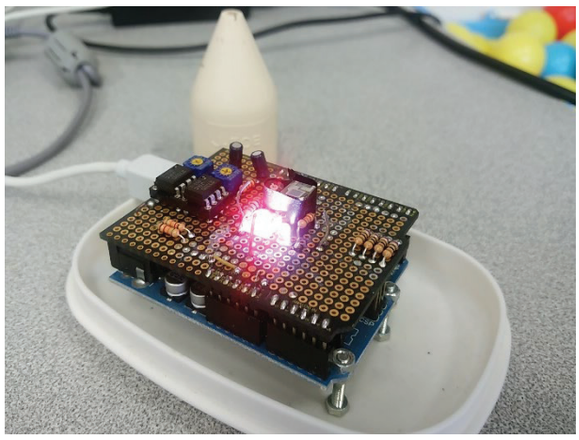

Figure 6. The inside of the color reader which consists of four colored LEDs and a photo IC diode.

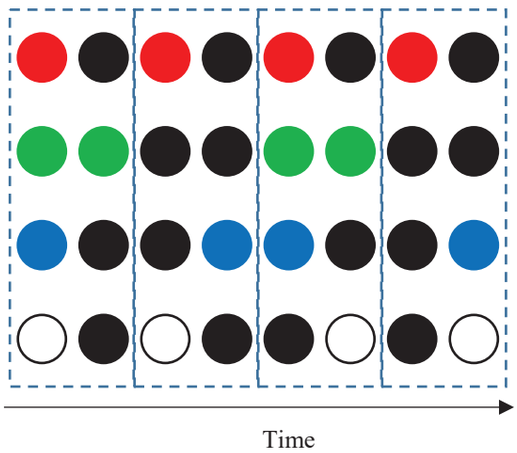

Figure 7. The series calculation of PLUS, MINUS, PLUS, MINUS, yields the green light's response only.

How can we estimate the color elements from the detected lights? Those can be estimated by the factor analysis. The reflected lights are denoted by y_1 to y_4 for the four colored LEDs, and are modeled by this matrix equation.

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} \approx \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \\ c_{41} & c_{42} & c_{43} \end{bmatrix} \begin{bmatrix} g_1 \\ g_2 \\ g_3 \end{bmatrix} \quad (1)$$

The four colored light are respectively assumed as the sum of the products of the emitted light and the reflection rate that vary depending on the wave length as shown in Figure 8.

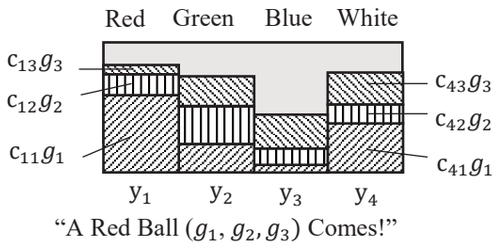

Figure 8. Decomposition of the responses of a red ball to each colored light

How shall we solve these elements of emitted lights and reflection rates? Let's standardize the detected lights. Standardization means the transformation to fix the average at 0 and the valiance at 1.

$$x_i = \frac{y_i - \bar{y_i}}{\sigma_{y_i}} = \frac{c_{i1}\sigma_{g_1}f_1 + c_{i2}\sigma_{g_2}f_2 + c_{i3}\sigma_{g_3}f_3}{\sqrt{c_{i1}^2\sigma_{g_i}^2 + c_{i2}^2\sigma_{g_2}^2 + c_{i3}^2\sigma_{g_3}^2}} \quad (2)$$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} \approx \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \\ a_{41} & a_{42} & a_{43} \end{bmatrix} \begin{bmatrix} f_1 \\ f_2 \\ f_3 \end{bmatrix} \quad (3)$$

The row vectors, such as (a_{11}, a_{12}, a_{13}), are called the factor loading vector, and the vector (f_1, f_2, f_3) is called the factor vector. This standardization fixes the length of the factor loading vector at one, and also standardize each element of the factor vector.

What's the benefit of the standardization? The correlation matrix of the detected lights tells the angles among the factor loading vectors. The elements of the correlation matrix indicate inner products among the factor loading vectors. The length of the factor loading vectors are all fixed at one, so the angles among them are determined.

$$\text{Correlation Matrix } R = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \\ a_{41} & a_{42} & a_{43} \end{bmatrix} \begin{bmatrix} a_{11} & a_{21} & a_{31} & a_{41} \\ a_{12} & a_{22} & a_{32} & a_{42} \\ a_{13} & a_{23} & a_{33} & a_{43} \end{bmatrix} \quad (4)$$

All relative directions of the factor loading vectors have been determined. Let's find a set of vectors that satisfies the angles among them. Equation (5) is the expansion of the correlation matrix, composed of the eigenvalues and the eigenvectors. These are the eigenvalues and eigenvectors of the correlation matrix. Approximating the smallest eigenvalue to 0, the following term is obtained. Here, the solutions having their angles conformed have been found.

$$\begin{aligned} R &= \begin{bmatrix} e_{11} & e_{21} & e_{31} & e_{41} \\ e_{12} & e_{22} & e_{32} & e_{42} \\ e_{13} & e_{23} & e_{33} & e_{43} \\ e_{14} & e_{24} & e_{34} & e_{44} \end{bmatrix} \begin{bmatrix} \lambda_1 & & & 0 \\ & \lambda_2 & & \\ & & \lambda_3 & \\ 0 & & & \lambda_4 \end{bmatrix} \\ &\quad \begin{bmatrix} e_{11} & e_{12} & e_{13} & e_{14} \\ e_{21} & e_{22} & e_{23} & e_{24} \\ e_{31} & e_{32} & e_{33} & e_{34} \\ e_{41} & e_{42} & e_{43} & e_{44} \end{bmatrix} \quad (5) \\ &= \begin{bmatrix} \sqrt{\lambda_1}e_{11} & \sqrt{\lambda_2}e_{21} & \sqrt{\lambda_3}e_{31} & \sqrt{\lambda_4}e_{41} \\ \sqrt{\lambda_1}e_{12} & \sqrt{\lambda_2}e_{22} & \sqrt{\lambda_3}e_{32} & \sqrt{\lambda_4}e_{42} \\ \sqrt{\lambda_1}e_{13} & \sqrt{\lambda_2}e_{23} & \sqrt{\lambda_3}e_{33} & \sqrt{\lambda_4}e_{43} \\ \sqrt{\lambda_1}e_{14} & \sqrt{\lambda_2}e_{24} & \sqrt{\lambda_3}e_{34} & \sqrt{\lambda_4}e_{44} \end{bmatrix} \\ &\quad \begin{bmatrix} \sqrt{\lambda_1}e_{11} & \sqrt{\lambda_1}e_{12} & \sqrt{\lambda_1}e_{13} & \sqrt{\lambda_1}e_{14} \\ \sqrt{\lambda_2}e_{21} & \sqrt{\lambda_2}e_{22} & \sqrt{\lambda_2}e_{23} & \sqrt{\lambda_2}e_{24} \\ \sqrt{\lambda_3}e_{31} & \sqrt{\lambda_3}e_{32} & \sqrt{\lambda_3}e_{33} & \sqrt{\lambda_3}e_{34} \\ \sqrt{\lambda_4}e_{41} & \sqrt{\lambda_4}e_{42} & \sqrt{\lambda_4}e_{43} & \sqrt{\lambda_4}e_{44} \end{bmatrix} \\ &\approx \begin{bmatrix} \sqrt{\lambda_1}e_{11} & \sqrt{\lambda_2}e_{21} & \sqrt{\lambda_3}e_{31} \\ \sqrt{\lambda_1}e_{12} & \sqrt{\lambda_2}e_{22} & \sqrt{\lambda_3}e_{32} \\ \sqrt{\lambda_1}e_{13} & \sqrt{\lambda_2}e_{23} & \sqrt{\lambda_3}e_{33} \\ \sqrt{\lambda_1}e_{14} & \sqrt{\lambda_2}e_{24} & \sqrt{\lambda_3}e_{34} \end{bmatrix} \\ &\quad \begin{bmatrix} \sqrt{\lambda_1}e_{11} & \sqrt{\lambda_1}e_{12} & \sqrt{\lambda_1}e_{13} & \sqrt{\lambda_1}e_{14} \\ \sqrt{\lambda_2}e_{21} & \sqrt{\lambda_2}e_{22} & \sqrt{\lambda_2}e_{23} & \sqrt{\lambda_2}e_{24} \\ \sqrt{\lambda_3}e_{31} & \sqrt{\lambda_3}e_{32} & \sqrt{\lambda_3}e_{33} & \sqrt{\lambda_3}e_{34} \end{bmatrix} \end{aligned}$$

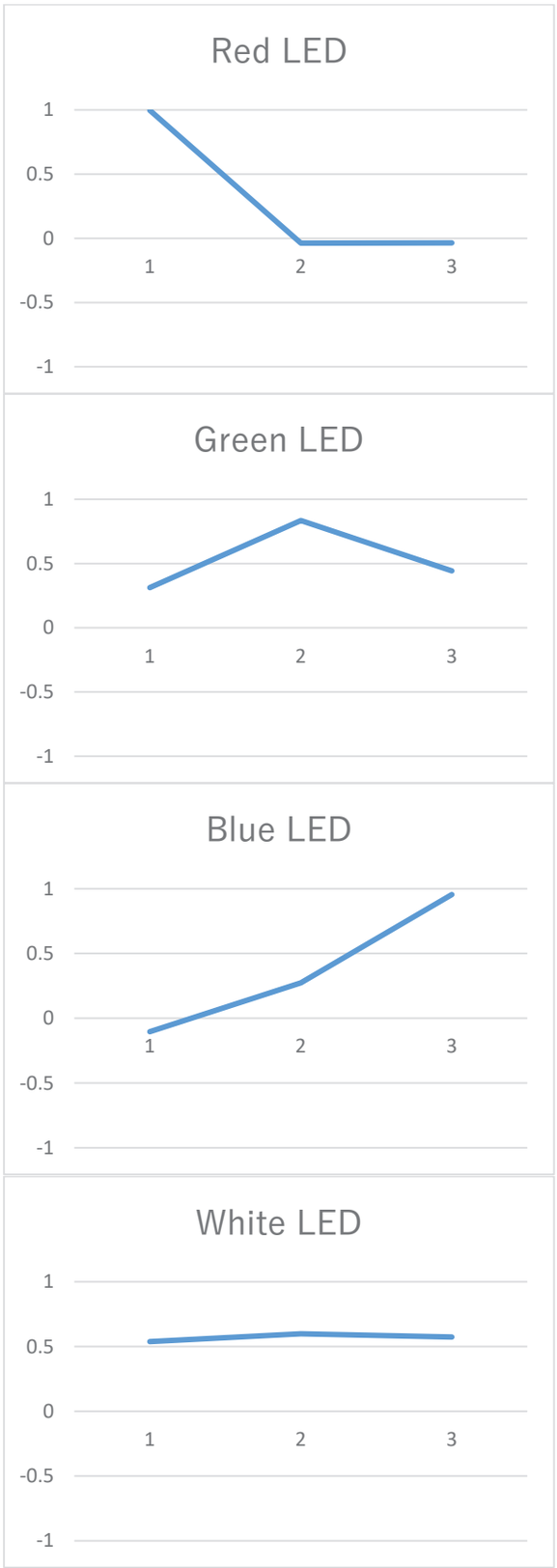

Figure 9. The factor loading vectors

Let's rotate them to find the factor loading vectors. They have been found as Figure 9. Let's find the factor vectors to minimize the errors. They have been found as Figure 10.

The color recognition is not always successful. The fault is supposed to be caused by chattering in the mechanics for picking up reflected lights at the fiber's end. This lead us to another educational opportunity.

The random deviation may cause wrong recognition between the colors which are close to each other in the factor vector. So, we can predict the colors into which a color changes. Unless the chattering is strong, we can confine the number of the colors.

The (6, 3) code can become the useful code for this case as the forward error correcting (FEC) code. The six bit length code consists of three data bits and three parity check bits. If one of the digits has been wrongly received, the receiver can be aware there has happened an error and correct it.

For the (6, 3) code, the code word is represented by Equation (6) with the calculation of modulo 2 additions,

$$\boldsymbol{c} = \boldsymbol{d}G \tag{6}$$

where G is called the generator matrix as

$$G = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$$

As the results, the code word $\boldsymbol{c}$ is represented for each data word $\boldsymbol{d}$ as Table 1. The Hamming distance among them keeps three bits at least, so a code received with one bit error can be corrected to the nearest code from it.

Table. 1 The code word $\boldsymbol{c}$ for each data word $\boldsymbol{d}$

Data Word $\boldsymbol{d}$	Code Word $\boldsymbol{c}$
000	000000
001	001110
010	010011
011	011101
100	100101
101	101011
110	110110
111	111000

For the received word $\boldsymbol{r}$, the error word $\boldsymbol{e}$ is defined by Equation (7).

$$\boldsymbol{e} = \boldsymbol{r} \oplus \boldsymbol{c} \tag{7}$$

The syndrome $\boldsymbol{s}$ is defined by Equation (8) with the calculation of modulo 2 additions,

$$\boldsymbol{s} = \boldsymbol{r}H^T = \boldsymbol{e}H^T \tag{8}$$

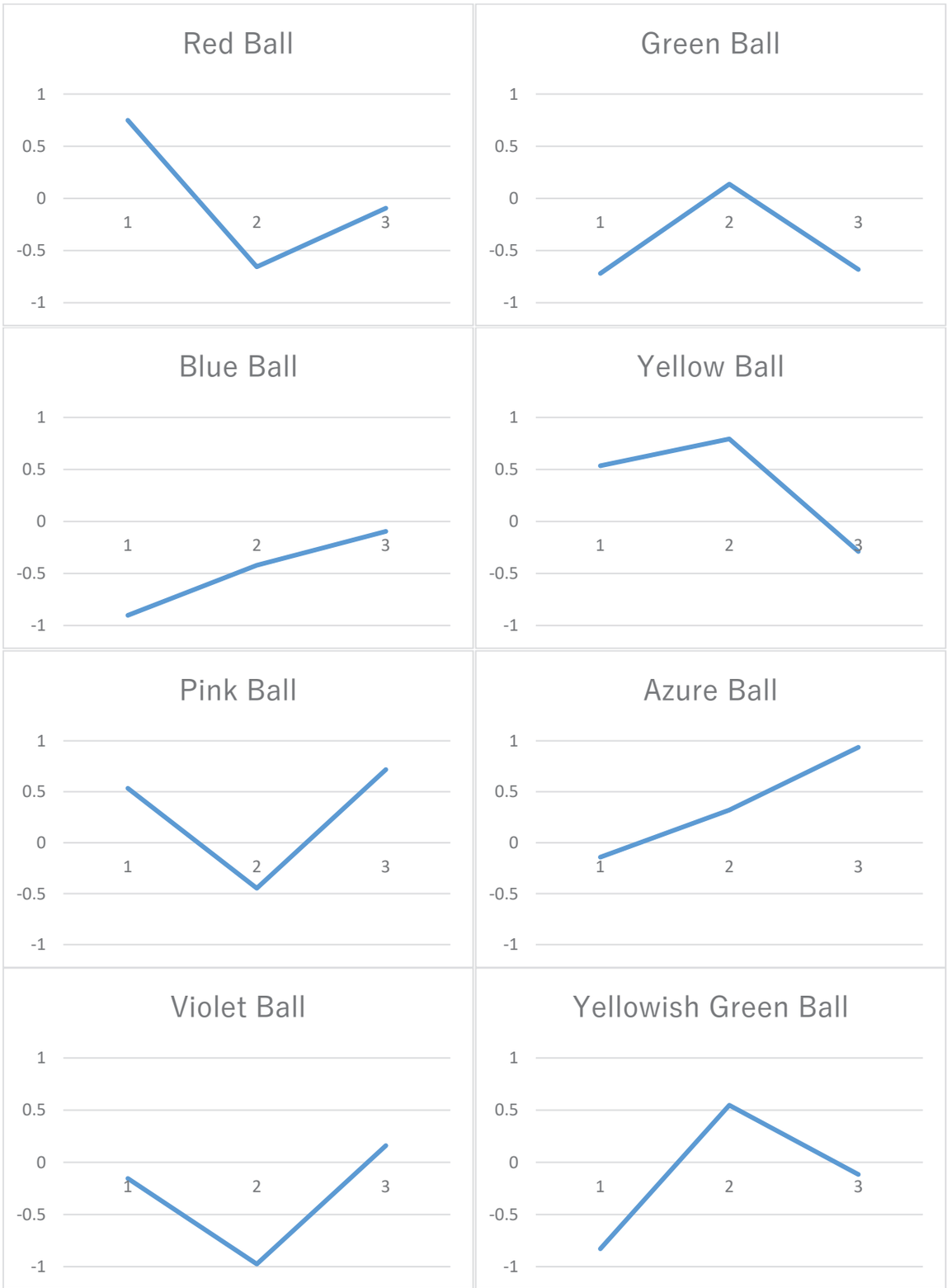

Figure 10. The factor vectors

where H is called the parity check matrix as

$$H = \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

To correct the received word, we used the error word ***e*** corresponding to the syndrome ***s*** as Table 2.

Table. 2 The error word ***e*** estimated by the syndrome ***s***

Syndrome ***s***	Error Word ***e***
000	000000
101	100000
011	010000
110	001000
100	000100
010	000010
001	000001
111	100010

To exploit the bit correcting function, we allotted three bits to the eight colors and had successive two colors represent the (6, 3) code as Table 3. That means one of two successive color balls can be recognized rightly and the other can't be recognized falsely beyond one bit, the error can be omitted.

Table. 3

000	Yellow Green	100	Green
001	Sky Blue	101	Blue
010	Yellow	110	Pink
011	Red	111	Violet

The number of Chinese characters in common use in Japan is 3596. So we prepared 3865 characters including others such as numbers and alphabets. That requires four balls of eight colors, $8^4 = 4096$. The (6, 4) code needs the redundant word of the same length of data word. So we need eight balls for each character.

Experiment

Japanese lyrics are tried to be sent. By the FEC, 43 characters were sent successively and correctly. Without FEC, only a few characters could be sent.

Conclusions

The DSSS modulation has been used effectively. The detected lights are standardized to define the factor loading vectors and the factor vector. The correlation matrix of the detected lights indicate the angles among the factor loading vectors. Rotation arrows to find the factor loading vectors and factor vectors. Japanese lyrics are tested to be sent. By the FEC, 43 characters were sent successively and correctly. Without FEC, only a few characters could be sent. The effect of the FEC has been proved.

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NEW ENERGY STEM GENERATION: SUCCESS IN LEARNING WITH SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) PROJECT-BASED LEARNING (PBL) WORKSHOPS

Shek Ho, Tony, WONG[a], Ho Yeung, Tommy, CHEUNG[b] and Man Hon, Billy, CHOW[b]

[a]Department of Engineering, Hong Kong Institute of Vocational Education (Tsing Yi), Hong Kong SAR
[b]Department of Engineering, Hong Kong Institute of Vocational Education (Haking Wong), Hong Kong SAR

*shwong18@vtc.edu.hk

Abstract

The paper reviews the recent student learning outcomes with Science, Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PBL) Workshop on New Energy STEM Generation (NESG) secondary school solar car racing challenge. Vocational Training Council (VTC) provides quality Vocational and Professional Education and Training (VPET) to nurture globally competitive individuals for the development of Hong Kong and the region. Marking the success of NENG 2017 with the 35th Anniversary of the VTC, the NESG 2018 provides the younger generation with immersive experiences in the application of solar power and smart mobility application.

NESG aims to inspire the younger generation on the use of renewable energy and deepen their knowledge of engineering and the STEM subjects in a fun and interactive approach. IVE Solar Car Team, develop the solar cars to demonstrate the viability of a renewable energy through the use of green transportation, and promote the awareness of environmental sustainability among the public. Proved the success of VTC STEM PBL project, IVE Solar Car Team with over 200 students from electrical and mechanical engineering field achieved the learning outcomes. To extend the STEM PBL core value to the younger generation, Team offers a series of NESG workshops on solar car technology to over 60 teams from local secondary schools, and provide students with board-based and deep engineering knowledge, skills, and value they need to build the deliverables as solar car with efficiency innovation, disruptive thinking and problem-solving skills within months, and work out the solar car for secondary school solar car racing challenge. It also provides students with an opportunity to put theoretical knowledge into practice, gain hands-on experience, and practice project management skills during development, and thus leading student to understanding science and new technology; and practicing engineering skills, and preparing for further smart mobility development in Hong Kong.

General observation and quantitative analysis was used to evaluate the extra-curricular and academic performance are affected by student participation in STEM PBL workshops. Simple questionnaire was used to gauge the effectiveness of the students taking part in the workshops to this with several parameters, include the gender, elective subjects, the STEM workshops experience, to see whether this had any effect on their learning outcome of the project.

Keywords: Science, Technology, Engineering, and Mathematics (STEM), Project-Based Learning (PBL), New Energy New Generation (NENG), Disruptive thinking, Problem-solving skill, Smart mobility

Introduction

Recalled the STEM education report, the Education Bureau of Hong Kong SAR, will keep impelling the renew and enrichment of the curricula and learning activities of STEM and allowing students to fully unleash their potential in innovation. It also stated that cross-disciplinary STEM learning activities are essential on producing synergies and make the learning activities become more effective.

VTC, as the quality Vocational and Professional Education and Training (VPET) provider, nurtures globally competitive individuals for the development of Hong Kong and the region. To inspire the young generation, STEM PBL project in IVE solar car team SOPHIE, and the New Energy STEM Generation campaign are established for promoting the STEM and develop their ability to integrate and apply professional knowledge, skills, and attributes (KSA), disruptive thinking, design thinking skills, and team management skills being applied in the smart city development, and the result showing that STEM give a positive influence to students.

STEM PBL project in IVE solar car team SOPHIE

Since 2010, the STEM PBL project – IVE solar car team SOPHIE is established by the Engineering discipline of Hong Kong Institute of Vocational Education (IVE), a member of the VTC Group, that focuses on the development of solar-powered vehicles.

Until now, the 6th generation solar car – SOPHIE VI, is released and remarking the 35th Anniversary of the VTC, team joining one of the international solar car race – World Solar Challenge 2017(WSC2017), with 30-year history. Over 40 teams from around the world, including teams with universities, institutes and industries representatives from UK, US, Asia, and Europe. Team completed the whole journey and received 3rd runner-up awards from cruiser class.



Pic.1 The SOPHIE team with SOPHIE VI on WSC 2017

To achieve the goals, the education of STEM PBL is no doubt plays a vital role in SOPHIE team development, and more is now being done to increase the student learning outcomes on facing the challenge. As a cross-disciplinary project, team consists of students from the electrical engineering, mechanical engineering, and graduates from the Hong Kong Design Institute (HKDI), brought together cross-disciplinary perspective and expertise in engineering and design. Team members are being inspired and making use of the design thinking and disruptive thinking skills to design an innovative and sustainable solar-powered vehicle so called "SOPHIE" to demonstrate the viability of a renewable energy through the green transportation and smart mobility application, under the smart city development. So far, from 2010 to 2017, over 2 hundred students directly participated in solar car design and fabrication works. With the Triple Helix Support, the project is fully-supported by industries, government and IVE. As the deliverable, task and context, students are motivated to develop the solar car based on their own knowledge and experience, and work on the research on problem-solving during the solar car fabrication, which including the solar power technology and advanced application, high tech automotive design and fabrication, team management practice and cooperation with industries on latest technology development. The vehicle 'SOPHIE' also allow students to learn by doing and applying ideas, that is the features of project-based learning (Blumenfeld, Fishman, Krajcik, Marx, Soloway, 2000), students tends to gain a deeper understanding of materials when they actively construct their understanding by working with and using ideas. Till now, 7 'SOPHIEs' were built under the massive effort of students. FOUR of them participated in 4 races under students' leadership, including SOPHIE SEM in "Shell Eco-Marathon Asia 2012"in Malaysia, SOPHIE IV in "World Solar Challenge 2013" in Australia, SOPHIE V in "World Solar Challenge 2015" in Australia, and recently SOPHIE VI in "World Solar Challenge 2017" in Australia.

Through each races, student have demonstrated their possibility on building solar-powered vehicles. Team allows students to apply the key Knowledge learnt in classroom or work out the research outside class, Skills and Attitudes (KSA) on designing and fabricating the solar car for races and showed their confidence and interest on solar car vehicle. These experience broaden their view in terms of problem solving, design concept and technology application, thus self-confident was highly enhanced. From that, it is shown that STEM PBL has positively influenced student's non-academic performances and match the result that STEM PBL showed positive attitudes toward learning itself, allowing effective feedback and reflection, and self and peer assessment (Howard Barrows, 1996). Furthermore, STEM PBL was examined with respect to incresing students' interest, self-confidence, and self-efficacy, which was highly related to the components of STEM BPL such as collaborations in group work and contextual problems reflecting students' real-world experiences.

In fact, design thinking process is also adopted to the team operation, the process is divided into five stages, including: Empathize, making use of Internet, Facebook, etc. and local visits to under the design challenges with effort to understand the way peoples doing similar projects and why, the needs are then identified; Define, through the empathizing stage, questions are uncovered and actionable problem statement of what needs to be built; Ideate, with the problem statement on hands, the team started to brainstorm and innovate on building the solar car; Prototype, these innovative ideas are realized by prototyping different parts of the solar car and were tested; Test, Improved version of these prototypes were put together for safe on road test (e.g. in campus parking lot), and to realize the target product is finally delivered, and the project outcomes are being demonstrated.

Workshop to secondary school

Received the positive resulting in STEM PBL project in IVE solar car team SOPHIE. Engineering discipline of Hong Kong Institute of Vocational Education (IVE) aims to inspire younger generation make use of their talents on the use of renewable energy and deepen their knowledge of engineering and the STEM subjects. To impel the transfer of knowledge, the New Energy STEM Generation campaign with SOPHIE team is formed for organizing a secondary school solar car racing challenge, and offer a series of NESG workshops on solar car technology to over 60 teams from local secondary schools students and provide students with board-based and deep engineering knowledge, skills, and value they need to build the

deliverables as solar car with efficiency innovation, disruptive thinking and problem-solving skills within months, and work out the solar car for secondary school solar car racing challenge. Deliverable including solar cars fabricated by the teams from secondary school after screening will have the opportunities for testing during the scrutineering and driving their solar car during the final competition. Team tasks including the worksheets, and technical submission will be required to submit by teams across the workshop session and are the important factor for screening process. Teams are required to perform the STEM subject knowledge, teamwork skill, disruptive thinking, design thinking skill, and team management skill on the competition.



Pic 2. Teams from secondary school on the scrutineering day in IVE (Tsing Yi) last year

The workshop introduces the basic solar car structure including solar panel working principle, energy conservation, mechanical system to the participants, with the real product demonstration, (i.e. SPOPHIE) and hands on a project of a small scale solar car model by divided them in group. From the workshop, it is observed that there are positive effects for students in content knowledge and attitude toward learning, the primary reasons are the workshop contains hands-on activities and field-based contexts. Moreover, students' problem solving skills are improved since STEM PBL were required to solve problems embedded in the project.

To measure the effect of series of workshops, the following survey are prepared for students on evaluating the pre-event and post-event, during the first and last workshops. 150 set of student survey are ddistributed for the pre-event and post-event session. Here below is the base info for students, including the gender, secondary school year, and learnt of STEM subject, and participation of STEM activities. Survey included the questions related STEM knowledge, and related score will be calculated to find out the ratio of change after NESG workshops.

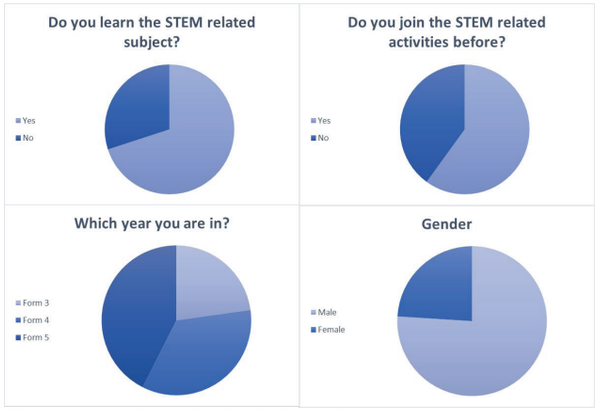

Figure 2. Students basic information being participated in NESG workshops

A set of pre-event and post event survey delivered to the participants, the results are in follow:

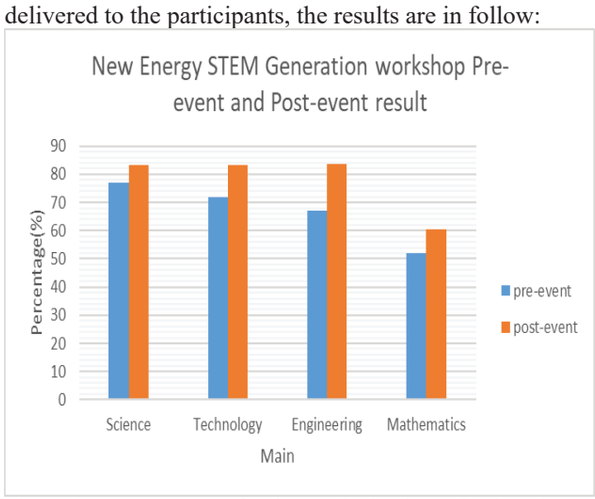

Figure 1. Survey score of Science, Technology, Engineering, Mathematics session under pre-event, and post-event

Result

	Science	Technology	Engineering	Mathematics
Pre-event: (%)	77.08	71.88	67.19	52.08
Post-event: (%)	83.33	83.33	83.59	60.42
Improved ratio: (%)	8.11	15.94	24.42	16.00

Table 1. STEM scores on pre-event, and post-event

The figures and the observation deliver that while STEM PBL was implemented, it is resulted in positive growth rate on students' achievement especially in technology mathematics and engineering scopes on table 1, with over 15% improved rate. Collaboration, group projects, ill-defined tasks, and student-centered environments are inter-relationally function with each other. STEM PBL activities benefitted students to have additional opportunities to communicate with peers and teachers than would traditional lecture. It is believed that the students who learnt/ joined the STEM related activities may also bring the reason of resulting.

Conclusion

The effectiveness of implementing STEM PBL in terms of improving students' STEM knowledge has not only demonstrated much improvement, but also improve their design thinking process. Founding of this paper assists teachers to rethink how to promote STEM to students out of the traditional classroom and how the STEM PBL varied the performance levels and benefit students from engaging in STEM PBL activities. STEM is an important key to nurture our next generation creativity, innovation, collaboration and problem solving skills for enhancing the international competitiveness of Hong Kong.

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GAMIFICATION PACKAGE FOR TEACHING AND LEARNING USING GAME-BASED AND STORY-BASED APPROACH

H.L. Woo[*,a], P.C. Leo Leung[**,b], S.Y. Tony Chan[c] and Dr. H.P. Joseph Leung[d]

[a,b,c,d] Information Technology Discipline, Hong Kong Institute of Vocational Education, Vocational Training Council, Hong Kong.

*lam681@vtc.edu.hk
**leoleung@vtc.edu.hk

Abstract

In the last academic year, two gamification packages for the teaching and learning on Mathematics and Programming were developed by the Information Technology Discipline at the Hong Kong Institute of Vocational Education, Vocational Training Council. The packages were designed with a digital game-based or story-based approach to engage the students to learn and enhance the students' learning experience and effectiveness.

The computer game in each of the developed packages has two modes: the story mode and the challenge mode. In the story mode, the student players will take part in a self-paced adventure for pre-class learning. In the challenge mode, the student players will do self-paced drills for post-class learning.

User feedback collection on the developed packages was carried out through an anonymous survey. The survey result was encouraging. It indicated that the packages were well received by the participants and the majority of them opined that the packages did motivate them to learn and enhance their learning experience.

In this paper, the ideas behind the design of the packages will be shared. The paper will also report the observations and findings from the survey taken by the students who have used the packages.

Keywords: *gamification, game-based, story-based, student engagement*

Introduction

Gamification is defined as the use of game design elements in non-game contexts (Deterding et al., 2011). It has been recently identified as a promising technique to improve students' engagement such that a positive effect could be obtained in the learning process (e.g., Ibanez et al., 2014; Connolly et al., 2012).

The Information Technology (IT) Discipline at the Hong Kong Institute of Vocational Education, Vocational Training Council (VTC), has developed two gamification packages for the teaching and learning on Mathematics and Programming to engage the students to learn and to enhance the students' learning experience and effectiveness.

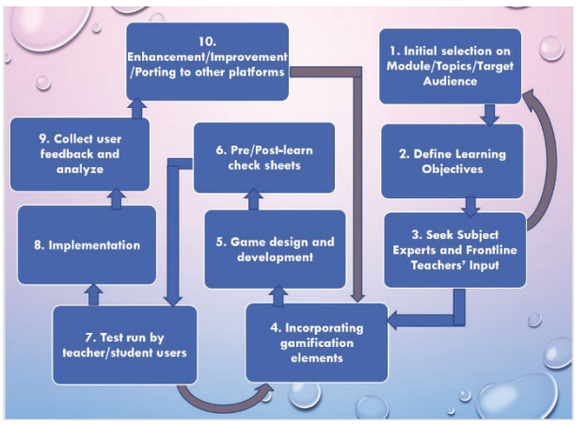
Background

The first package developed is for teaching/learning Mathematics. All the students studying the Diploma of Foundation Studies (DFS) Programme of all Disciplines at the Hong Kong Institute of Vocational Education, VTC, need to take the module "Foundation Mathematics". The module requires the understanding of abstract concepts and the mastering of complicated arithmetic and problem-solving skills. Weaker DFS students normally would find difficulties in studying this module. Some educational researchers (e.g., McLaren et al., 2017) commented that the investigation on the ways to inject the learning of traditional subjects, like Mathematics, into computer games had only begun recently. We therefore made this attempt.

The second package developed is for teaching/learning Programming. DFS students of the IT Discipline are required to learn the VB-Programming Language in the Programming module. Computer programs and algorithms are abstract and complex entities. This made the teaching/learning of programming difficult, especially for novice or weak students (e.g., Olsson, Mozelius & Collin, 2015; Guzdial & Soloway, 2002; Lahtinen, Ala-Mutka & Jarvinen, 2005). We therefore made this attempt.

Development Workflow

The following diagram summarizes the development workflow so that feedback from various stakeholders will be incorporated at various stages.



Delivery Pattern

There is a teaching and learning package (TLP) with teaching materials such as lecture notes, tutorials, etc., for each module offered in the VTC. The TLP was developed when the module was introduced and refined gradually by the module teachers. The gamification packages to be developed are designed not to replace but to be integrated into the existing TLPs in a way that the computer game has two modes: story mode for pre-class activities and challenge mode for post-class activities. It is suggested to the module teacher that the gamification package be used along the following line of flow.

(A) Before the Lesson

We have adopted some of the ideas proposed in the "Flipped Classroom" or "Flipped Learning" (e.g., Bergmann & Sams, 2012; Sams & Bergmann, 2013; Tucker, 2012). Students are expected to have some pre-class learning before coming to the class. To encourage the students to do so, we have developed the story mode so that the students when playing the computer game will have at the same time a brief touch on the topic that is going to learn. Learning elements like animations or tutorial clips with examples are included along the game play.

(B) During the Lesson

We suggested the module teacher to begin each class with a small start-up exercise to check how much the students have prepared/learned from the pre-class story-mode game play. The start-up exercise contains only very simple questions. Sample worksheets of this exercise are included in the gamification package. The exercise serves only as a lead-in for the teacher to start the topic. Marks obtained from this exercise will not be counted in the assessment. It only serves as a stimulation to encourage those students who have not done any pre-class preparation to do it next time.

(C) After the Lesson

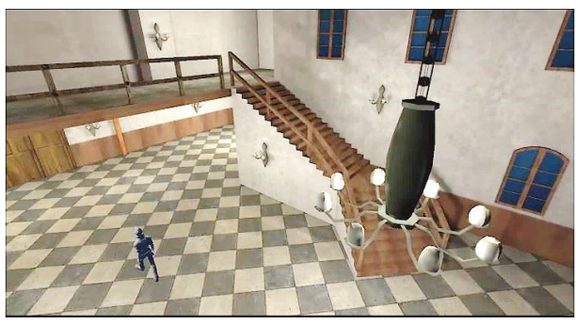
Students are encouraged to have repeated drills on the topic they have just learned by playing the Challenge-Mode of the computer game. A leaderboard is provided to show all participants' performance of the game play. This is one of the gamification elements we adopted to provide a platform for students to have positive competition among peers so as to engage them to play more and play better, which actually means practise more and learn better.

Description of the Games

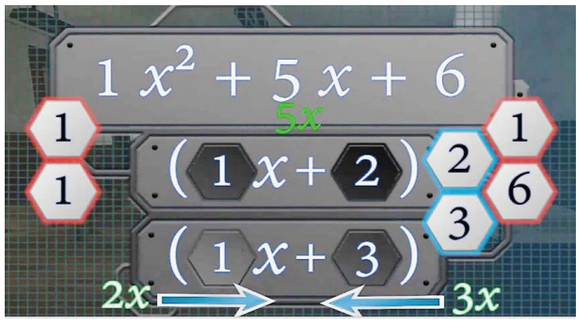
(A) MatheMonster - developed for teaching/learning Mathematics.



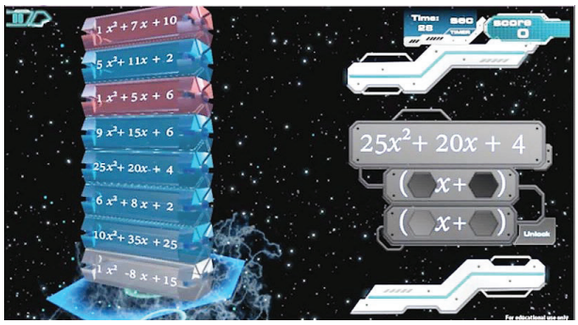
The story mode of the game is a 3D adventure game based on a scenario with the Second World War as the background and aliens are involved and have plans to conquer the world. The game player has to collect props to fight against the aliens in his adventurous journey.



Mathematics problems will be encountered at some point of the game.



The challenge mode of the game provides drills on the mathematics topics covered which have to be completed in a certain limit of time.



(B) GhostCoder – developed for teaching/learning VB-Programming.

The story mode of the game is a 2D story-based game in black comedy style. The game player follows the storyline is like reading a story book. Abstract concepts of programming and algorithms are introduced throughout the story.



The challenge mode is a turn-based card game. The player's hand (i.e., the set of cards that the player holds) will only be effective when relevant programming codes are completed on the card.



Design Strategy

Game-based learning uses an actual game to teach knowledge and skills. A learning game is a self-contained unit with a definitive start, game play and ending. Learners know that they are engaged in a game activity, and at the end there is a "win state". On the other hand, gamification uses a few game elements. Learners do not play an entire game from start to finish; they participate in activities that include video or mobile game elements such as earning points, overcoming a challenge or receiving badges for accomplishing tasks. (Kapp, 2014).

The design of the two developed packages employed a mixed strategy. The computer game has two modes: story mode and challenge mode. In the story mode, the digital game is of an adventure style which engages the player to continue digging in the adventure, which means at the same time more learning contents could be delivered to the player (learner). In the challenge mode, game elements such as posting a score to the leaderboard, earning points and badges, are incorporated to engage the player to keep on playing, which means keep on drilling.

We think the strategy adopted is appropriate. On one hand, a pre-class preparation in Story-Mode is effective in the learning process, especially for subjects with the content of abstract concepts. On the other hand, a post-class drilling in Challenge-Mode is useful in the learning process, especially for subjects where reinforcement and repeat practising would be helpful.

User Feedback Collection and Analysis

The two packages were tested by a few hundred students in this academic year and user feedback was collected by anonymous surveys which adopted a 5-point response scale from 1 (Strongly Disagree) to 5 (Strongly Agree).

The table below shows the average score of the responses to each question for the two packages.

(MM-MatheMonster; GC-GhostCoder)

Survey Questions		Average Score	
		MM	GC
Q1	Digital game-based learning software motivates you to learn	3.5	3.6
Q2	Interactive game elements and visual/audio effects can help you understand abstract concepts	3.5	3.6
Q3	Story-based learning engages you to learn	3.6	3.5
Q4	Challenge-mode provides a good way of drilling	3.6	3.6
Q5	The software provides good means of self-paced learning	3.5	3.5
Q6	The software enhances your learning experience	3.6	3.7

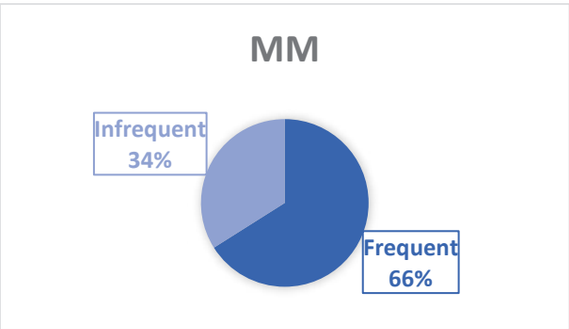
The average scores obtained by both packages were similar. Users in general agreed that the packages did motivate them to learn and help them understand.

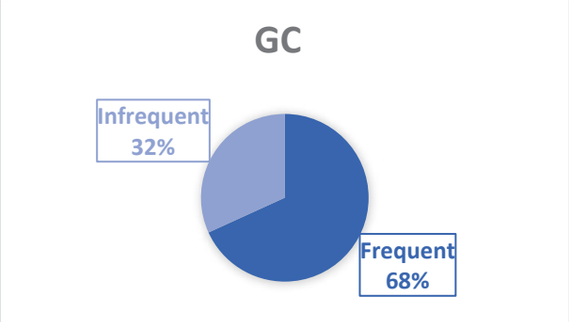
The table below shows a further breakdown that the percentage of responses with 4 or above and with 3 or above were summarized. The results show more than or close to half of the respondents responded agree or strongly agree (4 or above) in most questions. This demonstrates that both packages were quite well received by the respondents. A great majority of the respondents opined that the packages did motivate them to learn and enhance their experience.

(MM – MatheMonster; GC – GhostCoder)

Questions	% of responses with 4 or above		% of responses with 3 or above	
	MM	GC	MM	GC
Q1	49%	51%	86%	88%
Q2	52%	56%	84%	89%
Q3	57%	51%	85%	85%
Q4	54%	55%	87%	87%
Q5	48%	49%	82%	86%
Q6	54%	58%	87%	89%

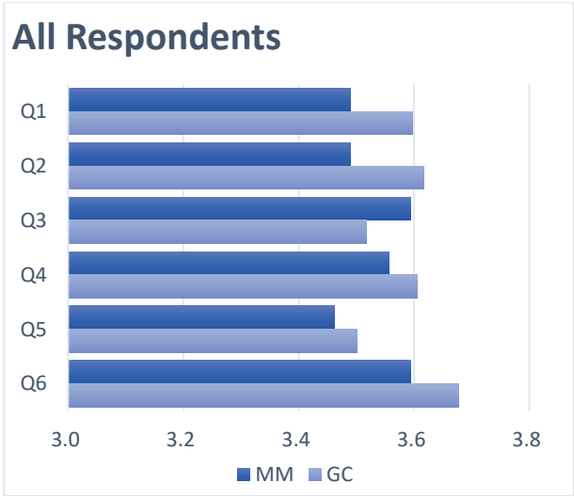
In the survey, we asked the respondents how many hours they would play on computer games per day. We adopted a definition that for a person who used to play three or more hours per day for computer games the person would be classified as a frequent computer game player. The distribution of frequent and infrequent game players in the surveys for the two packages can be found in the following charts

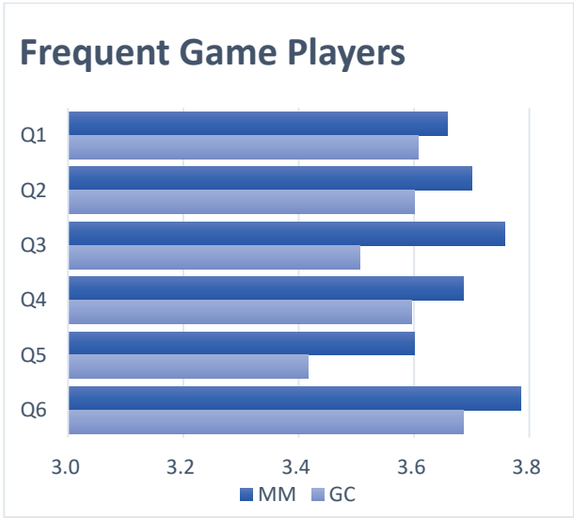


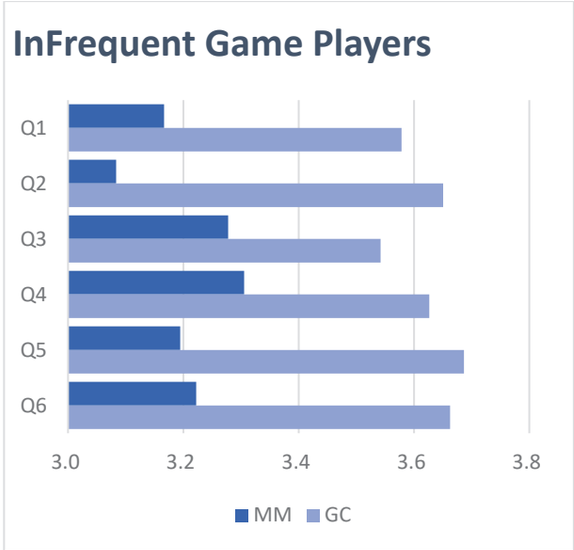


The surveys for both packages have about one third of respondents who are infrequent computer game players.

Interestingly, when the responses from frequent and infrequent computer game players are separately counted, some interesting differences could be observed which are summarized in the charts below.







For the package GC, the responses from frequent and infrequent computer game players are alike. But for the package MM, the responses from frequent and infrequent computer game players look quite different.

The story mode of GC is a 2D story-based game. The game player follows the storyline is like reading a story book. The challenge mode is a turn-based card game. This genre of game and presentation style shows no obvious difference to frequent and infrequent computer game players. The user control interface is also simple and straightforward. While the story mode of MM is a 3D adventure game. Infrequent computer game players need time to get used to this genre of game and presentation style (such as first-person subjective lens view). The user control is also relatively complex. We believe this is one possible reason that accounts for the difference.

Evaluation on Effectiveness

Evaluation on the effectiveness of the package MM was performed by using pre-test and post-test for a few selected classes. The questions in the pre-test and post-test were the same. The full mark of the tests was 10. The distribution of marks in the two tests are summarized in the following tables.

Result (Overall Average):

	Pre-Test	Post-Test
Average	2.96	4.12

Result (by Category):

Category	Pre-Test	Post-Test
A (8-10 marks)	28%	28%
B (6-7 marks)	0%	4%
C (4-5 marks)	4%	12%
D (0-3 marks)	68%	56%

Performance (by comparison of marks):

Comparison of Marks	Remarks	Percentage
Post-Test > Pre-Test	Getting Better	60%
Post-Test = Pre-Test	No Change	40%
Post-Test < Pre-Test	Getting Worse	0%

In general, the result shows that the package helped the students to get improvement.

Conclusion and Future Work

The user feedback of the two developed packages is encouraging. The participants opined that teaching and learning using gamification approach and the use of animations or visual/audio means are helpful for them to understand abstract concepts. In the coming academic year, the two packages MM and GC will be fine-tuned with the input from end users to be taken into consideration and formally delivered.

Gamificiation is best used for subjects that require reinforcement over time (Kapp, 2014). Kapp also suggested to have a structure and a framework to participate in the gamification effort and not simply a "bolt on" of meaningless, superficial game elements. In our future development, the direction of design strategy of adopting a mixed strategy of incorporating gamification elements into the teaching and learning package and at the same time introducing game-based or story-based elements into the content for student engagement is worth keeping on. The framework of using story mode to engage students' pre-class learning and challenge mode to engage the students' post-class drilling will be continued in the games to be developed.

There will be an extension to GC that the contents in package will be modified for teaching the Java Programming Language for the Programming module offered in the Higher Diploma (HD) programmes. The IT Discipline also has plans to work on building new gamification packages for a Networking module and a Database module for the HD Programmes.

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FOSTERING 'PROFESSIONAL LEADERS' WITH INTERNATIONAL COMPETENCY THROUGH THE 'GECEP': AN ATTEMPT BY THE NATIONAL INSTITUTE OF TECHNOLOGY, NARA COLLEGE

Yoshiaki Matsui [a], Kazuhiro Itakura [*b]

[a] Professor, National Institute of Technology, Nara College, Japan
[b] Specially Appointed Assistant Professor, National Institute of Technology, Nara College, Japan

* kitakura@libe.nara-k.ac.jp

Abstract

The National Institute of Technology, Nara College, which is the only institution for higher-education in the field of engineering in Nara Prefecture, Japan, is required to foster 'professional leaders' with international competency. For this purpose, Nara College launched its Global Education Center (GEC) in April 2017. Further, this organizational reformation attempts to respond to the growing local demand for "global engineers". In this 21st-century society, concepts like "diversity and inclusion" have important implications; moreover, social mobility is increasing at a fast rate. Consequently, the work environment is undergoing extensive changes. Modern workplaces encourage an environment that fosters diversity and inclusion and enable individuals from various backgrounds and with different identities to collaborate on creating innovative solutions. In this context, the GEC was inaugurated as a central body to promote global education and initiate the expansion of a global network in Nara College. In addition, the GEC developed the Global Engineering Collaborative Education Program (GECEP) for nurturing engineers with a global perspective. The special educational program GECEP offers students special courses to acquire the fundamental skills that are required for working in a global environment. The GECEP consists of two (basic and advanced) courses and sets down three basic skills for a global engineer ("good English communication skills", "cross-cultural understanding", and "global communication skills in a specialized field"). In addition, this program targets the development of Solution, Publication, Identity, and Collaboration skills in students by enabling them to experience collaborative project work with foreign students coming from diverse cultural backgrounds. We intend to give a presentation on our efforts for promoting global education, achievements, challenges, and future endeavors toward the development of a local knowledge base of global standards.

Keywords: global education, global engineer, cross-cultural understanding, student exchange, active learning

1. Introduction

As social mobility has increased from globalization, the demand for "global engineers" who can freely communicate with people from various cultural backgrounds and build trusting relationships is growing. As the movement of global human-resources expands, manufacturing that had previously been handled by highly homogeneous groups has been forced to change. The National Institute of Technology, Nara College, launched its Global Education Center (GEC) in April 2017, with the aim of fostering global engineers and promoting global education at our school, premised on the notion that these activities are an important educational mission in today's society[1]. The GEC is a central organization of global education at the National Institute of Technology, Nara College, which was newly established through the integration of three committees on international exchange, English education, and international student guidance. The steering committee includes faculties elected by each of the five-departments, and it is a central body that promotes global engineer training in Nara College. Today, under the GEC's initiative, we are collaborating with overseas institutes, especially in the Asian region, and neighboring universities in Nara Prefecture, to promote and expand overseas student dispatch and the overseas student acceptance program. Also, the GEC are overseeing the operation of a special education program. The programs related to global education that are developed under the leadership of the GEC are positioned as one of several significant attempts toward the specialization of education at Nara College, similar to initiatives related to training for "female engineers". Here, we report on various activities related to training global engineers that have been undertaken by Nara College through the "Global Engineering Collaborative Education Program".

2. Contents of GECEP

The "Global Engineering Collaborative Education Program" (GECEP) is a special extracurricular education program conducted by the Global Education Center to train global engineers. The program has established the cultivation of "global professional leaders" as an educational goal. In this program, we set down three basic skills required for global engineers as follows: A. "good English communication skills", B. "cross-cultural understanding", and C. "global communication skills in a specialized field". From that point on, we support the development of four specific skills from a global perspective: Solution; ability to solve problems, Publication; ability to transmit research results, Identity; identity and originality, Collaboration; collaborative research and work ability (SPIC). We aim to train professional leaders who can lead innovation in the international community. To achieve this objective, we established the GECEP Basic Program for the five-year basic course students and the GECEP Advanced Program for the advanced course students. Because it is a program aimed at nurturing global professional leaders who embody the above four abilities, students are required to participate in exchange programs with overseas institutions (e.g. participation in overseas training programs), or, for students in advanced courses, to give presentations at international conferences. Also, students are required to take special courses to improve their global SPIC skills. The program started in April this year. Currently, twenty first graders are registered in the Basic Program, and nine advanced course students are registered in the Advanced Program.

3. Achievement goals and subject composition of GECEP

The goal of each of the three basic skills is as follows. First, with regard to "good English communication skills", we aim for students to achieve the following goals by the time they complete the program.

(Basic Program)
A-a: You can generally understand the flow of speech and discussion about familiar topics.
A-b: You can read and understand English sentences about familiar topics without using a dictionary.
A-c: You can actively participate in conversations about familiar topics and express your own ideas based on your interests and experiences.
A-d: You can give an English presentation while referring to prepared documents in advance.

(Advanced Program)
A-e: You can understand the speaker 's intention about the topics of contemporary society and specialized fields spoken at natural speed.
A-f: You can read necessary information and arguments from papers and materials in your specialty field.
A-g: You can participate in a conversation on a wide range of topics, and can logically express your own ideas.
A-h: You can give an English presentation based on the manuscript, and also respond to questions to some extent.
A-i: You can write an English essay according to the logical order of your specialty field and areas of interest.

Next, with regard to "cross-cultural understanding", we assume that "attitude", "knowledge", "skills" are three key components in a person's ability to nurture an understanding of different cultures[2]. Students are required to achieve the following goals.

(Basic Program)
B-a: Attitudes: Attitudes such as "susceptibility to culture", "tolerance to ambiguity", "respect for different things" are concerned.
B-b: Knowledge: You can understand and explain the basic aspects of "social product and lifestyle", "religious beliefs", "sense of values", and "attitude" in Japan and foreign countries.
B-c: Skills: You can interpret different cultures in relation to your culture, and analyze the values of unknown cultures and have the ability to accept them.

(Advanced Program)
B-d: You can practice the above three components in nurturing an understanding of different cultures and exchange opinions with others from a global perspective.

Finally, with regard to "global communication skills in a specialized field", we aim for students to achieve the following goals at the end of the course.

(Basic Program)
C-a: You have basic knowledge on mathematics and the natural sciences, and you can apply them to solving problems in your specialty fields.
C-b: In order to solve the problem of your specialized engineering field, you can use the knowledge of the specialized field. You can also solve the problem related to multiple technical fields by understanding the principles in your own field of specialization and applying them to the resolution of problems.
C-c: By using technical terms, mathematical formulas, units etc., you can freely conduct basic communication in English related to your specialized field.
C-d: You can make brief oral presentations in English, and you can also provide a summary of research in English, which consists of hundreds of words.
C-e: You can understand the importance of subjective actions and actively exert your own ability to improve the situation in your surroundings.

(Advanced Program)
C-f: You can combine various types of knowledge related to specialized engineering to tackle issues and consider the influence of that knowledge on society.
C-g: You can make oral presentations in English about your subject area and answer questions, and you can also write an English essay of a few pages.

C-h: You can collate your position with your surrounding situation in more diverse environments and promote work by taking subjective actions.

In order to achieve the above objectives, GECEP provides the following extracurricular subjects.

(Basic Program)
-English Active learning I, II: self-learning through e-learning (Relevant goals: A-a, -b, -c, -d)
-Global Communication: Project-type learning, presentations, and discussion in English (A-a, -b, -c, -d)
-Cross-Cultural Exchange: Participation in short-term overseas students' acceptance program, Presentation at the report meeting (B-a, -b, -c)
-Overseas Training: Participation in overseas dispatch programs (assumed that exchanges are made in languages other than Japanese)
Length must exceed 5 days - 30 hours (equivalent to the hours entailed in 15 classes) or more. (B-a, -b, -c, C-e)
-Global Challenge: Participation in the GEC organized events or seminars
The GEC provides students with 15 opportunities for practice to audit English presentations or lectures.
(A-a, -b, -c, B-b, -c, C-b)
-Global Engineer Skills: Lectures and exercises for developing English proficiency in specialized fields (e.g. reading of scientific technical papers and equipment manuals) (C-c, -d)

(Advanced Program)
-Advanced Global Communication: Project-type learning, presentations and discussions in English (Relevant goals: A-e, -f, -g, -h, -i)
-Advanced Global Engineer Skills: Lectures and exercises for English language proficiency training in specialized fields (e.g. Reading English tech-scientific texts, writing short letters in English on special research) (C-f, -g)
-Overseas Internship: Participation in educational programs related to specialized fields for over 10 days - 80 hours (equivalent to the hours entailed in 40 classes) at overseas polytechnic, university etc.
Presentation at the report meeting (B-d, C-h)
-Advanced Global Challenge: Preparation for presentation in English at the international conference and learning about basic presentation etiquette
Presentation at the international conference is required as a condition for credit completion.
(A-f, -g, -h, B-d, C-g)

To complete the Basic Program, students must complete all credits of courses provided in the Basic Program and maintain the average value of JASSO-GPA, which requires first to fifth graders to achieve 2.3 or higher for regular curriculum[3]. For the Advanced Program, students are required to complete all courses (other than elective compulsory courses) provided in the program and achieve an average score 80 or more in all courses taken as part of the regular curriculum. In addition, as a measure to ensure that students are able to give priority to the achievement of learning goals in the regular curriculum, conditions for continuation of the program are established. In the Basic Program, it is a condition for continuation in the program that the total average score of the grades from the regular curriculum, including elective subjects, is 70 points or more. Therefore, if the total average points at the conclusion of the grade are less than 70 points, students will not be able to enroll in that following year's program. However, for a situation in which the total average of the grade results is 70 points or higher in the following year or after, students can resume their participation in the program in the following year.

4. Examples of educational practice

I would like to introduce the contents of 'cross-cultural exchange', which is one of the GECEP subjects. These are activities of the short-term overseas students' acceptance program that were undertaken before the establishment of the Global Education Center. This program became a new elective subject in Nara College this year. Now, all regular course students are able to participate in the program as one of their elective subjects. Here, we will report on the activities and accompanying aims to be carried out within the course, focusing on international exchange activities with Singaporean Polytech students conducted every March beginning in 2009.

Approximately 20 to 30 students participate each year in the acceptance program, and 23 students participated in acceptance activities in March of this year. The following is a brief course schedule of various activities related to international exchange activities conducted in March 2018. The course was held from December to April.

Lesson 1: Course guidance
Lesson 2-4: Special lectures and workshops
Lesson 5-9: Preparation activities
Lesson 10-13: Acceptance activities
Lesson 14: Preparation for report meeting
Lesson 15: Presentation at Report meeting

Participating students began preparation activities before the arrival of Singaporean students. This time, the meeting was held about once a week beginning 2 months ago and preparations were initiated. In preparatory activities, it is becoming standardized to work on a group basis. We created three groups to introduce Japanese culture, the school profile, campus life, and to play ice breaking games. We conducted rehearsals in advance and discussed opinions among students to improve the contents. A faculty member of the English department also participated in this rehearsal. The English teacher provided opportunities for students to receive guidance and advice on technical aspects, such as whether words are correctly pronounced and whether speakers are aware of audiences' attention. As the activity became an elective subject as 'cross-cultural exchange', we held a 'cross-cultural understanding workshop' as a part of the lecture on the subject. In the workshop held last December, two international students studying in their

five-year regular course in Nara College gave presentations about their country (Mongolia, Malaysia), and two teachers in charge of the course also lectured on their respective specialized areas (Thailand and India). The workshop was held with the aim of learning about foreign cultures and society and providing students with the opportunity to acquire a wide range of cultural knowledge that we believe is necessary for global engineers. Also, we intended to provide an opportunity to students, other than classmates and dormitory students, to build friendships with international students.

During the exchange program, it is becoming a standard to conduct campus tours in addition to presentations and games by students. On the campus tour, visiting students tour each department and facilities of our school and learn more about the characteristics of education. The primary objective of this activity is to prepare English manuscripts to introduce Nara College to visitors. However, it seems that this leads to rediscovering the charm of the school for our students at the same time. Apart from activities in school, the program includes companies and factory tours in Nara and neighboring prefectures, as well as visits to cultural heritage sites. These activities are aimed at giving overseas students the opportunity to learn about Japan's technical capabilities, skilled technologies, and the temperament of Japanese engineers, who provide support. Furthermore, we aim for them to discover "Japanese sensibility" which is part of the tradition of Japanese culture. Conversely, it is expected that Japanese students will also be able to rediscover the cultures and traditions that should give them a sense of pride, and their own Japanese sensibility, by conducting cultural visits with overseas students.

In the exchange activities with Singaporean students that we have had so far, an understanding of different cultures and intercultural exchange are central to the program. In another program, the Hong Kong IVE student acceptance program, which started in 2016, project work is included which is not part of the winter program. This is a new initiative to encourage Japanese and overseas students to acquire more practical English communication skills through collaborative work during which they use English. In the past two programs, we held a workshop on 'Robotics and Disaster' and 'How to take action for environmental conservation'.

5. Reflection

By actively participating in acceptance activities at an earlier age and in a lower grade in school, students seem to be able to overcome their sense of resistance towards endeavoring communication using English through exchanges with overseas people who cannot speak Japanese at all. Among faculty members who have been mainly involved in the international exchange activities of our school, it seems that one idea that is shared in common is to encourage students with abundant experiences related to international exchange to participate in the overseas dispatch program. Meanwhile, a lot of students have decided to participate in acceptance activities considering participating in the dispatch program in the future. Participation in acceptance activities is a precious opportunity in which students can practice their English communication skills using the knowledge of English they have learned in the classroom. Although problems can be observed in terms of English ability, at the same time, we observed that students developed the ability to actively use English to communicate without being afraid of overseas students, as their friendships with overseas students deepened. Also, through the activities, students could notice that there is a problem with their lack of English vocabulary and listening skills. It seemed that their recognition of this fact subsequently led to the motivation for English learning.

We also provide opportunities for participants to talk about their activities for other students and write activity reports to be posted on the website of the Global Education Center to send their experiences to the outside. It is expected that international exchange activities will be acknowledged by many of those inside and outside of the school and that the participation of the students will become more active, through which global education will come to be recognized as one of Nara College's defining characteristics.

Notes

1. Training of engineers who can be active globally is regarded as an important issue for the entire National Institute of Technology as mentioned in its third mid-term targets. (http://www.kosen-k.go.jp/disclosure.html#mokuhyo_keikaku)
2. For these three components, we refer to Byram's model on "Intercultural Communicative Competence" (Byram 1997).
3. Regarding Jasso-GPA, see below.

JASSO-GPA Formula

$$\frac{([\text{No. of GP3 Credits}] \times 3) + ([\text{No. of GP2 Credits}] \times 2) + ([\text{No. of GP1 Credits}] \times 1) + ([\text{No. of GP0 Credits}] \times 0)}{\text{Total Number of Registered Credits}}$$

GP=Grade Point

Correspondence table between the end of the school year scores and JASSO-GPA point

Evaluation	Excellent	Good	Fair	Failing
Year-end Score	100～80	79～65	64～60	59～0
JASSO-GPA Point	3	2	1	0

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INTRODUCING ARTIFICIAL INTELLIGENCE FOR CYBERSECURITY THROUGH PROJECT-BASED LEARNING

Peter Leong*,a and Calvin Siak a

a Singapore Polytechnic/DMIT, Faculty, Singapore

*peterleong@sp.edu.sg

Abstract

Artificial intelligence (AI) has gained prominence over the last few years. The field of AI is not new; in fact it has its roots in 1956. It soon became apparent to the researchers that they had underestimated the difficulty of creating intelligent programs given the limitations of computer hardware at the time. Fast forwarding to 2018, the computing hardware available has vastly improved. There are huge amounts of data being collected by the Internet and mobile applications. In addition, large amounts of computation power are available on demand through cloud computing. All these three factors have led to a growth in AI applications. The World Economic Forum (WEF) as well as governments around the world have predicted that AI would bring disruption into many industries. Future professionals for smart cities must also be ready for an AI pervasive workplace.

In the Diploma in Infocomm Security Management (DISM), we had not introduced a module on AI. There a two key reasons for this. It has long been assumed that a topic such as AI would be beyond the ability of students at the diploma level. There was also some resistance from the students as they could not see the relevance of AI to cybersecurity. In the last two years, innovative AI cybersecurity companies, such as Darktrace, have removed some of the concerns about relevance. To overcome the two hindrances, we have started introducing AI into the course through project-based learning.

In this paper, we will describe our experience with using project-based learning to introduce AI into a cybersecurity course. The first is an independent study project, where AI or machine learning was used to detect malware in collection of binary executable files. The second project involved a group of final year students using Robotic Process Automation (RPA) and AI to detect the presence of web attacks. We have identified several knowledge gaps that prevented students from fully understanding the advantages of AI and also the weaknesses in AI. We are currently studying the scaffolding we need to include for such projects in the future.

Keywords: *Artificial Intelligence, Machine Learning, Cybersecurity, Project-based learning*

Introduction

Artificial Intelligence (AI) has gained prominence over the last few years because of novel applications of AI (Russell & Norvig, 2009) in the financial sector (algorithmic trading), in transportation (self-driving cars and trucks), in retail (predicting customer preferences and providing personalized recommendations), and even in government (optimizing use of government resources)(Harvard Business Review, 2018). The growth of AI has been fuelled by three factors: (1) better computing hardware, (2) availability of big data, and (3) on-demand cloud computing power.

Computing hardware has improved many fold since the pioneering days of AI in the 1950s. The original goal of AI was to create computer programs that could simulate intelligence behaviour that would be indistinguishable from that exhibited by an intelligent human. The researchers originally thought it could be accomplished in a few short years. However, they underestimated the difficulty of the tasks and were hampered by the computational power available in their day. Fast forwarding to 2018, the already massive computational power of today's processors (CPU) can be further augmented by thousands of parallel computational units found within each Graphics Processing Unit (GPU)(Bengio, 2009).

The second factor that has led to an "AI Spring" is the availability of large amounts of data from devices, applications and sensors. This large volumes of data has been termed as big data. Big data is difficult, if not impossible, to use without AI (Goodfellow et. al., 2016) techniques to sift out and extract useful knowledge from it. AI helps to identify patterns that would not be recognized by human eyes. AI is able to group similar data together and detect anomalous behaviour (Goel, 2011).

The third factor is the availability of warehouse-sized computers to organizations and individuals' on-demand through cloud service providers (Patil et. al., 2017). Many cloud service providers are providing computation-intensive virtual machines that have GPU accelerated processing capability. Improvements to hypervisors have enabled GPUs to be virtualized such that its computing resources can be shared by several virtual machines running within the data centre.

Motivations

AI has found many applications in the area of cybersecurity ranging from malware detection, to user-entity behaviour analytics (UEBA), and threat intelligence. However, in the Diploma in Infocomm Security Management (DISM), we had not introduced a module on AI for the students.

There a two key reasons for this. It has long been assumed that a topic such as AI would be beyond the ability of students at the diploma level. There was also some resistance from the students as they could not see the relevance of AI to cybersecurity. In the last two years, innovative AI cybersecurity companies, such as Darktrace, have removed some of the concerns about relevance.

To overcome the two hindrances, we have started introducing AI into the course through project-based learning. In so doing, we have two-fold objectives. The first is to understand some of the gaps in the student pre-knowledge that need to be addressed (Steeg, 2013) before they embark on learning AI. More specifically, we were especially concerned that students at the diploma level may not have the basic mathematical background to facilitate their understanding of AI. In addition, students may need to use software programming tools such as R or Python libraries which could be new to the students. The second objective is to understand what learning strategies (Blumenfeld et. al., 1991) would be most effective and any necessary scaffolding that should be included to facilitate student learning.

Approach

Our approach is to introduce AI into the course through project-based learning. The first project we selected was an individual project. It was a project for the independent study module (Brown, 2002). This students taking this module are those with higher ability. In this particular project, the student assigned, LKM, had expressed his own personal interest in AI before embarking on the project. Each independent study project has a project supervisor/tutor assigned to student. For assessment, the supervisor and a second examiner would conduct two assessments. One assessment is conducted mid-way through the project and the other final assessment is conducted at the conclusion of the project. The project scope was defined by the supervisor. For this project the scope was defined to be investigating the use of machine learning to detect malware in executable binaries. Students doing the independent study module have to be self-directed in their learning. The supervisor assigned would only provide some guidance or coaching if the student gets stuck during some stage of the project. Student have to find their own learning resources and conduct their own research. No scheduled tutorial or class time is provided to the student with the supervisor.

The second project selected was a group project involving a team of 5 students. This project is for the capstone project module (which we name the final year project or FYP). The project scope is defined by the project sponsor and not by the team itself. The project scope assigned to the FYP team is to investigate the use of Robotic Process Automation (RPA) and Cybersecurity for detecting website defacement. For this problem statement, the students were asked to investigate the use of AI techniques to detect defacement of websites from the visual snapshot instead using a signature-based approach on the HTML and JavaScript files. This is to avoid false positives where to content has modified intentionally. In particular, in dynamic web sites where content is changed frequently it is difficult to detect defacement using a signature-based approach. For assessment of the FYP, one assessment is conducted one-third (1/3) way through the project and the other final assessment is conducted at the conclusion of the project. The students do not define their own scope for the project, but they are responsible to do their own independent research and obtain suitable learning resources to understand the scope better. For the FYP project, the approach is more structured than the independent study project. There is scheduled class time for the supervisor to meet with the project team on a weekly basis. However, supervisors do not provide additional teaching to the students. The supervisor's role is to ensure the project follows the timeline. For the FYP project, the students are required to adhere to an Agile Methodology for project management.

Tools

AI can be implemented in a number of programming languages including Python (Numpy, 2018), C++, Java, Lisp, Prolog, Clojure (Lisp like), JavaScript, and R. We have decided to use Python (Pandas, 2018) as the programming language for the projects. This is because Python has gained adoption for many machine learning (Scikit-learn, 2018) and deep learning tools (Keras, 2018). In addition, Python is also suitable for Big Data, which an important driver for AI. There are Python libraries for Hadoop and Spark Big Data platforms.

For development and rapid prototyping, the Python Jupyter notebook allows for integration of documentation, graphs, tables and Python code seamlessly. It provides a common language for different developers to share code, data and algorithms. Notebooks can be shared with others using email, Dropbox, GitHub and the Jupyter Notebook Viewer.

The Jupyter Notebook is an open-source web application that allows students to create and share documents that contain live code, equations, visualizations and narrative text. Uses include: data cleaning and transformation, numerical simulation, statistical modelling, data visualization, and machine learning. The students' code can produce rich, interactive output: HTML, images, videos, LaTeX, and custom MIME types (see Figure 1).

It is possible to configure the Jupyter Notebook server as a public server such that multiple users can connect to it and share notebooks from the same public server. There are public servers available such as the notebook viewer server, NBViewer (nbviewer.jupyter.org/) which allows users to view (but not edit) the notebooks shared by other

students. This also allows students to display a portfolio of their work to the public.

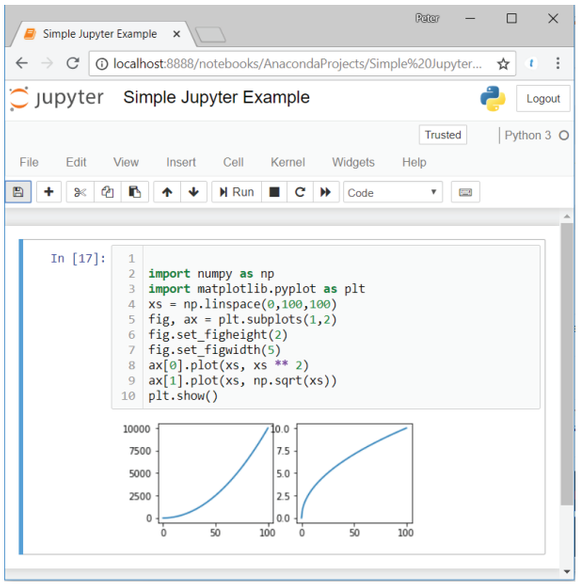

Figure 1. Python Jupyter Notebook

Both the project students used the Python library Tensorflow (www.tensorflow.org). TensorFlow (Tensorflow, 2018) is a mathematical library that contains routines to make it easier to implement machine learning algorithms such as neural networks and deep learning. In addition, higher-level APIs such as Keras (www.keras.io) enable deep-learning architectures such as convolutional neural networks and recurrent neural networks to be implemented conveniently. The students ran most of the TensorFlow experiments on their own laptops. However, the FYP project students also ran the TensorFlow model training process on cloud services because the training process took hours on their own personal laptops for the larger snapshot images of web pages that they were using. Data preparation of the images was done using the Python Pillow library (python-pillow.org) which is a Python based imaging library.

Another Python library that the students were able to use is the scikit-learn (scikit-learn.org) machine leaning library. Data wrangling is done using the Pandas library (pandas.pydata.org) and matrix / vector operations with Numpy (www.numpy.org). In addition data visualization used the python plotting library Matplotlib (matplotlib.org) or Statistical Data Visualization library Seaborn (seaborn.pydata.org/)

Training the computationally intensive deep learning models on the students' laptops took long periods of time if the training data were large. For example, using 1024x768 sized snapshots of the web pages as training data resulted in 2 hour long training periods on the student laptop. As students have to use their laptops for different classes at different venues, they often could not complete the training cycles in time. Aborting the training, meant restarting the training epoch from the beginning again later.

There are several cloud providers that provide cloud services suited for machine learning and for TensorFlow. Google provides the Cloud Machine Learning Engine (cloud.google.com/ml-engine). Amazon AWS provides support for TensorFlow using the Amazon SageMaker (aws.amazon.com/tensorflow/). On the Microsoft Azure Platform the Data Science and Deep Learning Virtual Machines (DSVM) supports running TensorFlow and other machine learning tools (azure.microsoft.com/en-us/services/virtual-machines/data-science-virtual-machines/). There are smaller cloud providers that offer GPU accelerated virtual machines (VM) such as Nimbix (www.nimbix.net/cloud-computing-nvidia/), Paperspace (www.paperspace.com), and FloydHub (www.floydhub .com).

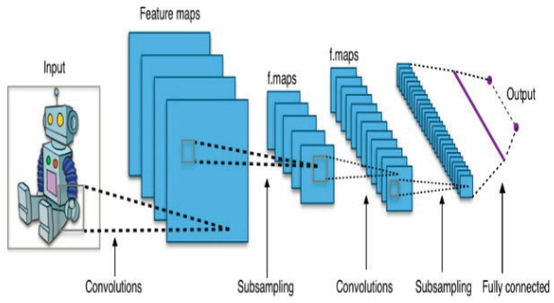

Figure 2. Deep Learning Convolutional Neural Network

Results and Discussion

We decided to measure the projects based on the project deliverables and student learning outcomes. The different measure dimension are indicated on the left. For each project, we assigned a value to indicate the quality of the outcomes; where 1 is the least and 5 is the best. Table 1 indicates the project outcome based on the measures we have selected.

Table 1 Project Outcomes

Measures	Individual Project	Group FYP Project
Project report	4	5
Project code deliverables	4	4
Student learning of AI concepts	5	4

We also decided to perform some qualitative assessment of the project outcomes by surveying the students for the responses. The questions we asked and their responses are indicated in the Table 2. For the group project, the response returned is the group response

reached after the five students had some discussion among the group members. For the individual project, the response is that from one single student.

Table 2 Project Qualitative Assessment

Questions	Individual Project	Group FYP Project
Top mistakes made?	..the model may be build with no issue, but the accuracy is not guaranteed. .. you can just code without understanding the math: This is one point that I found that I am the most wrong about. ..	None
Data selection / Data Preparation?	The selection of data was done with caution, since I need to make sure that the data are unpacked and not using custom packer that cannot be decrypted.	We did not adequately select the data. Needed to randomly generate data using a script or manually collect data.
Computing resources adequate?	The computer that I worked on with my training did have enough resources, ..I have spent most of my time working on a smaller dataset to get the model building code correct. Maybe if I really needed accuracy, and have a large enough dataset that will require the laptop to be left on from more than a day, I will be looking at cloud solution.	Insufficient computer resources. Windows IO is slower than Linux, so when dealing with a lot of files there will be significantly more time needed. This issue is only prevalent when dealing with large amounts of data.
Any helpful online resources?	(many youtube links and github repositories provided)	Sentdex youtube, he referred to online resources, such as https://pythonprogrammming.net/
Additional help from supervisor?	The data was not shown to the lecturer until at the later stage, Hence, I suggest that to make the project better, it will be good that the student relay to the lecturer more. In addition, I would suggest that it will be good for the lecturer to guide the student, but do the guiding in the form of suggestions. This allows me the chance of making mistakes and I found that I learn more when I find out why I make that mistake.	A server with GPU access or a machine learning cloud would have made the project a lot smoother.

When comparing the project outcomes for both the individual project and group project, we found that the group project generated better deliverables because of the combined effort by the group. They were better able to divide the tasks and work done. However, the learning outcomes were better for the individual project because he had to learn and do everything by himself. Despite the lack of structure in the independent study project, the student also reported that he felt he learnt more from the mistakes he made.

From the qualitative assessment responses, the individual project student did more reflection on his mistakes. He also confirmed what we had suspected would be a problem. He mentioned that it was a mistake to start to code without first understanding the mathematics behind the algorithm and the effects of tweaking various parameters. The student reported that this resulted in, "I know it works, and how to make it work, but have no idea how it works situation".

Data selection and data preparation were issues in both project, but students were able to overcome them. We found that the lack of computing resources was not a problem where the amount of data was not sufficiently large or the machine learning algorithm used is not deep learning neural networks.

Students could learn from many online resources from youtube and github. Some of online resources provided code examples as well. However, it is difficult for students to gauge the accuracy of these online resources and if they lead to future misconceptions.

One of our concerns was the need for scaffolding in the projects. For the more structured group project, the student did not mention any need for scaffolding. However, for the individual project, the student felt that he needed more coaching at the beginning of the project so that he could generate more ideas. He also mentioned that he thought the being able to make mistakes helped in his learning. However, he was frustrated by moving in the wrong direction during the project but he did not realise it. He reported, "it is essential that the lecturer make sure that the student don't stray to a wrong concept, or get stuck for too long."

Conclusions

AI could be introduced to diploma students through project-based learning. Students have to be self-directed in the learning in order to overcome difficulties such as gaps in their pre-knowledge. However, many resources are available online to help students self-learn concepts even in the absence of formal lessons by their supervisors. Even though there are many online resources, students do encounter difficulty making correct judgements about the effectiveness of the algorithms. Beyond simple measures such as accurary or recall, students also need to consider if the model has inherent bias or problems of overfitting. Students have difficulty understanding the need for the model to be generalizable in order for it to be usable for future examples.

One of the gaps in the student pre-knowledge is in in the understanding of linear algebra for machine learning. This topic in mathematics is not covered in the present syllabus of the mathematics module taken by the students. Moving forward, we would plan to include a tutorial or workshop on linear algebra for machine learning for the students prior to them embarking on such projects.

We concluded that we should include some scaffolding for the independent study projects because students need some additional structure in their learning in order to be more effective in grasping new concepts such as AI concepts. One scaffolding strategu is to have coaching sessions scheduled at regular intervals with the student doing the independent study module.

For the group FYP projects, where students have the benefit of learning collaboratively and also where there is a more structured approach to their project, we concluded that perhaps a curated set of reference learning materials would be helpful to the group to embark on the project together. This also helps the students to build a common vocabulary in reference to AI concepts. The common vocabulary would help them communicate and colloborate better on the project.

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APPLICATION OF PROJECT-BASED LEARNING TO SMART BUILDING ENGINEERING EDUCATION – A CASE SHARING

T.H. Ng*, Ivan C.H. Cheng and Anthony S.S. Lai

Department of Engineering, Hong Kong Institute of Vocational Education (Sha Tin), Hong Kong

*rogerng@vtc.edu.hk

Abstract

Hong Kong government determines to transform this vibrant city into a world class smart city. Among the six major areas under promotion, "Smart Living", "Smart Environment" and "Smart People" are highly related to smart building engineering education. This drift reinforces the current pressing task of educators, i.e. to nurture young talents to have the 21st century competencies and multidisciplinary knowledge and skills in order to cope with the complex problem of designing and maintaining intelligent, healthy and sustainable buildings for the smart city.

As a member of the Vocational Training Council (VTC), Hong Kong Institute of Vocational Education (IVE) is the leading vocational and professional education and training (VPET) provider committed to nurturing professionals for the development of the city. The curriculum of IVE engineering programmes requires every student to complete an industry-based student project (IBSP), in which he or she integrates and applies the learnt knowledge to tackle a practical problem encountered in an authentic workplace.

To align with the government's policy on pursuing smart city development, IVE (Sha Tin) adopts project based learning (PBL) in the IBSP module within the scope of smart building engineering education. PBL is an innovative approach designed to engage students with different backgrounds in the investigation of a real-world problem. By using PBL, lecturers facilitate students through engineering design processes while students drive their own learning through sustained enquiries and team-based cooperation. PBL helps to strengthen students' conceptual knowledge, build up their problem-solving abilities, and develop a positive attitude towards learning.

A total of six students studying in the final year of higher diploma programmes in computer engineering (CE) or building services engineering (BSE) were engaged in the same PBL-adopted IBSP which targets to create an automatically controllable, highly energy efficient and sustainable living environment inside buildings. Three lecturers having expertise in smart energy management, sustainable built environment and cutting-edge IoT applications respectively jointly supervised these six students. The synergy of the CE and BSE programmes was fully unleashed.

This paper reports the work of the students' PBL-adopted IBSP, shares the challenges of implementing PBL in the teaching of smart building engineering. The assessment rubrics of the PBL-adopted IBSP are discussed. The student feedback taken at the end of their study is also analysed.

Keywords: *Pedagogies in VPET, project-based learning, smart building engineering, smart city, multidisciplinary collaborations.*

Introduction

VTC is committed to nurturing talents for developing Hong Kong. In the 21st century, educational practices that solely emphasize theoretical concepts are no longer sufficient. It is now more crucial for engineering students to learn how to become practical engineers. Practising to apply theoretical principles is the best done when real problems and hands-on activities are given in "projects". For this reason, every IVE engineering student is needed to have exposure to projects about real-world problems which are usually mixed with complexity and uncertainty. Upon the end of their engineering studies, they should be able to identify the roots of the problem, encounter the difficulties, deal with the project constraints, and work out a feasible solution with creative design thinking skills and a positive learning attitude. PBL is a suggested VPET approach to guide engineering students to become work-ready engineers. In alignment with the recent policy of Hong Kong government on developing the city to be a world class smart city, six students studying in the final year of CE or BSE HD programmes were jointly guided by three lecturers with different expertise to conduct a PBL-adopted project on creating a smart, energy efficient and sustainable living environment in buildings. This paper shares the experience of applying PBL in the teaching of smart building engineering. Challenges of implementing PBL in the curricula of IVE engineering programmes and the assessment rubrics associated with PBL are discussed. The students' outcome on developing smart city features based on the PBL approach are also reported.

Hong Kong Smart City Blueprint

Last year, Hong Kong government issued the "Smart City Blueprint" to propose measures to build Hong Kong

into a world class smart city. Plans of developing "Smart Living", "Smart Environment" and "Smart People" were mapped out. These three areas are highly related to smart building engineering education.

Hong Kong is a technology-rich city. At this moment, the household broadband penetration rate of this city is 92.5% and its mobile subscriber penetration rate reaches 242.5%. The Hong Kong population is however ageing rapidly. It is projected that the population aged over 65 will increase from 16.6% of the total population in 2016 to 31.1% in 2036, which is causing a potential risk to this city. "Smart living" is therefore promoted such that more technology applications are adopted to support a healthy living style of the elderly.

In Hong Kong, 67% of carbon emission comes from electricity generation while buildings accounts for about 90% of electricity consumption currently. It is therefore necessary to create a "smart environment". By promoting energy efficiency and conservation with the use of more smart technologies inside buildings, it is targeted that the carbon intensity of Hong Kong can be reduced by at least 65% by 2030 compared with the 2005 level, and people can enjoy better IAQ and a low carbon, more sustainable living environment.

Towards these two directions require "smart people". Hong Kong government is promoting STEM education among the community to enhance the youngsters' R&D capability. It is expected that in the near future, there will be a sufficient local supply of technology practitioners in Hong Kong and they could build up a knowledge-based society to support the smart city development of this city. VTC is nurturing smart people for building up the smart city.

Industry-based Student Project in IVE Engineering

VTC is a leading VPET provider in Hong Kong. IVE as its member institute is committed to nurturing talents to fully support the development of the city. We focus on equipping students with the competencies required in the 21st century, e.g. complex problem solving capabilities, creative and innovative thinking skills, communications and coordination abilities, etc. In the curricula of all IVE engineering programmes, every student has to complete an industry-based student project (IBSP) in an authentic or highly simulated engineering workplace environment.

On completion of the IBSP module, it is expected that students are able to:

- Integrate and apply knowledge and skills learned in the programme and experience gained from industrial attachment to solve engineering problems through different stages of development, including literature and information search, design, installation, testing, commissioning, evaluation and maintenance with exposure to current developments in building services engineering related industries;
- Implement relevant aspects of project management, for example scheduling, user requirements, costing, documentation, project supervision and coordination;
- Perform project tasks individually and as a team member to solve encountered problems with due reflection on safety, energy and environmental issues, and
- Produce formal written reports and give oral presentations explaining the project work.

Students will commence their IBSP at the beginning of the second semester of the final year of study and work on it full-time throughout the whole semester. Groups can be formed depending on the project nature despite individual assessment. Students are asked to demonstrate adequate research and planning capacities, project implementation abilities and reporting skills. The project work should be highly student-centred, in that students can gain knowledge through their own research and application of findings to solve problems associated with the work in a creative manner.

Conventionally, students will conduct the IBSP under a real industrial or commercial organization, but when it is not feasible, students can also opt to conduct their IBSP in campus. Similar work environment will be provided to the students who undertake in-house projects. To support the students, the project supervisor, who is a lecturer, will act as a mentor and guide the student throughout the IBSP.

In order to echo the government's policy on pursuing smart city development, a team of six students studying in CE or BSE HD programmes was formed to undertake a project within the scope of smart building engineering education. The project aims to create a smart living style in an intelligent, sustainable and energy efficient building by using IoT control. Under the umbrella of this project, each of the six students is responsible for dealing with a particular aspect of the project for his own in-house IBSP so that at the end each of their works could be integrated to achieve the ultimate objective of the project. Figure 1 shows the systematic framework of the smart building engineering project.

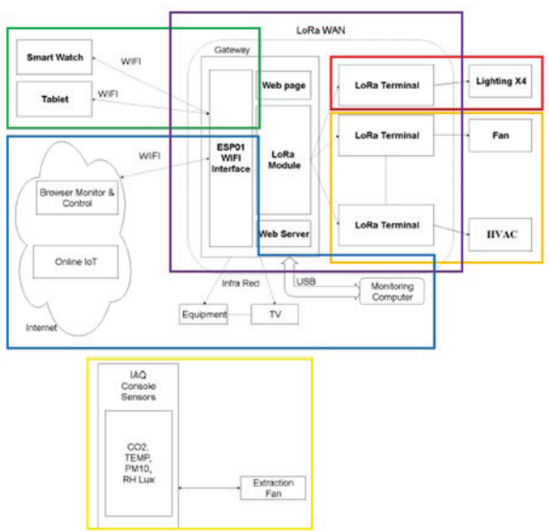

Figure 1. The systematic framework of the smart building engineering project showing the scopes of work of the six students as highlighted in different coloured boxes.

The scope of work of each student is listed as below:

- Student A (BSE): Establish communications between LoRa terminal and lighting fixtures (in red);

- Student B (BSE): Establish communications between LoRa terminal and fan and HVAC system (in orange);
- Student C (BSE): Establish the relationships between IAQ parameters and IAQ sensors (in yellow);
- Student D (CE): Establish communications between WiFi and various smart wearables (in green);
- Student E (CE): Establish communications between WiFi and AV and other IoT control systems (in blue);
- Student F (CE): Establish the LoRa WAN system (in purple).

PBL projects require appropriate design and selection based on the learning outcomes desired. These projects must allow open-ended problem solving and application of theories. It is also an important criterion that the PBL projects allow for multiple solutions. A design problem usually has a number of solutions. Students can learn to evaluate these solutions and opt for the most suitable one for the situation. The PBL projects should give students sufficient freedom to explore the context, set the scope of work, identify the research sources and come up with a list of possible solutions. The project brief should not tell the students directly or narrowly specify a single solution. Students should instead select the most suitable solution based on the existing situations. The PBL projects should allow for considerations not limited to technical aspects, but also including economic, socio-cultural and ethical issues.

Students are encouraged to do their PBL projects with the sense of commercialization as it trains up students to handle real-world problems that they may encounter in their future professional careers. Also, the PBL projects should be designed in the way that, through working on the projects, students could learn to combine theoretical knowledge and practical experiences in new ways and build up a concrete foundation of knowledge and skills so as to lead to innovative but feasible solutions. The PBL projects should be designed ambiguous such that students could do research, think thoroughly the current situation and decide the tasks of various levels, the development direction, and the outcomes that they wish to achieve.

Last but not least, PBL encourages team work. Most real-world problems and their solutions are not of single discipline. Collaborations across disciplinary boundaries are usually required.

Students' work on the PBL-adopted IBSP

The smart building engineering project was made up of six students' PBL-adopted IBSP. Its ultimate goal is to develop a smart living system, equipped with IoT control, to be installed in a smart, energy efficient and sustainable building.

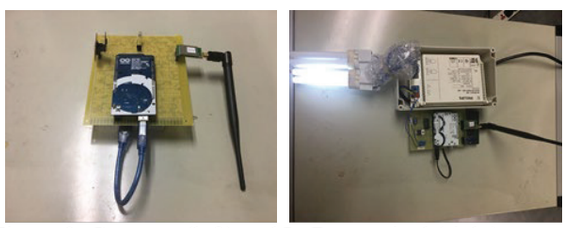

Figure 2. Gateway (left) and LoRa terminal (right)

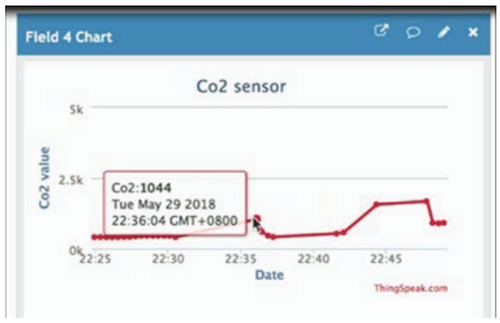

Figure 3. Measured values by different sensors would be uploaded to Cloud for history record and graph plotting for easy reference

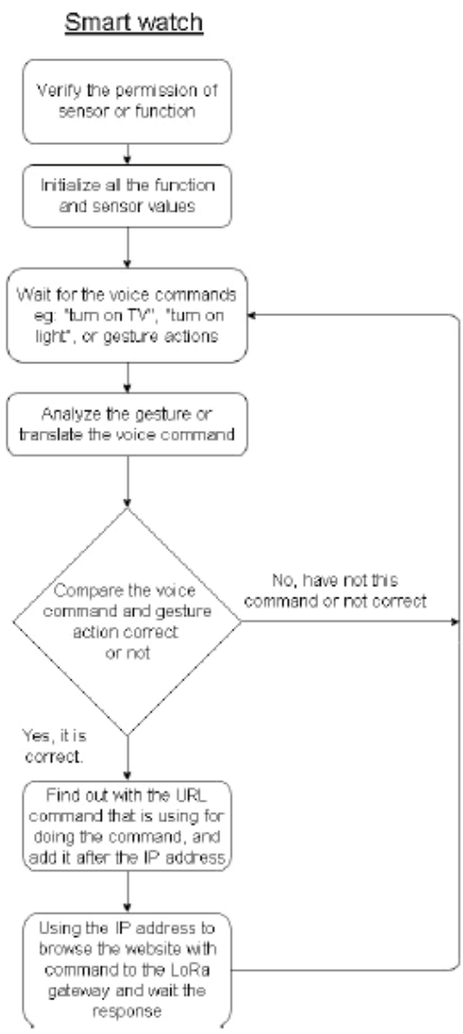

Figure 4. Flow chart of the operation of the smart watch

The system consists of four parts. The first two are the long-range radio (LoRa) gateway and the terminals. Figure 2 shows the gateway and the terminal that were used in the project. The LoRa gateway is the core of the whole project. It uses Arduino as the core processing

system and adds on the ESP0101 for connecting to the Internet via the web server. The LoRa gateway transmits commands to the terminals. The terminals receive data given by the various sensors, e.g. the values of light level, temperature and relative humidity, and send back the data to the gateway. The control part analyses the received data and implements different control strategies according to the situations. The third part is a wearable device control. Based on the human voice command, "Android wear" talks to the gateway and takes further actions. The last part is the indoor environmental quality (IEQ) system, also linked with gateways and terminals. It automatically monitors the various environmental data, such as CO2 and PM10, and controls the operation of some electrical appliances and keeps maintaining a good IAQ environment. Figure 3 shows a webpage of how the measured parameters are presented. Figures 4 and 5 show the flow charts of operating the smart watch and the LoRa terminal respectively.

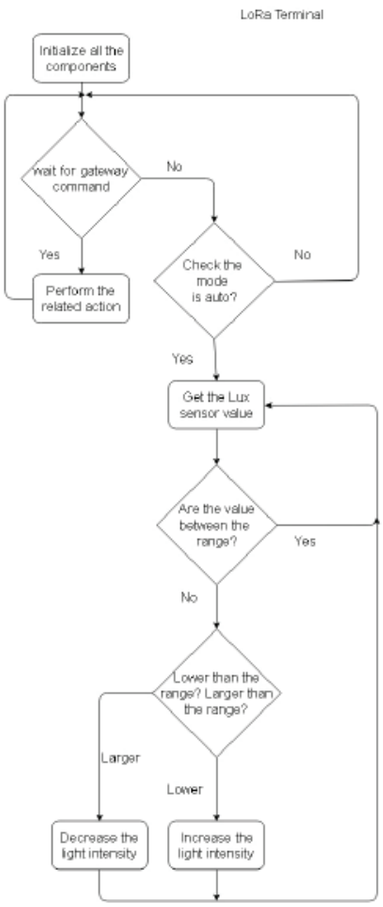

Figure 5. Flow chart of the operation of LoRa terminal

Assessment for PBL

Assessing students' performance in the PBL-adopted IBSP requires a special care in consideration of choosing an appropriate assessment technique suitable for PBL (Hosseinzadeh and Hesamzadeh, 2012). Real assessment is used to evaluate students' performance. It is markedly different from the traditional exam which assesses the students at the end of a module; instead it evaluates the students' performance over time regularly throughout their learning.

For obtaining a pass in the IBSP module, students have to pass 2 continuous assessment (CA) components: engineering competence and soft skills, and all 3 End of Module Assessment (EA) components. Students who are unable to complete the module for various reasons, or who fail to reach a satisfactory standard in any of the above components, are deemed to fail the module. Table 1 shows the assessment plan of IBSP.

Table 1. Assessment plan of IBSP

Continuous Assessment (CA)	60%
End of Module Assessment (EA)	40%
Total	100%

During the three-month PBL-adopted IBSP module, students are required to submit five types of assignments and conduct two presentations. These five types of work include one "reflection report", nine "weekly project logs", one "progress report" and one "final report".

The "reflection report" demands students to write a short essay for illustrating that their achievements in the IBSP. The students should describe and provide evidence of how they have applied technical knowledge and professional skills that were learnt from classrooms in their PBL-adopted IBSP. Salient examples of applying interpersonal skills, teamwork skills, management skills, problem solving skills, and communication skills should also be provided.

"Weekly project logs" intend to let students reflect on their contributions to conducting the project, including the problems that they encounter and the solutions that they think of. Most important is that they should be aware of their own learning progress over time through this type of assignments.

The two reports and two presentations aim to assess whether the students could perform to a prescribed level as stated in the three module intended learning outcomes, i.e. research and planning, project implementation and project reporting.

Assessment rubrics provide clear criteria about how marks are allotted in the PBL-adopted IBSP. The rubrics give students a good idea of what is expected. Like what a previous paper highlighted, "Assessments need to take into account of appropriateness to the context of problem, how well the problem has been investigated, understood and resolved, the clarity of the definition of the problem, whether the solution space has been sufficiently explored, and how creative and innovative the solution is." (Shekar, 2014).

Among the six students involved, one student got A, two got A-, two got B+ and one got B in their IBSP module. The good assessment results reflected that these six students performed well in their IBSP module and the intended learning outcomes of IBSP were satisfactorily achieved. Figures 6 and 7 show the rubrics of the IBSP Interim Assessment and Final Assessment respectively.

IBSP - Project Supervisor Interim Assessment Report

Assessment Component			Weighting (0.0 – 1.0 or %)	Student Mark
Continuous Assessment (CA)	Engineering / Professional Competence (6%) #	Comprehension of the problem		/100
		Idea, concept, design and build		/100
		Testing and development, realization and implementation		/100
		Problem solving skills		/100
		Environmental and safety awareness		/100
		Others		/100
	Soft Skills (6%) #	Planning of the work		/100
		Investigation and research		/100
		Motivation and independent work		/100
		Communication skills		/100
		Leadership and team work		/100
		Others: Design Thinking Skills		/100
	Project logbook for interim assessment (4%)			/100
	Progress review (10%)			/100
	Interim Presentation (10%)	Appearance: (Punctuality, attire, attitude and confidence)	10%	/100
		Clarity: (Good English, fluency, voice, clarity and sequence of presentation)	25%	/100
		Content: (Material presented is related to and has adequate coverage of the issue)	30%	/100
		Time Management: Presentation finished on time (10 – 15 mins, overrun = 0, under-run = 0)	5%	/100
		Overall Performance: (Preparation of work, answering skills, use of AV aids, etc)	30%	/100

Parentheses (%) indicate the weight of the marks contributing to the total mark of this module.

 # The component has to be passed individually to pass the module (Please read Module Assessment Scheme).

Figure 6. Rubrics of IBSP Interim Assessment

IBSP - Project Supervisor Final Assessment Report

Assessment Component			Weighting (0.0 – 1.0 or %)	Student Mark
Continuous Assessment (CA)	Engineering / Professional Competence (9%) #	Comprehension of the problem		/100
		Idea, concept, design and build		/100
		Testing and development, realization and implementation		/100
		Problem solving skills		/100
		Environmental and safety awareness		/100
		Others		/100
	Soft Skills (9%) #	Planning of the work		/100
		Investigation and research		/100
		Motivation and independent work		/100
		Communication skills		/100
		Leadership and team work		/100
		Others: Design Thinking Skills		/100
	Project logbook for final assessment (6%)			/100
End-of-Module Assessment (EA)	Deliverable / Portfolio (15%) #			/100
	Final Report (15%) #	Content		/100
		Presentation of the report		/100
		Independent view and suggestion to problem encountered		/100
		Investigation and research work		/100
		Others		/100
	Final Presentation (10%) #	Appearance: (Punctuality, attire, attitude and confidence)	10%	/100
		Clarity: (Good English, fluency, voice, clarity and sequence of presentation)	25%	/100
		Content: (Material presented is related to and has adequate coverage of the issue)	30%	/100
		Time Management: Presentation finished on time (10 – 15 mins, overrun = 0, under-run = 0)	5%	/100
		Overall Performance: (Preparation of work, answering skills, use of AV aids, etc)	30%	/100

Parentheses (%) indicate the weight of the marks contributing to the total mark of this module.

 # The component has to be passed individually to pass the module (Please read Module Assessment Scheme).

Figure 7. Rubrics of IBSP Final Assessment

Student feedback

Student feedback about the implementation of PBL-adopted IBSP was obtained at the end of their study in two ways: (i) through a survey, alike the typical student feedback on a module, and (ii) from the part of students' assignments, where students were asked to write a piece of self-reflection report on their learning experience in doing the PBL-adopted IBSP and how they achieve the learning outcomes of this module. The survey result on the satisfaction with the learning through the PBL-adopted IBSP was encouraging. The average overall score attained 8.2/10. Besides, the student' reflection was very positive. For example, one of the students expressed his view that:

"Smart city development is an irreversible trend. It is nice for me to gain hands-on experience in building up a smart system with a group of team mates to solve the real-life problems about the elderly's declining living quality and energy over-consumption in this city."

Remark

This smart building engineering project obtained the champion of Chiang Chen Industrial Charity Foundation Student Project Competition (AY2017/18).

Conclusion

PBL is one of the recommended VPET pedagogies. It provides a wide range of credits to the students' learning experience. For nurturing talents to develop Hong Kong to become a world class smart city, PBL was adopted in the IBSP module about smart building engineering. Six CE or BSE HD final year students under the supervision of three lecturers having different expertise backgrounds carried out the project as a team. Each student contributed a part via their IBSP in achieving the ultimate goal of the project, i.e. to develop a smart IoT control system for promoting smart living style in smart, energy efficient and sustainable buildings. The impact of using PBL as the teaching method was very positive. Involved students offered a high rating to the learning effectiveness of PBL-adopted IBSP module. Challenges of implementing PBL in IBSP are described in this paper. Assessment rubrics and the final product of the students in the PBL-adopted IBSP are also discussed. It is suggested that PBL should be widely adopted during the student learning process in the future.

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AN APPLICATION OF THE PROCESS OF MATHEMATICAL MODELING TO THE MODEL CORE CURRICULUM

K. Okumura[*,a], Y. Furihata[b] and K. Takamura [c]

[a] National Institute of Technology, Asahikawa College/Mathematical and Scientific Subjects, Japan
[b] National Institute of Technology, Asahikawa College/Mathematical and Scientific Subjects, Japan
[c] National Institute of Technology, Asahikawa College/Department of Electrical and Computer Engineering, Japan

*E-Mail okumura@asahikawa-nct.ac.jp

Abstract

The model core curriculum fully carries out in National Institute of Technology (KOSEN) from fiscal 2018. The required abilities for engineers are clarified, and reforms of curriculums and lessons are required that can acquire such skills. In particular, we aim at the application level, not the comprehension level, with regard to the fundamental abilities that we need to acquire in common fields. In other words, it is necessary to aim to be able to utilize knowledge in real situations. However, almost of former mathematical education in KOSEN was aimed at acquiring knowledge and confirming it. The part of application of mathematics in engineering is entrusted to specialized fields of KOSEN. Obviously, there exists the gap between previous mathematical education and the future mathematical education in KOSEN. Moreover, there also exists the gap among instructors. Hence, we want to investigate the construction of lessons of mathematics for the application level. To do this, we focus on the following aspects: (1) Consider the question to change from the problem of the comprehension level to the problem of application level; (2) Consider a method that many instructors can easily do, not a method that only a specific instructor can do; We have developed the experiment with respect to the above aspects in the class of the mathematics for first year students in National Institute of Technology, Asahikawa College. We consider the development of lessons based on the process of mathematical modeling and share the lesson plan. Here, the process of mathematical modeling means a series of the processes for solving problems in the real world by using mathematical methods. Then, in particular, we focus on the ease of sharing. To do this, we also construct a lesson plan. As a result of our approach, we find a certain approach to change from the comprehension level to the application level. Moreover, we can make lessons easier to construct and share.

Keywords: *Model core curriculum, Mathematical education application level, mathematical modeling, real-world problems*

Introduction

Currently, National Institute of Technology (KOSEN) carries out *the model core curriculum*. The model core aims to develop skills that engineers should have. In particular, we aim at the application level, not the comprehension level, with regard to the fundamental abilities that we need to acquire in common fields. The subjects of mathematics in KOSEN also aim at the application level. However, there exist problems to make it the application level. For example, we have the following problems: In the education provide at KOSEN, mathematics subjects are basic to the education of engineering. So, all KOSEN students spend a lot of time on mathematics. However, many subjects of mathematics in KOSEN keep learning mathematical processing. Namely, most of the students do not grasp the contribution of mathematics to engineering. Roughly speaking, most of them can not apply mathematics to engineering.

On the other hand, many subjects of specialized fields are intended only for higher year students. Hence students do not fully grasp the contribution of mathematics to engineering until the later years of their education. In addition, most of them have not used mathematics for solving real-world problems. We also wondered whether students suddenly could use mathematics for studying subjects of specialized fields at KOSEN. It is necessary for them to construct how to connect mathematics and specialized fields. To do this, we want to construct a way to deal with applications of mathematics in the class of the mathematics for lower year students. We also want to share that way with other instructors.

In the mathematical education, the notion of “the process of mathematical modeling” is well known (Miwa, 1983). This notion is a series of processes for solving problems in the real world using mathematical methods. We consider that these processes provide a

smooth connection between the mathematics and its applications. Namely, these processes are useful to make it an application level. In addition, if students learn these processes earlier in their education, teachers can train them for solving problems.

In this paper, we report our approach for first year students in Asahikawa KOSEN.

The Process of Mathematical Modeling

In this section, we recall the process of mathematical modeling. Miwa (1983) defined this notion. After that the process of mathematical modeling has been extended and modified by many mathematical educators. This research uses Nishimura's process of mathematical modeling. These processes are the following (Nishimura, 2012):

(1) Social problems (Problems in the real world)
- Interpreting the problem
- Formulating

(2) Mathematical problems
- Making mathematical model
- Mathematical processes

(3) Mathematical results
- Interpreting the solution
- Evaluation

By repeating these processes, students obtain a more rigorous solution for social problems (spiral development). These processes do not necessarily proceed as shown in the figure 1. There are things that go back and jump forward.

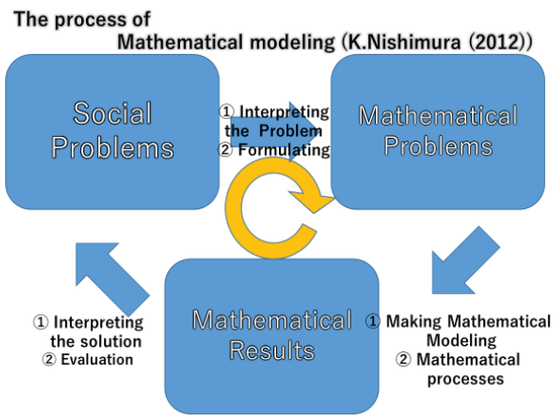

Figure 1: The process of mathematical modeling.

Our Approach in Asahikawa KOSEN

Most first-year students have not had the experience of formulating social problems (see the result of Q1 in Figure 4). Hence this process is difficult for them. However, this process is inevitable for solving problems in the real world. The authors have tried to seek to help students formulate of social problems (see Okumura and Takamura (2017)). However, we could see that students felt difficulty to interpret the social problems. In general, it is also difficult to find how formulated a given problem can be formulated. Even under such circumstances, we need to aim at application level in KOSEN.

We considered the following two methods as a method of making it to the application level.

(1) The instructor gives real-world problems;
(2) The students create real-world problems.

The method (1) seems to be standard method. However, it is difficult for instructors to prepare real-world problems for all mathematical matters. Furthermore, the problems given by the instructor tend to depend on the characteristics of the instructor. Hence the method (1) may be difficult to share with other instructors.

In this research, we focus on the method (2). So, we have developed the lesson with respect to a quadratic function in the class of the mathematics for first year students in National Institute of Technology, Asahikawa College. In particular, the students have investigated the application problem of the maximum or minimum value of the quadratic function. To do this, we adopted the following teaching tools:

(i) Create real-world problems that can be solved by finding the maximum or minimum of the quadratic function (see Figure 2);
(ii) Check each other for problems students created.

By this approach, the students themselves investigate how the problem of finding the maximum and minimum values of quadratic functions can be utilized. Moreover, the process of solving the problem was organized using the figure of the mathematical modeling process.

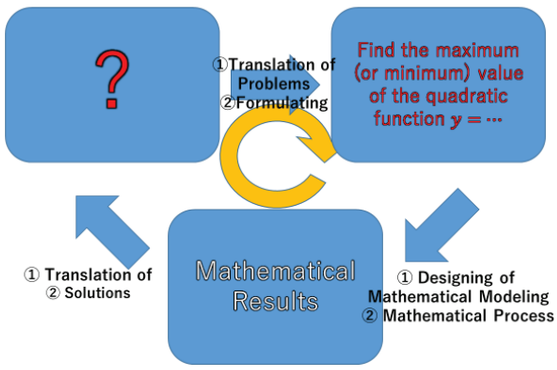

Figure 2: Creating real-world problems.

This method is simple and easier to share than the way instructors give problems. Indeed, we shared the above teaching tools with other instructors. To do this, we prepared the lesson plan (Table 1).

Students' Reactions

The students created real-world problems as homework. They created the following problems:

- The problems with respect to the constant acceleration motion;
- The problems with respect to the parabolic motion;

- The problems with respect to finding the area of the rectangle from the given circumference length;
- Problems that maximize the sales of certain products.

They solved each other's problems and evaluated the problems. The viewpoint of evaluation was set as follows:

① Is it realistic?
② Is it clear what you want?
③ Is the problem established?
④ Is there enough information to solve the problem?
⑤ Can it be solved without using the maximum of minimum values of the quadratic function? (Are there other solutions?)

Based on evaluations and comments, they revise the problems they created.

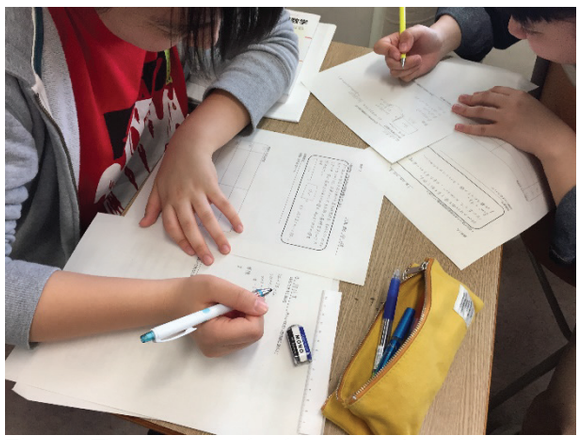

Figure3:The students solved each other's problems and evaluated problems.

Analysis of Questionnaires

We conducted a follow-up questionnaire with the following items:

Q1 Have you ever experienced solving problems in the real world using mathematics?
Q2 Have you ever experienced creating mathematical problems?
Q3 Did you understand the problem of finding the maximum or minimum value of the quadratic function even more by creating a problem?
Q4 Did you solve the problems that other students created?
Q5 Do you want to apply the mathematics for future learning activities?
Q6 Do you want to learn the process of the solving problems for future learning activities?

They evaluated the above items on a 5-point scale, where 5 = strongly agree, 3 = neither agree nor disagree, and 1 = strongly disagree.

Figure 4 contains the results of the questionnaire.

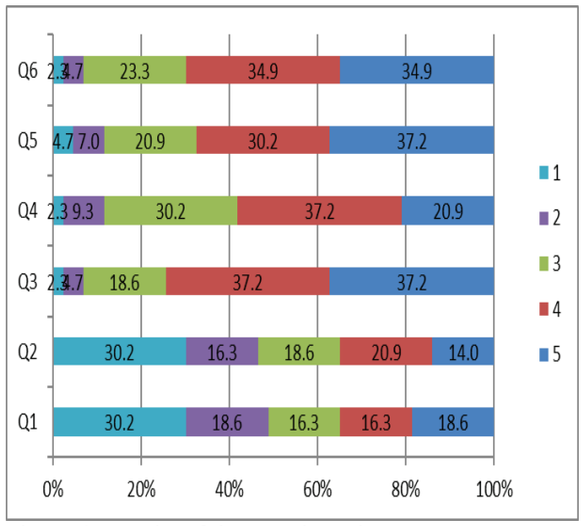

Figure 4: Results of the questionnaire

Results and Discussion

Figure 4 indicates that many students understood the problem of the maximum or minimum values of the quadratic function even more. Hence it means that they can understand the notions of mathematics even more by creating real-world problems and evaluating each other.

In particular, result of Q5 and Q6 indicates that they recognized the necessity of learning applications. In addition, they also felt that they wanted to use the mathematics to solve future problems in learning activities. For that reason, they felt that they also wanted to learn how to solve problems.

Moreover, by sharing the lesson plan with other instructors, many students are able to aim the application level. As a result, it makes the model core curriculum easy to operate.

However, several problems remain. Specifically:
(1) We need to consider objective evaluation by the instructor.
(2) We need to develop the smooth connection between mathematics and its applications for *middle*-year students.
(3) Teaching materials must be developed to help students learn application of mathematics.

Conclusions

We think that in order to apply mathematics to real world problems, it is useful to create real-world problems to some mathematical problems. The students can understand the notion of mathematics even more by creating real-world problems and evaluating each other. Moreover, they feel that they want to utilize mathematics for future learning activities by our approach.

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Table 1:The lesson plan (in Japanese).

段階		学習活動	予想される学生の反応	◇教師の指導・援助　評価	時間	備　考
課題把握・活動内容の把握	問題をつかむ　活動内容の把握	1 学習問題を確認する。	【学習問題】 ２次関数の最大値、最小値を求めることで、解決できる現実の問題を作ろう。	◇宿題の内容を確認する。	5 分	スライド
				◇作成してきた問題を、ワークシート①に記入させ、他の学生に出題できるように準備させる（宿題をやってきていない学生がいればこの段階で把握しておく。その学生は、解く係に特化させる）。		ワーク シート①
			ア　自分と同じような問題を作っている。 イ　２次関数の最大値、最小値を求めることで現実の問題に対する解を得られた。	◇作成してきた問題を、ワークシート①を利用して、ペアで出題し合い、解かせる。 ◇互いに出題し合うことで、２次関数の最大値、最小値を求める活動を利用する問題になっているか、確認する。	7 分	
		2 問題を確認し合う際の観点を考える	ウ　問題文の表現に問題がないかチェックしたらよい エ　２次関数の最大値、最小値を求めることで解決できる問題なのかチェックしたらよい。 オ　実際に解ける問題かチェックすればよい。 カ　出題者の模範解答と実際の問題を照らし合わせたときに問題がないかチェックしたらよい。 キ　現実の問題の解決になっているかチェックすればよい。	◇作成してきた問題をどういう観点で、見たらよいかを学生から意見してもらう。 ◇エの意見を受けて、必ずしも２次関数の最大値、最小値を求めることで解決しなくても、他の方法で解決できる場合には、どうなのか学生に問う。 →出題された問題が他の方法で解決でき、また異なる解が得られるかもしれない可能性もあることに気づかせる。 ◇オ、カ、キの意見を受けて、作成した問題に対して、条件が不足している場合や問題に修正が必要な場合は、問題の修正を行ってよいことを確認する。	8 分	ワーク シート②
追求	実践	3 作成した問題を出題し合う	【学習課題】 自分が作ってきた問題を、学生同士で出題し合い、問題を解き、互いに問題を確認し合おう。 (a)　例えば、面積に関する現実の問題は、２次関数の最大値最小値を求めることで解決できることが分かった。 (b)　現実の問題から、２次関数を立式するのは、やってみると結構難しい。 (c)　条件が不足していると、２次関数でないことも考えられるので、不足している場合は２次関数になる条件を付与する必要がある	◇最低２人の学生に、出題し合い、解いてもらい、全体で確認した観点に則って、コメントし合う。→教室内を自由に動いて相手を見つけて良いと指示する。 ◇ペアの組めないところは、こちらで援助する（４５人なので、３人のところが１グループできるが、互いに回して行う）。 ◇解法の説明をし合う。	16 分	ワーク シート③
追求	確認	4 感想、アンケートを行う	1　どのような場面で２次関数の最大値、最小値を活用するのか知ることができた。 2　問題を作ることは難しいことだが、解法まで考えることで２次関数のことがより理解できた気がする。 3　中学校までは問題を作るということやってこなかったので今後学ぶ内容もどのように活用されるか考えることで、新しい側面を積極的に知りたいと思う。	◇感想、アンケートを書かせる ①　コメントをもとに修正することで現実の問題を作ることができた。 ②　他の学生の出題した問題を解くことができた。 ③　今後学ぶ内容も活用する場面を考えてみたいと思った ◇感想・アンケート内容を共有する（ペア、全体）	9 分	感想 アンケート
一般化	定着・活用	5 どのような数学の内容を適用するかわからないような状況は想定させる	α　どのような数学の内容が使えそうか考えることは、とても難しい。 β　問題解決するには、使える数学的道具を増やすことは、少なくとも必要だと思う。 γ　実際に問題解決するときは、結局こういう状況であるから、このような状況でどうやって問題解決していくかという術を学びたい。	◇今回は２次関数の最大値、最小値を求めることを利用した問題を作ったが、現実の問題が与えられたときに、一般にはどういう数学の内容を利用するのかわからないということを認識させる。	5 分	ワーク シート

ROBOT CONTEST FOR THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

Y. Kobayashi*,[a] and S. Suzuki [b]

[a] National Institute of Technology, Maizuru college/Mechanical engineering department, Japan
[b] National Institute of Technology, Fukushima college/Mechanical engineering department, Japan

*E-Mail kobayashi@maizuru-ct.ac.jp

Abstract

This is a report on N.I.T. Maizuru, a participant of a robot contest organized by N.I.T. Fukushima College. The creative robot contest is based on problem-based learning (PBL) education and was held at the decommissioning Fukushima Daiichi Nuclear Power Station. It aims to encourage student interest in decommissioning and to simultaneously discover problem-solving abilities. For the team who passed the document screening, a summer school was conducted as a preliminary learning of the nuclear power plant. In the summer school, the contestants actually observed the situation of the decommissioning work at the Fukushima daiichi (=first) nuclear power plant (core damaged) and daini (=second) station where the core damage was avoided, Tours in the building and storage containers are also carried out.

The competition was held in two fields, the mock-up stairs and the step fields, assumed inside the reactor building. The two fields have the following common environment. ① There is no lighting and it is dark. ② Since the robot is remotely operated, it is impossible to look directly. ③ Radio waves will not reach because there is a thick wall of concrete. ④ Because of the influence of strong radiation, there is time limit to the operation of the camera / semiconductor device.

The N.I.T. Maizuru team proposed an idea to use multiple balloons divided into a parent node and child node for these difficulties. The balloon is divided into a parent node that transports the tip of the fiberscope, a child node that carries the optical fiber and the electric cable. By changing the direction, only the direction of the parent node changed so that the change of direction for all nodes was completed.

In the questionnaire after the contest, many students answered "I want to learn or study more about the Fukushima first decommissioning." As a result, this PBL is considered to have succeeded.

Keywords: *problem based learning, robot contest, nuclear power plant, Fukushima Daiichi, step field, mock-up stairs*

Introduction

In the Great East Japan Earthquake in March 2011, serious damage was caused due to the effects of the earthquake and tsunami. At TEPCO's Fukushima Daiichi Nuclear Power Plant, which was in operation in Fukushima Prefecture, the emergency stop was steadily implemented, but the earthquake the supply of electricity from the grid and the emergency power generator were both cut off. It became a crisis situation as the total power supply was lost and the equipment was flooded and therefore stopped functioning. A nuclear reactor, that failed to remove the heat of the collapse, became a catastrophe that destroyed the building and pressure vessel after an explosion was caused by the generation of gas and release of radioactive materials to the surroundings. Currently, the decontamination of radioactive materials, and the demolition of nuclear power plants that caused accidents, are rapidly being advanced.

The dismantling of the nuclear power plant that caused the accident is a long project which is thought to continue for the next 40 years or so. Many human resources are necessary, and many new technologies are required for the development. In particular, it is not the technology of past research and development of nuclear power that is required, but the engineers trained by the Kosen colleges who need the strong technologies oriented to this field. Under such circumstances, N.I.T Fukushima College in Fukushima Prefecture, which suffered damage in this accident, was the center of the creation and hosting of Robocon, a robot contest aimed at nurturing human resources for decommissioning furnaces. The first tournament was held in FY 2016 and 15 teams from 13 Kosens participated.

Outline of the competition

The competition was held in two fields for the 1st and 2nd games. One field was a mock-up staircase and the other was a step field. In either field, the task is accomplished if the robot gives the name of the object in front of it and clears the field on the way to the monitor. Figure 1 shows a picture of the mockup staircase. Figure 2 shows a picture of the step field. Other rules include the environment in which the task is carried out is considered according to the actual situation, the robot cannot be

viewed directly, and differences exist in competition time depending on the shielding performance.



Fig. 1 Mock-up staircase



Fig. 2 Step field

Outline of the Maizuru robot team

The team who joined Maizuru consists of one faculty of the mechanical engineering department and three fifth-grade students. The robot proposed by the Maizuru National College Team is a flying robot. In this year's decommissioning robot contest, a number of teams proposed a flying robot, but all used multi-copters. In addition to the difficulty of limiting the usage time of electronic devices under radiation environments, the robots were required to move in rubble. The N.I.T. Maizuru team proposed an idea to use multiple balloons, divided into parent node and child node, to overcome this difficulty. The parent node balloons transported the tip of the fiberscope, and the child node carried the optical fiber and the electric cable. By changing the direction, only the direction of the parent node changed so that the change of direction for all nodes was completed. To utilize self-controllability, the balloon can keep the same altitude in any situation using an anchor cable. As the on/off control of the propulsion motor was sufficient, electronic devices were not installed. In addition, the imaging device was mounted onto the robot using optical fiber. The robot was able to avoid the influence of the radiation by moving to outside the radioactive area.



Fig. 3 Robot of the Maizuru team

Results and Discussion

After finishing the competition, we administered a questionnaire to find out the change in awareness before and after joining the waste furnace creation of Robocon. Three students, who participated from NIT, Maizuru, completed the questionnaire, all of whom were impressed with the decommissioning of the nuclear power plant reactor, resulting in the objective of this contest being achieved. Figures 4 to 6 show the questionnaire results.

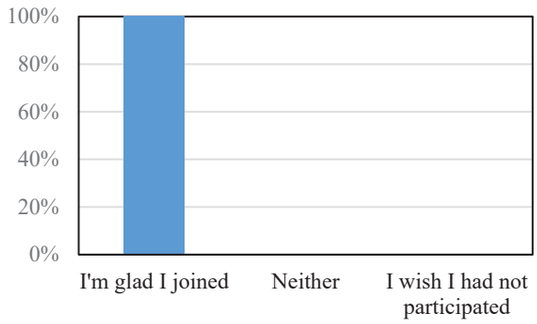

Fig.4 The answers to “What is your impression of participating in the waste furnace creation Robocon?”

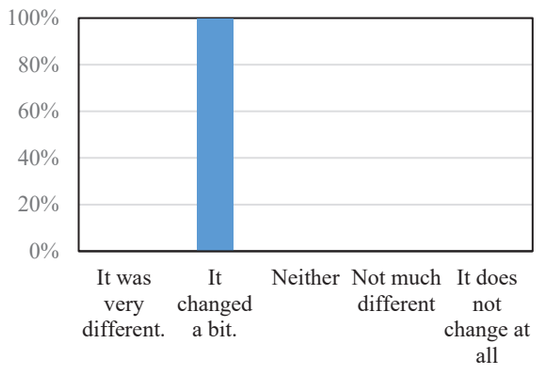

Fig.5 The answers to “Did you participate in this contest and did it change your thoughts on the Fukushima Dai-Ichi Furnace?”

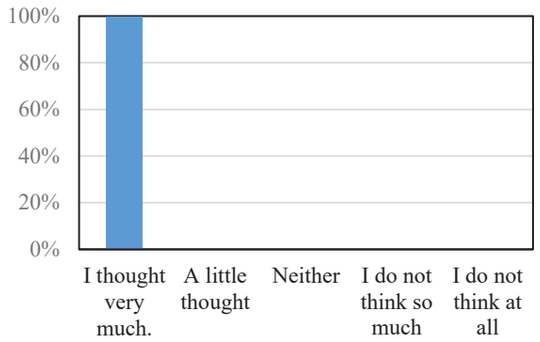

Fig.6 The answers to “Do you want to learn more about the Fukushima Daiichi Decommissioning Furnace, to study related technology, or perform research?”

Conclusions

The educational effect of the waste furnace creation of Robocon began with the purpose of increasing the interest from students of the nuclear power plant waste furnace, and led to verification of the responsible human resources for the waste furnace. The robots produced by the students proved to be of high quality, considering the limited time and budget provided and students’ manufacturing skills. Among them, some colleges of technology have proposed innovative ideas and have proven a high level of problem solving power.

Based on the results of the questionnaire, it can be said that all the students who participated from Maizuru college gained a strong interest after the contest on the decommissioning furnace and related technology, and the purpose of the contest was achieved.

SUSTAINING STUDENT INTEREST IN BUSINESS STATISTICS USING ICT-ENHANCED, APPLICATION-BASED BLENDED LEARNING

Eddie YEOU[*,a], PUAR Leong Sing[b] and Alan FONG[c]

[a]School of Business Management, Nanyang Polytechnic, Singapore
[b]School of Business Management, Nanyang Polytechnic, Singapore
[c]School of Business Management, Nanyang Polytechnic, Singapore

*eddie_yeou@nyp.edu.sg
[b]puar_leong_sing@nyp.edu.sg
[c]alan_fong@nyp.edu.sg

Abstract

This research aims to evaluate if an ICT-enhanced, application-based blended learning approach is more effective in improving the module performance and sustaining student interest in learning business statistics as compared to the traditional approach. Under the traditional approach, business statistics was taught mainly in a lecture-tutorial setting with the teaching staff demonstrating standard textbook lecture examples and students practising standard textbook tutorial questions. The opportunity for the application of statistical concepts to the real business world was limited. The deployed intervention adopted a blended learning approach. The teaching materials for e-learning topics such as regression & correlation analysis and statistical estimation were enhanced using e-learning tools such as PowToon and Articulate Storyline to illustrate how these topics could be applied to solve business problems across industries. Besides that, relevant free-to-use computer simulation exercises on the internet, were also introduced during face-to-face lessons in topics such as the sampling distribution of the sample means to allow students to experiment and "play" with parameter values, visualize and see for themselves how statistical theorems work. In terms of results, the module performance for the experimental group taught under the blended learning approach was compared with the previous cohort taught under the traditional approach (the control group). The experimental group had shown improvement in their business statistics module passing rate and average mark. The group also displayed greater motivation to apply their learning in real-world situations. The ICT-enhanced computer simulations used in the face-to-face lessons enabled students to learn by doing and seeing and promoted better understanding, retention and interest. In conclusion, ICT-enhanced tools and technology can provide effective ways to enhance module delivery. It is recommended that educators should deploy relevant and useful ICT applications to promote students' understanding and learning. Besides that, the focus of educators should be on the application of knowledge and theories to real life to sustain student interest and motivation.

Keywords: *ICT-enhanced, Application-based, Blended learning*

Introduction

Business statistics is a module that trains students to solve problems in a systematic approach. Through solving business statistics problems, students can learn to sieve and extract useful and relevant information from the business problems at hand (during the input stage); think critically and assess various options and alternatives (during the processing stage); before coming up with the final business decision (during the output stage). Although the module can provide excellent training opportunities to enhance the information processing and critical thinking skills of students (two important 21st century competencies), the traditional teaching pedagogy adopted by educators usually fails to arouse student interest and motivation in learning the module.

Traditionally, business statistics was taught mainly in a lecture-tutorial setting with the teaching staff demonstrating textbook examples during lectures and students practising standard textbook questions during tutorials. The focus of the traditional teaching pedagogy was mainly to let students memorize and practise standard procedures and statistical formulae to obtain the required textbook model solutions. The opportunity for the application of statistical concepts to the real business world was limited. Besides that, there was little emphasis to let students fully understand the business problems at hand; weigh and assess possible alternative choices and options before coming out with a final business decision.

The study aimed to evaluate if an ICT-enhanced, application-based blended learning teaching pedagogy was more effective in improving the module performance and sustaining student interest in learning business statistics as compared to the traditional approach. Based on the results obtained, the study hoped to offer pragmatic suggestions for educators and course designers to consider when they were developing learning materials for their modules.

Literature Review

The use of technology in teaching and learning was a valuable practice for supporting student learning and engagement (Cydis, 2015). Technology and ICT tools were also increasingly used in statistics education due to its many advantages in facilitating students' learning of statistical concepts. Chance et al. (2007) highlighted that technological tools could support the teaching and learning of statistics by providing automation of calculations, visualization of abstract concepts, emphasis on data exploration, and investigation of real-life problems. The automation of calculations allowed students to spend more time focusing on understanding and interpreting statistical results rather than burdening them unnecessarily on complicated calculations using statistical formulae. The visualization of abstract statistical concepts such as probability distributions and the Central Limit Theorem using computer simulations allowed students to experiment with different parameter values and analyzing the effects of the different parameter values on conceptual ideas. Thus, these computer simulations facilitated student learning by allowing them to learn by doing and seeing and not just memorizing abstract concepts. Zieffler et al. (2008) also encouraged the use of computer simulation tools and web applets to correct the faulty statistical reasoning by students.

Besides the use of technology, authentic learning was also highlighted by previous researchers as an effective instructional approach for teaching business statistics. Authentic learning allowed students to explore and discuss meaningful concepts in contexts that involved real-world problems relevant to the learner (Donovan, Bransford, & Pellegrino, 1999). Harrington & Schibik (2002) concluded that application-based learning by using business case studies was an effective tool for increasing student engagement in learning business statistics. Gandhi (2006) also suggested educators to promote the use of active learning through real-life project data to improve student statistical thinking.

Methodology

Based on the results and suggestions by the studies above, an ICT-enhanced, application-based blended learning approach was adopted in the teaching of the BM3034 business statistics module in 2017 semester 2. BM3034 business statistics module is a 60-hour compulsory core module for all year-one business students from the School of Business Management (SBM), Nanyang Polytechnic. In terms of module delivery, e-learning lessons constituted 18 hours (30%) of module delivery hours while face-to-face lessons constituted the remaining 42 hours (70%) of module delivery hours.

448 year-one students from the Diplomas of Accountancy & Finance, Banking & Finance, Marketing and Sport & Wellness Management, who took the module in 2017 semester 1, were assigned as the control group. 442 year-one students from the Diplomas in Business Management and Food & Beverage Business, who took the same module in 2017 semester 2, were assigned as the experimental group. The control group was taught using the traditional approach while the experimental group was taught using the blended learning approach. The 2 groups of students were homogenous across characteristics such as gender, age and mathematical abilities. (All students must obtain at least a GCE 'O' levels C6 grade in mathematics, or a GCE 'N' levels B4 grade in mathematics and a pass in mathematics in foundational bridging programmes.)

A comparison between the blended learning approach adopted and the traditional approach used for both e-learning lessons and face-to-face lessons in the module was shown in table 1 and 2 respectively below.

Table 1. Blended Learning Vs Traditional Approach for E-Learning Lessons

Blended Learning Approach	Traditional Approach
1. Materials E-learning content in descriptive statistics, regression & correlation and statistical estimation topics were enhanced using e-learning design tools such as PowToon and Articulate Storyline to illustrate how these topics could be applied to solve business problems across industries such as banking & finance, food & beverage, retail and entrepreneurship. The focus was on the application of theories and concepts to the real business world.	1. Materials Content in the e-learning topics were focused on the replacement of physical lessons towards e-delivery. Few attempts made to illustrate how these topics could be applied to the real business world.
2. E-Quiz Quiz questions related to the e-learning content were designed to let students probe deeper into the business problems to sieve and extract useful and relevant statistical data and information, interpret meaning and implications of the calculated statistical results, think critically and consider all options and alternatives before reaching the final business decision.	2. E-Quiz Quiz questions were mainly asked to let students practise standard procedures and statistical formulae to obtain the required tutorial model solutions.

Table 2. Blended Learning Vs Traditional Approach for Face-to-Face Lessons

Blended Learning Approach	Traditional Approach
1. Lectures Lecturers used relevant computer simulation exercises available on the internet in topics such as the sampling distribution of the sample means and continuous probability distribution to demonstrate how abstract concepts such as Central Limit Theorem (CLT) and normal distribution work.	1. Lectures Lecturers explained abstract statistical theorems and demonstrated standard lecture examples.
2. Tutorials Students experimented and "played" with parameter values using computer simulations of statistical theorems and learned by doing and seeing.	2. Tutorials Students memorized the statistical theorems and practised standard tutorial questions to obtain the required tutorial model solutions.

Under the ICT-enhanced, application-based blended learning approach, the content for e-learning topics such as descriptive statistics, regression & correlation and statistical estimation were enhanced to be application-based. The focus was on how the concepts learnt in these topics could be applied to solve real-world business problems across industries. The shift towards the application of statistical knowledge to solve business problems allowed higher-order thinking questions to be administered for students in the e-quizzes that followed. These quizzes trained students to probe deeper into the business problems at hand to sieve out useful and relevant data and information, interpret the implications of statistical calculations and assess alternative options and solutions before making the final business decision. In contrast, under the traditional approach, the e-learning lessons (content and e-quiz) were made to merely transfer the delivery mode from physical lessons to e-delivery.

For the face-to-face lessons, the new blended learning approach utilized relevant computer simulations of abstract statistical concepts in topics such as continuous probability distribution and sampling distribution of the sample means. One of the web applets used during the face-to-face tutorial lessons was the illustration of the Central Limit Theorem (CLT) by the "Rice Virtual Lab in Statistics". During the tutorial, students could experiment and "play" with parameter values such as different shapes of the parent population, and different sample sizes (n) chosen from the parent population to derive the shape of the sampling distribution of sample means through repeated sampling using the computer simulation generated by the applet. The students could learn the theorem, not just by memorizing it, but through experimenting with the web applet and seeing the results generated. Being able to generate and see the results from the computer simulation exercises by themselves, students could understand the theorem better and were more confident in applying it since they had convinced themselves that the theorem really worked through the simulation exercises. In contrast, the focus of the traditional teaching pedagogy was merely to let students memorize the theorem, and practise standard procedures and statistical formulae to obtain the required tutorial model solutions.

Results

The module performance (passing rate and average mark) and the semester module feedback of the experimental group (in 2017 semester 2) was compared with the control group (in 2017 semester 1). The experimental group had shown improvement in the business statistics module passing rate (from 95.09% to 95.92%) and average mark (from 64.02 to 65.55 marks) compared to the control group.

Based on the compulsory end-of-semester feedback data collected from all students taking the module in both semesters (measured on a 4-point ordinal scale: 1-Strongly Disagree, 2-Disagree, 3-Agree, 4-Strongly Agree), students had found the blended learning approach to be more effective in helping them learn the topics as well as interactive and engaging enough to sustain their interest (Figure 1).

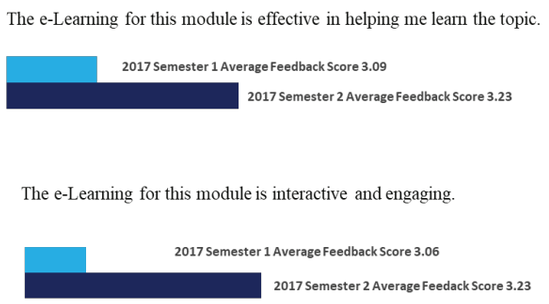

Figure 1. Semester Feedback Score for 2017 semester 1 and 2.

Discussion

Based on the improvement in module performance and module feedback in 2017 semester 2 as compared to 2017 semester 1, the ICT-enhanced, application-based blended learning approach is a more effective teaching pedagogy to sustain student motivation in learning as compared to the traditional approach of teaching. The new approach enabled students to appreciate that the topics they had learnt could be applied in the real business world. This created and sustained intrinsic motivation for students since they were now convinced of the value in their learning. The ICT-enabled computer simulations during face-to-face lessons

enabled students to learn by doing and seeing. These hands-on experiences deepened their understanding, retention of knowledge and interest in learning business statistics. The improved motivation, interest and understanding had also translated into better module performance in terms of passing rate and average marks.

Conclusion

ICT-enabled tools and technology can provide effective ways to enhance module delivery as seen in the study above. Educators need to focus on the users' and students' needs and learning styles to deploy relevant and useful ICT applications to promote their understanding and learning. This can be in the form of computer simulations and web applets which allowed students to learn by experimenting, visualizing the results obtained, forming their own conclusions to deepen their understanding. Besides that, technology and e-learning development tools can facilitate the creation of interesting and relevant e-learning content to enhance students' understanding. In this respect, the focus of educators should be on the creation of content that is related to the application of knowledge and theories to real life to create and sustain student interest and motivation in learning.

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AN OUTLINE AND OVERVIEW ON EXPERIENTIAL LEARNING ACTIVITIES FOR ENHANCING STUDENTS' ENGLISH FOR LEARNING STEM

R.C.S. Man* and K.C. Wong

Engineering Discipline Planning Office, Hong Kong Institute of Vocational Education, Hong Kong

* mcsing@vtc.edu.hk

Abstract

Upon the robust and rapid development of various technologies, the global demand for talents with high-quality STEM (Science, Technology, Engineering and Mathematics) knowledge and skill is increasing in the industry. STEM education has become a focus of global education over the past two decades since its firstly promoted in the United States in the 1990s. In STEM education, students are educated with interdisciplinary knowledge, problem-solving and innovative skills. However, there are many different factors to hinder the students from learning STEM knowledge. Language used in leaning STEM is one of the barriers to students, especially for the students whose first language is not English whereas English is a typical language traditionally used for interpreting STEM knowledge. In many cases, learning STEM in English is unavoidable as most of the latest STEM knowledge is published in English. Therefore, it is important to address this issue.

Recently, an attempt was made to design and implement a series of strategic and experiential teaching and learning activities for enhancing students' English for learning STEM, and hence to improve various skills of students in acquiring and applying their knowledge. Apart from enhancing English for learning STEM, by adopting a mixed traditional and non-traditional way of teaching and learning, the students' interest to STEM could be substantially increased. Students are inspired to learn STEM and to apply their STEM knowledge in solving problems. In terms of learning English for STEM, this paper aims to present and discuss the methods and activities designed and implemented for English learning for STEM education. The feedbacks from students are also evaluated. Recommendations for improvement are suggested at the end.

Keywords: *English for STEM, experiential learning, Interactive learning, learning and teaching tools, STEM education, student competition, student workshop, teaching strategies*

Introduction

Over the past two decades, STEM education has become a focus of global education because of the strong demand of talents for driving the development of various technologies. In STEM education, students are educated with interdisciplinary knowledge, problem-solving and innovative skills that are crucial to their personal development. However, there are many different factors to hinder the students from learning STEM knowledge effectively. Language used in learning STEM is one of the barriers to students, especially for the students who first language is not English, like most of the students in Hong Kong. In Hong Kong, most of the sub-degree or above levels of students who are studying STEM related programmes are required to use English as a medium of instruction in classes. Whereas English is a typical language traditionally used for interpreting STEM knowledge. In many cases, leaning STEM in English is unavoidable as most of the latest STEM knowledge is published in English. Therefore, it is important to address this issue. In order to help students to tackle the language barriers and to raise their interests in learning STEM knowledge, a series of strategic and experiential teaching and learning activities were proposed to enhance students' English for learning STEM at higher diploma level.

This paper will describe the designed strategic and experiential teaching and learning activities, elaborate on the impact of the activities to the students, evaluate feedbacks from students in some of the activities, and suggest some recommendations for improvement of the activities.

Experiential learning

In simple definition of experiential learning, it is interpreted as learning from experience or learning by doing (Schwartz, 2012). Upon "learn by doing", students would apply knowledge to experience and develop skills or new ways of thinking (Lewis & Williams, 1994). For an extended definition, experiential learning is a process through which learners develop knowledge, skills and values from direct experiences outside a traditional academic setting (University of Colorado Denver, 2018). Experiential learning encompasses different activities including internships, service learning, undergraduate research, study abroad, and other creative and professional work experiences.

Experiential learning can be described as a four-stage cyclic process that an individual can start from any stage but the sequence of the stages remains the same as shown

in Figure 1 (Lam and Chan, 2013; Henton, 1996). The four stages included:

- Concrete experience (Doing): Students obtain hands-on experience on problem solving tasks through engagement of learning activities.
- Reflection (Observing): Students review and reflect on their process either individually or in group by recalling their memory or looking at records of the learning activities.
- Abstract conceptualization (Thinking): Students generalize knowledge and theory from the previous experience based on the reflection.
- Active experiment (Planning): Students modify existing concepts and knowledge with the new knowledge and theory they obtain and apply in later occasions.

This cycle can enable students to develop various skills in problem solving, for example, analyzing, synthesizing and evaluating (Ministry of Education, 2018).

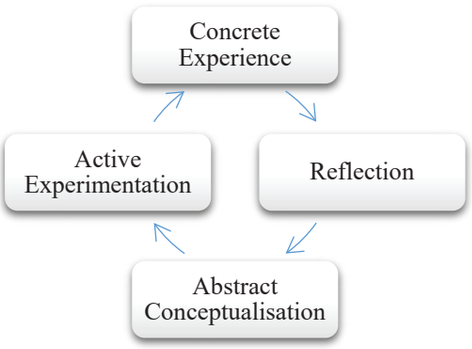

Figure 1: Experiential learning cycle

Designed experiential teaching and learning activities

In the curriculum of the group of higher diploma students under the study, the students have to complete an industrial attachment, which the students are required to attach to a company or organization of relevant field of study for a period to obtain work experience. At the same time, the students have to identify industry-related topics for their final-year projects – industrial-based student projects (IBSPs). Through the industrial attachment and the IBSP, students can obtain valuable experiential opportunities to apply their STEM knowledge from classroom and acquire new knowledge and skills by going through the experiential learning cycle. During the industrial attachment, students can obtain hands-on experience on various tasks that given by their employers (Doing). Throughout the attachment period, students have to log down the tasks that they work on, as well as review and reflect what they have learnt in the process (Observing). The students have to generalize the knowledge and theory learnt from the experience based on the reflection (Thinking). The above process can simulate their thinking to identify the topics for their final-year projects that allows an opportunity for them to modify their existing concepts and knowledge with new knowledge and theory they obtained, and apply the new concepts and knowledge in the project or later occasions (Planning).

The industrial attachment and the IBSP combined as a main stem of the experiential teaching and learning activities for learning STEM knowledge. The students have to complete their IBSP reports and presentations of their identified industry-related topics. According to previous experience and general observation, the students often find difficulties in writing a formal report and giving a presentation of STEM related topics. There are difficulties for the students to organize, collocate and express their ideas and findings. Besides, some students under-performed may because of their weaknesses in understanding STEM knowledge in formal classes. It is observed that English proficiency is one crucial hurdle for the students to understand STEM knowledge.

To enhance students' English in learning STEM, the experiential teaching and learning activities are extended (see Figure 2). Along the main stem of the experiential teaching and learning activities, a STEM project presentation competition was held. The students were invited to join the competition. In the competition, the students were required to give a ten-minute English presentation on a STEM project which could be developed from their IBSP. Through competition, it was aimed to boost the performance of students in the use of English and presentation skills on one hand. On the other hand, it was aimed to increase the interest and incentive of students in learning STEM.

Before the competition, as a base to improve students' English, lectures on writing and presentation were organized. A native English-speaking lecturer with STEM background was employed to give the lectures to the students with the aim to allow the students more opportunities to practice and communicate with a native English speaker. In the delivery of lectures, the lecturer tried to keep it informal to create a relax and comfortable atmosphere for students to practice English. Different interactive activities were conducted in the lectures. Some mini games that incorporated with the use of technology and online education tools were carried out. For example, in the recap of the concepts delivered in previous lectures, a mini game that worked with an online education tool, called "Kahoot!", was applied. "Kahoot!" is a game-based learning platform that enable teachers to set up multiple-choice quizzes that allow students to access via web browsers by using mobile devices. Students can access the quiz and compete with others by determining the one who can answer all the questions correctly with the least time. "Kahoot!" is an interesting tool to reinforce students' learning. It can be used to review students' knowledge and especially it can log the quiz results of students for reference (Kahoot, 2018). However, it cannot be overused because students may lost the interest. Sometimes, the students may not get down to the quiz.

On top of the lectures delivered to the students, other experiential teaching and learning activities or supports are provided to the students. STEM English help desk by native English-speaking lecturer was organized to

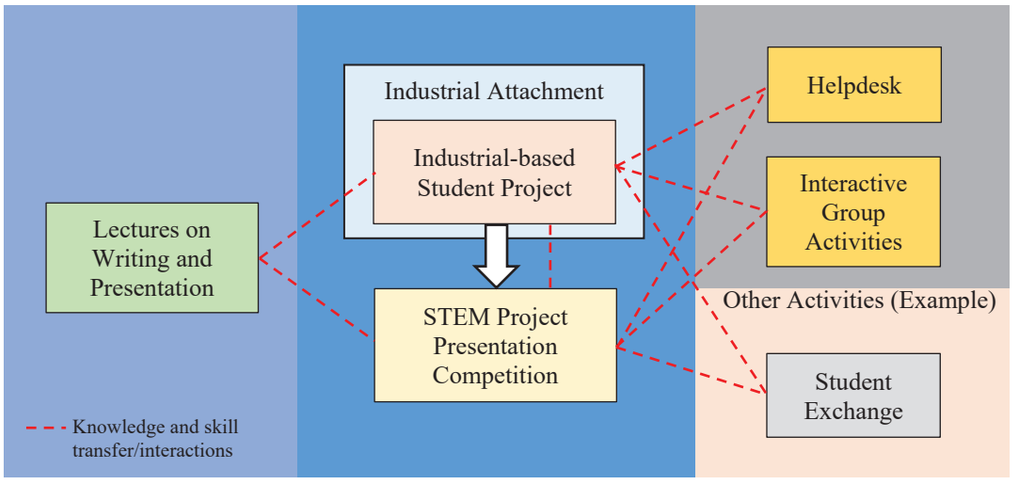

Figure 2: Designed experiential teaching and learning activities

provide STEM English enhancement support to the students. This could further extend the opportunity for students to practice English outside the class. Besides, students could also join the interactive group activities organized by the STEM center of the institute. The activities were conducted in English. The activities could facilitate the students to learn from experience and allow peer learning.

Furthermore, student exchange programmes with overseas institutions were organized to allow students to experience the STEM education in an English-speaking environment. Through the interactions with foreign students, language acquisition could be achieved through practical immersion. The international learning and knowledge could propel students towards acceptance and understanding of different cultural and community perspectives. Valuable experience leading to the enhancement of global vision, self-confidence and self-esteem could be gained by the students in the exchange programmes.

Pilot questionnaire survey for feedbacks from students

As a pilot study on the effectiveness of the designed experiential teaching and learning activities, a questionnaire survey was conducted to obtain some feedbacks from the students who have participated in the activities, mainly focused on IBSP and STEM project presentation competition.

The questionnaire survey was divided into two parts, A and B. Part A of the survey asked students to conduct a self-evaluation on their various aspects of improvement in learning STEM and English for STEM after the IBSP and the STEM project presentation competition. The students were requested to rate their improvements on a 10-point scale: from "1" for "unsatisfactory" to "10" for "excellent". The following nine aspects of improvement were asked:

A1. Improvement on students' learning
A2. Improvement on trade knowledge
A3. Improvement on problem solving skills
A4. Improvement on communication skills
A5. Improvement on presentation skills
A6. Improvement on written English
A7. Improvement on oral English
A8. Improvement on self-learning ability
A9. Interest in STEM

Part B of the survey asked for the students' perceptions on the effectiveness of experiential learning (B1). The students are requested to rate their perceptions on a 10-point scale: from "1" for "unsatisfactory" to "10" for "excellent".

Results and discussions

A total of 12 students completed the pilot questionnaire survey. The average rating on each of the aspects in Part A and the average rating on the effectiveness of experiential learning in Part B were calculated. The results are shown in Figure 3. Horizontal axis of the figure refers to the questions/aspects asked in the two parts of the questionnaire, while vertical axis of the figure refers to the average rating calculated. Satisfactory improvements were found in the nine aspects concerned according to the self-evaluations of the students. All the nine aspects of improvement under the study obtained average ratings of higher than 7. Among the nine aspects, relative larger improvement on self-learning ability was perceived by the students. The students found they have well improvements in problem solving skills and communication skills after the activities. Focusing on the improvements in language abilities and presentation skills, similar results were found in students' written English, oral English and presentation skills with average ratings of 7.8, 7.9 and 7.8 respectively. Besides, the students' interests in learning STEM was greatly increased (average rating = 8.3). It seems that the experiential teaching and learning activities could effectively increase students' interests in learning and stimulate development of students in different aspects. Overall, the students found the experiential learning approach was effective (average rating = 7.5).

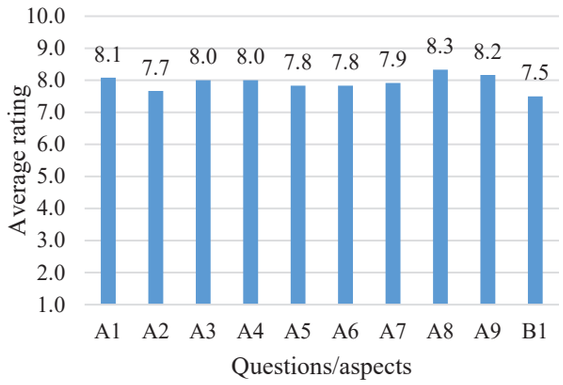

Figure 3: Average ratings of different aspects asked in the questionnaire survey

Limitation and recommendations for improvement

Though satisfactory results on the self-evaluation of the students were obtained in the pilot questionnaire survey, further verification on the improvements and performance of the students should be conducted to provide a stronger support on the effectiveness of the designed experiential teaching and learning activities for enhancing students' English for learning STEM or even enhancing different skills of students applicable in learning or working.

As far as the effectiveness of the designed experiential teaching and learning activities is concerned, the effectiveness can be further increased by the application of technology. Online forum or chatroom support, or even instant messaging tools, for example telegram, can be used for creating a space for learning and communication in a large class setting with the intention to create an informal learning community for peer learning.

Conclusions

This paper presented an outline and overview on the application of experiential teaching and learning activities to enhance students' English for learning STEM.

According to a pilot questionnaire survey on the students' who participated the designed experiential teaching and learning activities - IBSP and STEM project presentation competition, positive results were obtained to demonstrate the effectiveness of the activities. The positive impact on students was not just limited to English improvement but also improvement in learning STEM knowledge and personal development of the students. Further investigation on the effectiveness of the whole package of the strategically designed experiential teaching and learning activities for enhancing students' English for learning STEM can be conducted in the future.

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INTRODUCTION OF SOME APPROACHES FOR EDUCATIONS OF ROBOT DESIGN AND MANUFACTURING

T. Matsuo[*,a], M. Tatsuguchi [a], T. Higaki [a], S. Kuchii [a], M. Shimazu [a] and H. Terai [a]

[a] Department of Creative Engineering, National Inst. of Tech, Kitakyushu College, Japan

*matsuo@kct.ac.jp

Abstract

Recently, educations for development of robots attract attentions. The robot educations can make students to have interest in manufacturing through development of robots. Our Course has a practical training which is called "Practice of Creating Robot I" from 2018 for the 4th grade students. In this practical training, students are developing mobile robot which is able to carry some objects using limited materials and components which are an aluminum plate, two aluminum bar of different diameter, three stepping motors for actuating arm which is enable to carry objects. A mobile robot is given to each group and students can design arm for carrying objects on the mobile robot. Some gears and shaft bushes are able to be selected and used freely. At first, students are divided into 20 groups. Each group consists of 3 or 4 students and consider method of carrying objects, structure of their robot and so on. Then, they decide details of mechanism using 3DCAD and redesign structure of their robot. After that, they design some components and assembly diagram of their robot by hand. After 6 month into this practical training, each group presents an interim report and 20 ideas are narrowed down to around 10 ideas. Students of 10 group who are not selected their idea join into selected group, and start to manufacture based on some components and assembly design of their robot. This practical training underlies "Practice of Design and Manufacturing" which is traditional practical training of our course. "Practice of Design and Manufacturing" were practical training and students developed a crane type robot. In "Practice of Creating Robot I", a crane type robot is extended into a mobile type carrying robot. This paper shows our longtime approaches which are enable to realize educations of development of robots and propose some method of design and manufacturing.

Keywords: *robot design and manufacturing, robot education, PBL, active learning*

Introduction

Recently, the development of robots and social advancement attract attention with the rapid development of science and technology, and opportunities for robots to be active in society have increased. Since the 1980's, industrial robots have been used in the automobile industry, and have been doing work such as welding, painting and assembly. At present, automatic driving robots applying robot technology and home cleaning robots also attract attention in the development of home appliances and automobiles. Subjects concerning the training of robot engineers in engineering education are indispensable, and in recent years, it is one of theme that various educational institutions are working on. National institute of technology, kitakyushu college was established in 1965 and consists of Department of Machine Engineering, Department of Electrical and Electronic, Department of Materials Chemistry, Control and information system engineering until 2014, therefore it was reorganized into the Department of Production Design Engineering in 2015. In the Creative Department of Engineering, the 1st and 2nd year students study fundamental subjects for engineering. From the 3rd year, the students will choose one specific engineering course from five specialized ones as their expertise: Machine Systems Engineering Course, Robotics and Mechatronics Course, Electrical and Electronic Engineering Course, Information and Systems Engineering Course and Materials Chemistry Course. This education system provides the students with opportunities to learn basis of knowledge and technology in wide engineering fields as well as to acquire advanced expertise about the engineering field in which they are interested. Robots need to recognize environments and own conditions, manage some information and decide behavior for carrying out complex works which are worked by human. Moreover, robot technologies are used in appliances and automatic operating systems of cars and one of the most important technologies for resolving some social issues. In robotics and mechatronics course, an education curriculum was constructed, which is enable to acquire interface, robot design, embedded system, intelligent technology, system control and system integration. In this paper, we introduce the educational approach for training robot engineers in this course.

Contents of the previous curriculum

The previous curriculum had some contents for students were able to learned mainly about mechanical engineering, computer science and control engineering, and engineers who are able to create interfaces which combine computer and machines were developed. In this section, typical classes of the previous curriculum were introduced.

Practice of fundamental robotics: The Practice of robot fundamental robotics had a purpose that students were able to learn some fundamental knowledge required robots control throughout lectures and practices. In the lectures, students learned histories of control engineering, some method of robots control and outline of control using sensors and a computer. In the practice, students carried out manufacturing an autonomous robot and programing by using a practice kit called "Robodesigner" and produced by JAPAN ROBOTECH, and learned fundamental methods realized motions using sensors and computer as shown in Figure 1. Visual programing tool called "TiColla" was employed as the programing tool and robot programing was carried out combining function blocks of TiColla as shown in Figure 2. In this practice, basic practice such as programming and experiments related to input processing from the touch sensor and infrared sensor are carried out, and the control program of an autonomous mobile robot such as a line trace robot and an obstacle avoiding robot is created and the robot operation is confirmed.



Figure 1 Overview of practice

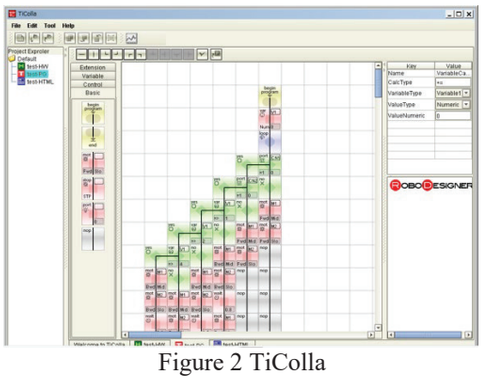


Figure 2 TiColla

Sensor technology engineering: The purpose of sensor technology engineering is to understand fundamental points of hardware control using sensors and to learn interface technology which combines machines and computers. In the lecture, students learned operating principle of several sensors such as thermocouple, strain gauge, infrared sensor and so on. A thermocouple is a thermometer that makes a circuit by bringing the tips of two types of metal wires into contact with each other and measures a temperature difference through a Thermal electromotive force generated at the junction. Some methods and principles of creating interface circuit as shown in Figure 3. In the experiments, circuits using micro-computer, sensors and Discrete electrical parts were created. PIC micro-computer was employed as the micro-computer and students learned fundamental embedded technology such as IO control, AD conversion, serial communication between PC and PIC, interrupt control, PWM control and so on. Additionally, PBL are was carried out; students discussed and surveyed about some problems of sensor technology, and presented the result.

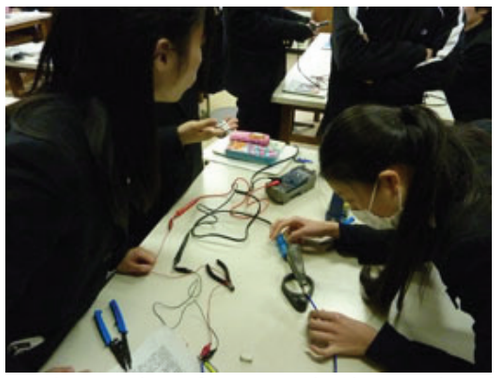


Figure 3 Overview of Sensor technology engineering

Practice of design and manufacturing: In Practice of design and manufacturing, students learned how to solve the problem by applying mechanical engineering, control engineering etc. with the theme of designing and manufacturing cranes. the class was divided into 10 groups and designed and manufactured a crane for each group. The crane operates on the field as shown in Figure 4,5. A function to move the weight of about 300 g as shown in Figure 6 from a start point to finish point is required for the crane and students can use two aluminum bares of different diameter and an aluminum plate as materials and gears and shaft bushes can choose what they need for each group. Three stepping motors can be used as actuators, and cranes were designed and manufactured by combining motors, gears, bushes, and aluminum materials. Students designed in the second semester of the fourth grade and manufactured in the first semester of the fifth grade. Students manufactured robots using some processing machines such as Lathes, Drill machines, a Shearing Machine and so on as shown in Figure 7. Then, they assembled their robots and created a circuit for the crane control as shown in Figure 8,9. Finally, presentations were carried out and qualities of the robots were evaluated.

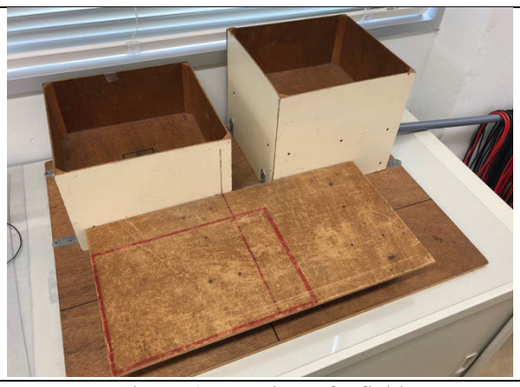


Figure 4 Overview of a field

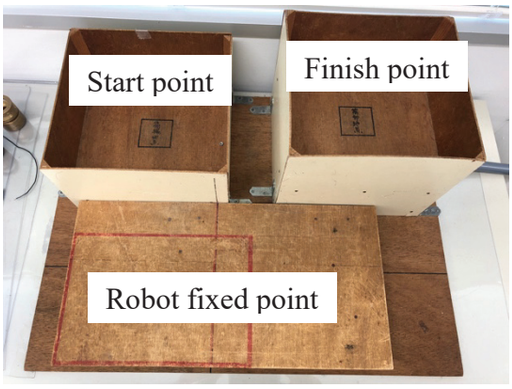


Figure 5 Start point, finish point and robot fixed point.



Figure 6 weight carried by a crane



Figure 7 Manufacturing robot parts using a lathe



Figure 8 overview of assembly works

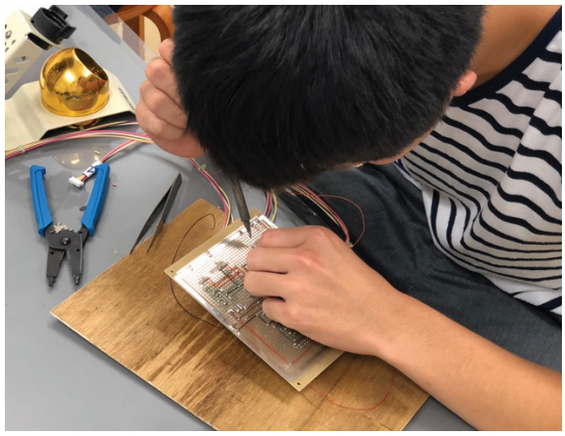


Figure 9 Creating a circuit for robot control

Problem of the previous curriculum: In the previous curriculum, several classes were conducted and students got some beneficial effects. However, some problems were appeared. In practice of fundamental Robotics, a visual programming tool was employed as a programming tool and students could understand the robot behavior easily. On the other hand, how robot behaviors are expressed using C programming language. There was a problem that consistency was not given between practice of fundamental robotics, sensor technology engineering and practice of design and manufacturing because programming languages were different in those class.

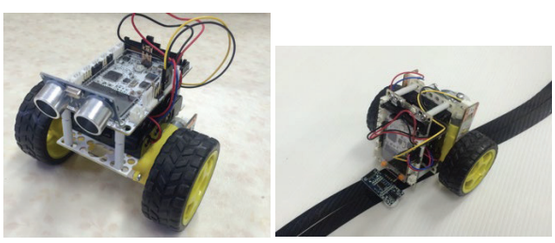
In sensor technology engineering, it was very effective for students to make circuits using a breadboard, however some problems appeared because of bad electrical contact and others. As one of the problems, it was difficult to find the point of bad electrical contact, therefore it took students long time to correct. In additionally, programming of the PIC microcomputer was advanced, so it was difficult for students to understand the essence of the program.

A class of practice of design and manufacturing was conducted for long period and several ideas were produced. Accordingly, it was difficult for students to come up with a new idea. So, we needed to change the theme and enable students to create several new ideas.

Contents of the current curriculum

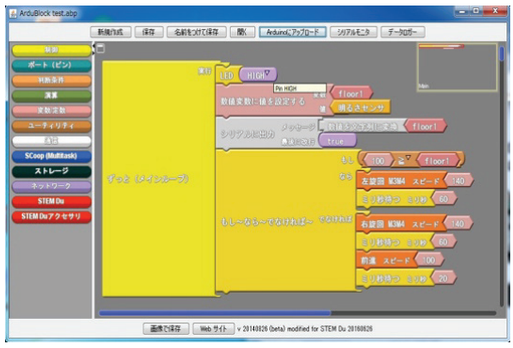
Feature of the current curriculum: In the new curriculum, as purposes of unifying the programing language and simplifying the circuit making, we chose “Arduino” as using a micro-computer. Fundamental points are the same as C language, though a programing language of Arduino has some characteristic points, and students are able to use “if statement”, “for loop” and so on for the programing of Arduino. Programing of Arduino is easier than programing of PIC micro-computer, and it is enough to learn some fundamental programing and principles of micro-computer such as IO control, AD conversion, serial communication, PWM control, interrupt control and so on. Additionally, Arduino is a micro-computer module constructed fundamental circuits, therefore students just construct circuits of motor control, led control and so on. Student can focus on their learning. In lower grades, we adopted visual programming for Arduino's programming and also made it possible to check the program structure of actual Arduino. We further developed class of design and manufacturing, and set up the contents of the practice that motivates students' creativity. In this section, typical classes of the current curriculum were introduced.

Fundamentals of Engineering II: Fundamentals of Engineering II carries out the basic contents of 5 courses in an omnibus style. The other four courses provided lectures and exercises on the basis of each specialized field such as Mechanical engineering, Electrical and electronics engineering, Information engineering, Chemical engineering, Bioengineering and so on. In our intelligent robot system course, we carried out two lectures on the foundations of robot engineering, control engineering, mechanical engineering, and carried out two robot production practices. In the robot production practices, students created an obstacle avoidance robot (Figure 10(a)) and a line trace robot (Figure 10(b)) using the robot kit "ROBO DESIGNER +" sold by JAPANROBOTECH. A microcomputer module of this robot is compatible with Arduino. “ArduBlock” was employed as a programming tool. ArduBlock is an Arduino extension program that allows you to develop Arduino IDE programming with a combination of working blocks. Also, since you can actually output the Arduino IDE program as shown in Figure 11(a)(b), students can see what structure of program actually will be. In engineering foundation II, we aimed students to be interested in robots by programing and production of robots.



(a) (b)

Figure 10 A robot kit “ROBODESIGNER +” (a) an obstacle avoidance robot (b) a line trace robot



(a)



```
sketch_jan30a §
#include <STEMDu.h>

STEMDu _STEMDU_robot = STEMDu();
int _ABVAR_1_floor1 = 0 ;

void setup()
{
  Serial.begin(9600);
}

void loop()
{
  _STEMDU_robot.led((bool)HIGH);
  _ABVAR_1_floor1 = 0 ;
  Serial.print("message");
  Serial.print(" ");
  Serial.println();
  if (( ( 100 ) >= ( _ABVAR_1_floor1 ) ))
  {
    _STEMDU_robot.leftM3M4(140);
    delay( 60 );
  }
  else
  {
    _STEMDU_robot.rightM3M4(140);
    delay( 60 );
    _STEMDU_robot.forwardM1M2(100);
```

(b)

Figure 11 programming using ArduBlock. (a) A visual programing of ArduBlock. (b) A program source outputted by ArduBlock.

Embedded system practice II: In embedded system practice II, students learn the basics of embedded technology. Because class of embedded system practice II is a subject that followed the contents of sensor engineering technology, students develop robots for each group in the class. Students learn about how to build an embedded system by practicing in 20 groups. They learn Led control and switch as practice of IO control and serial communication for communication between PC and Arduino. In addition, students learn about difference between analog signal and digital signal, experiment about AD conversion, and learn how to read the AD converted value to PC by serial communication. Then, they learn about interrupt control which is one of the important concepts for constructing embedded system, experiment about timer interrupt, and learn the importance of interrupt control. Finally, in order to realize motor control which is one of the important technologies for moving the robot, learn the concept of PWM control and create a mobile robot that can be controlled by serial communication with the PC as shown in Figure 12. This robot has a circuit created with Arduino, breadboard and some discrete electrical parts on the mobile cart, so it can operate by commands from PC and read information from touch sensors to avoid obstacles. As a summary of the practice, students create

control programs and circuits for this robot and learn the basics of system integration.

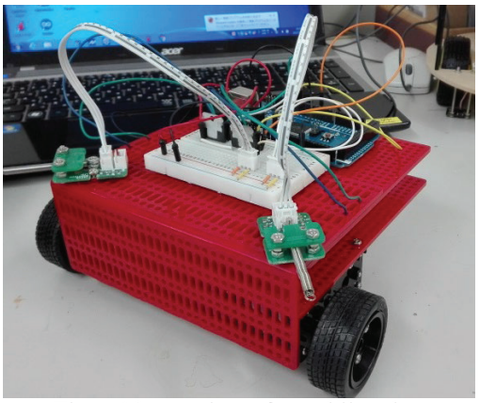


Figure12 overview of a mobile robot

Robot creating practice I: Because class of robot creating practice I is a subject that followed the contents of practice of design and manufacturing, students develop robots for each group in the class. At the end, we will conduct a competition and evaluate the presentation and the quality of the robot. In the first semester, students divided into 20 groups and designed the robot. In the second semester, ten ideas are selected from 20 ideas, reorganize the group and start to manufacture the robots. When choosing ten ideas, it is decided by the student's vote. This aim is to raise the awareness of the students and to activate the discussion. A robot manufactured in practice of design and manufacturing class is a crane type robot that does not have a mechanism for moving a field, whereas class of robot creating practice I will develop a baggage carrying robot that can freely move a field. At the last time of the classes, we will hold a competition and evaluate the presentation and the quality of the robot. In order to evaluate the quality of the robots, battle-style game will be held by the robots. Competition are carried out in the fields shown in the Figure 13 each team is divided into a blue team and a red team, carry baggage and put baggage in the red and blue areas. The baggage has structures as shown in the Figure 14, and points are different depending on the size and shape of the hook. The baggage is placed in the center of the field in Figure 13. Robots do not put baggage directly in the red / blue field, but they must be transported in a box once mounted on the robot. Based on the above, the robot to be developed is required to have a function to lift the package and put it in the box, a function to move the baggage to team's field, and a function to put the baggage out of the box and put it in team's field. Students are provided with a mobile robot as shown in Figure 15 so that the students have to consider the structure of the arm part for picking up baggage, the method of installing a box containing baggage and put out it from the box. Other materials, stepping motors, gears, bushings are provided as with Practice of design and manufacturing. In the first semester term, 20 teams have completed the design, and as an example there is an idea as shown in Figure 16. This idea is to scoop baggage by rotating boards, put them in a box, boxes are up and drops the baggage to their own field.

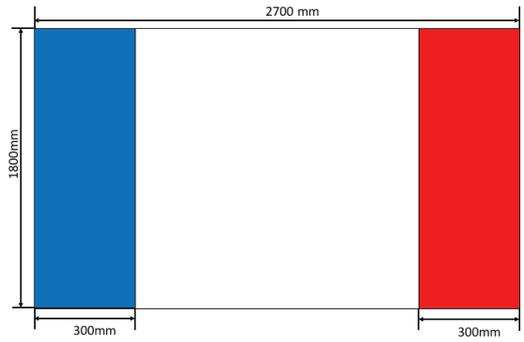


Figure 13 Field of competition

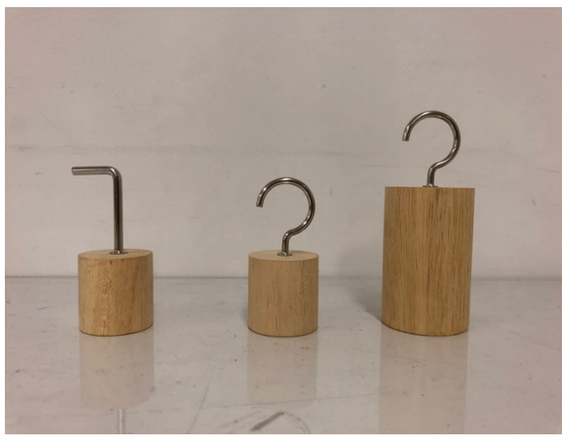


Figure 14 Structures of baggage. Weight of small baggage is about 40g. Weight of big baggage is about 110g

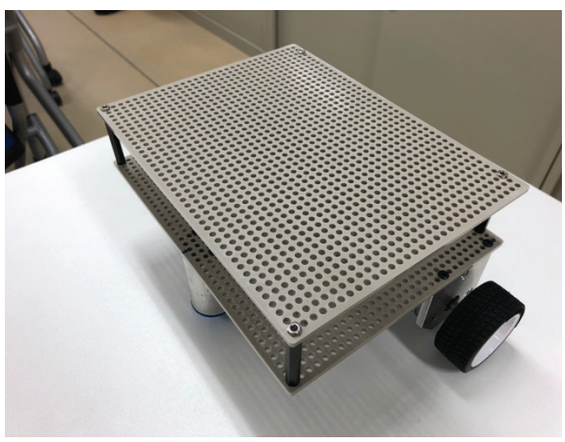


Figure 15 a mobile robot

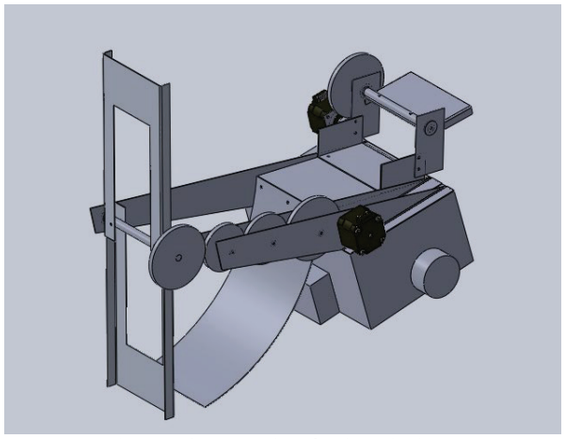


Figure16 Example of robot design

Conclusions

Some approach of our school's intelligent robot system course for robot engineer training were introduced. We adopted Arduino to unify the programming languages in fundamentals of engineering II of the second grade, embedded system practice II of the third grade, robot creating practice I of the fourth grade and to simplify the circuit production. In engineering foundation II, we aimed students to be interested in robots by programing and production of robots and robot production was carried out. In embedded system practice II, students learned the basics of building an embedded system using Arduino and experiments about IO control, interrupt control, PWM control, serial communication, AD conversion and so on were carried out. In robot creating practice, contents of practice of design and manufacturing were followed, and designed and manufactured a baggage carrying robot. In the first semester, 20 teams have completed the design and they will manufacture the robots from the second semester. At the last time of the classes, we will hold a competition and evaluate the presentation and the quality of the robots. As a future schedule, we will incorporate lesson on robot intelligence in fifth grade and deepen knowledge of robot development.

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AN APPROACH TO ENCOURAGE ALL KOSEN IN JAPAN TO USE THE EVALUATION INDICATORS OF ACHIEVEMENT IN ENGINEERING EXPERIMENTS

K. Takamura [*, a], S. Mitsui [a], S. Kano [b, d] and J. Kobayashi [c, d]

[a] National Institute of Technology, Asahikawa College, Japan
[b] National Institute of Technology, Suzuka College, Japan
[c] National Institute of Technology, Hakodate College, Japan
[d] Educational Research Office, National Institute of Technology, Japan

*takamura@asahikawa-nct.ac.jp

Abstract

In Japanese higher education, there has been a great emphasis on guaranteeing the quality of education. Each school of the National Institute of Technology, Japan (NIT, or KOSEN) had individually been making an effort to enhance students' experimental skills. However, there had been no consensus as to what kind of abilities students should acquire before they graduated, and it had been difficult for us to thoroughly ensure the quality of education. In order to solve the problem, KOSEN recently established the Model Core Curriculum (MCC), which clarifies the abilities and skills each student should acquire while at college whichever college they belong to. Moreover, in order to carry out the experimental section of the MCC properly, the present authors launched a project and developed a set of new indicators to evaluate the KOSEN students' achievement in engineering experiments. The evaluation indicators are now used by only eleven out of fifty-one KOSEN colleges (Hakodate, Tsuruoka, Sendai, Oyama, Nagaoka, Kisarazu, Gifu, Suzuka, Niihama, Tokuyama, and Miyakonojo Colleges), which have participated in the project.

The aim of this paper is to introduce our new approach to spread the use of the evaluation indicators mentioned above to all KOSEN in Japan. System of our evaluation indicators consists of three parts. In the project, we first made a common guideline to make textbooks in all fields in engineering experiments; i.e., Mechanical, Material, Electrical and Electronics, Information, Chemistry and Biochemistry, Civil, and Architecture engineering. The guideline proposes three levels of achievement (Level 1: knowledge and memory; Level 2: comprehension; and Level 3: application, which was determined based on the Revision of Bloom's Taxonomy). Second, we made a total of more than 200 model textbooks on experiments based on the guideline. Third, we made evaluation sheets for each model textbook.

In our new approach to promote the use of the evaluation indicators, we made instruction books which show how to use the model textbooks and evaluation sheets we developed. In addition, we showed how to make new evaluation sheets for the experiment textbooks each Kosen had individually made before. We also propose the way to modify each Kosen's original textbooks on experiment so that they can easily make evaluation sheets for the textbooks.

Keywords: *engineering experiment, evaluation, achievement, KOSEN, model core curriculum, skill sheet*

Introduction

The National Institute of Technology (NIT or KOSEN), which an institution of higher education in Japan, offers a five-year unique education system for engineering. In higher education, there has been a greater emphasis on guaranteeing the quality of education. The model core curriculum (MCC) in KOSEN, which summarizes skills and attainment target outcomes, was released in 2012 as a tentative plan and in 2018 as a regular plan. The MCC list the skills that students should acquire over the course of their 5-year education, and the attainment levels for each skill (e.g., Kuroda, 2016; NIT).

It is one of most important classes to do scientific experiments, workshop training, and practical manufacturing in the curriculum of KOSEN. Each KOSEN college had individually been making an effort to enhance students' experimental skills. However, there had been no consensus as to what kind of abilities students should acquire graduating from KOSEN. Therefore, a standard way to evaluate engineering experiments throughout KOSEN has not been established.

Very recently, in order to carry out the experimental section of the MCC properly, the present authors launched a project and developed a set of new indicators to evaluate the KOSEN students' achievement in engineering experiments. This is the first approach to be developed for many fields of engineering under a common guideline. (e.g., Takamura, 2017; NIT).

The evaluation indicators are now used by eleven KOSEN colleges, which are Hakodate, Tsuruoka, Sendai, Oyama, Nagaoka, Kisarazu, Gifu, Suzuka, Niihama,

Tokuyama, and Miyakonojo. They have participated in the project named "Experimental Skill Project".

In this report, we introduce our new approach to spread the use of the evaluation indicators mentioned above to all KOSEN in Japan.

Asahikawa experimental skill project

A project to develop evaluation indicators related to engineering experimental skills was begun in 2015. System of our evaluation indicators consists of three parts. In the project, we first made a common guideline to make textbooks in all fields in engineering experiments; i.e., Mechanical, Material, Electrical and Electronics, Information, Chemistry and Biochemistry, Civil, and Architecture engineering. The guideline proposes three levels of achievement. Second, we made a total of more than 200 model textbooks on experiments based on the guideline. Third, we made evaluation sheets for each model textbook.

The attainment targets in specialized skills required for engineers through specialized experiments are defined in the following 3 levels: Level 1 – knowledge and memory; Level 2 – comprehension; and Level 3 – application. These levels were based on the Revision of Bloom's Taxonomy (cognitive domains) (e.g., Anderson and Krathwohl, 2001). A rubric for experimental skills that did not depend on the field was proposed (e.g., Mitsui, 2016; Takeichi, 2016).

We also drafted a common guideline for textbooks on experiments in all fields of engineering. The following is an example of the guidelines: As a general rule, in a textbook for level 1, authors should write documents using a fill-in-the-blanks format or lists. For level 2, documents should be carefully detailed so that students can perform the experiments reading along with the textbook. Level 3 documents are written for those able to perform the experiments by themselves. Under the common guidelines for writing textbooks, we made "model textbooks for experiments" in the 7 fields of engineering.

A teacher should use the experimental textbook model and the experimental skill sheet in pairs for the evaluation. We also prepared a column for self-evaluation, to check students' own sense of their attainment level. Table 1 shows typical experimental skill sheet for evaluation in electrical and electronics engineering. If an attainment level is different, the attainment target for the experiment also changes. For examples, in Level 1, students can perform the experiments by filling in the blanks of the textbook. Meanwhile, by Level 3, students can perform the experiments by themselves, even if they require a bit of advice.

Students carried out experiments and practised using the experimental textbook model and skill sheet at 10 KOSENs and in 7 fields of engineering. We also compared student self-evaluation results with those by the teacher. We produced more than 200 new teaching materials for engineering experiments (textbook models and evaluation sheets) based on our guideline in the 7 fields of engineering. A total of more than 2,000 students carried out experiments using our materials.

We assume that a teacher uses "model textbook for experiments" and "experimental skill evaluation sheet" in pairs for the evaluation, which calls them "the experimental skill set"

Instruction books to use the evaluation indicators

In our new approach to promote the use of the evaluation indicators, we made instruction books. They show how to use the model textbooks and evaluation sheets we developed. In addition, we showed how to make new evaluation sheets for the experiment textbooks each KOSEN had individually made before. We also propose the way to modify each KOSEN's original textbooks on experiment so that they can easily make evaluation sheets for the textbooks.

The contents of instruction books are below:

- Characteristic of the field

  It is written about each characteristic every field including thinking of the attainment level according to the field and the guidance policy of the experiment skill set.
- Examples of experimental skill set

  It is shown as examples of the experimental skill set about attainment level 1 to 3, which we provided as a standard model of KOSEN. The experimental skill set becomes the pair of experiment book model and experiment skill evaluation sheet every attainment level.
- How to use experimental skill set

  It is written about a method to utilize an experimental skill set we provided when using it in each KOSEN.
  - ① It is written about a point that pays attention when using as is.
  - ② It is written about a utilized method of experimental skill set, when students cannot satisfy attainment target by each KOSEN's original current experiment.
  - ③ It is written about a utilized method of experimental skill set, when students can perform the experiment to level 2, but cannot satisfy an experiment of level 3.
- How to make original experimental skill set

  It is written about a guidance to make a new experiment book and/or a new experiment skill evaluation sheet, using current experiment textbook in each KOSEN.
  - ① It is written about a method to customize a current experiment textbook, and to make an experiment skill set.
  - ② It is written about a method to just use the experiment textbook, and to make only an experiment skill evaluation sheet.
- Others

  It is written about knowledge, the know-how that we notice during the project.

Table 1. Typical experimental skill sheet for the evaluation for attainment level 1 to 3 in the field of electrical and electronic engineering

Experimental Skill Evaluation Sheet

Category	Electrical and Electronic								Grade	… Grade	
Experiment Theme	Wheatstone Bridge								Achievement Level	3	
Item	Skill	Achievement Objective	Equivalent to Level 3		Equivalent to Level 2		Equivalent to Level 1				Self Evaluation
			3 A	3 B	2 A	2 B	1 A	1 B	C	D	
Planning and Implementation	Bridge Circuit	Produce a bridge circuit according to the circuit diagram using resistor and power source.	Being able to produce a bridge circuit on one's own.	Being able to produce a bridge circuit on one's own with little advice from the staff.	Being able to produce a bridge circuit by following the experiment procedure.	Being able to produce a bridge circuit by following the experiment procedure and with little advice from the staff.	Being able to produce a bridge circuit by filling in the brackets and blank spaces of the experiment manual.	Being able to produce a bridge circuit by filling in the brackets and blank spaces of the experiment manual with advice from the staff.	Being able to produce a bridge circuit with detailed instructions from the staff.	Not being able to produce a bridge circuit even with advice from the staff.	
Preparation and Operation of Machine and Equipment	Digital Multimeter	Being able to use digital multimeter.	Understand the necessity of digital multimeter and being able to operate it on one's own.	Understand the necessity of digital multimeter and being able to operate it on one's own with little advice from the staff.	Correctly understand the operation procedure in the experiment manual and being able to operate the digital multimeter.	Correctly understand the operation procedure in the experiment manual and being able to operate digital multimeter with little advice from the staff.	Correctly understand the detailed operation procedure and being able to operate digital multimeter.	Correctly understand the detailed operation procedure and being able to operate digital multimeter with advice from the staff.	Being able to operate digital multimeter with detailed instruction from the staff.	Not being able to operate digital multimeter even with advice from the staff.	
Result / Analysis / Discussion	Balance Condition of Bridge	Being able to explain the experiment result from the balance condition of bridge.	Being able to explain the experiment result from the balance condition of the bridge through one's own thinking.	Being able to explain the experiment result from the balance condition of the bridge through one's own thinking with little advice from the staff.	Being able to explain the experiment result from the balance condition of the bridge following the specified procedure.	Being able to explain the experiment result from the balance condition of bridge following the specified procedure with little advice from the staff.	Being able to explain the experiment result from the balance condition of bridge following the procedure and method specified in detail.	Being able to explain the experiment result from the balance condition of bridge following the procedure and method specified in detail with advice from staff.	Being able to explain the experiment result from the balance condition of bridge with detailed instructions from the staff.	Not being able to explain the experiment result from the balance condition of bridge even with detailed instructions from the staff.	

In order to encourage all KOSEN to use the evaluation indicators, we distributed instruction books to all KOSEN in Japan. In addition, we held a symposium, where instructors participated from 51 KOSENs. In the symposium, we made a presentation about evaluation indicators and discussed a problem of its instruction to each KOSEN.

Conclusions

The recent education reform in KOSEN sought to clarify the learning outcomes of each student graduating from KOSEN. Standards of quality assurance for experimental skills should be provided.

We produced more than new teaching materials for engineering experiments based on our guideline in the 7 fields of engineering. More than a total of 2,000 students carried out experiments using our materials. We clarified skills and attainment target outcomes that students acquired through the KOSEN engineering experiments.

We made instruction books in order to encourage all KOSEN in Japan to use evauation indicators of experimental skill.

Acknowledgements

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IMPLEMENTATION AND EVALUATION OF THE FLIPPED CLASSROOM APPROACH IN ENGINEERING EDUCATION

B.W. Drew*,[a]

[a]University of the West of England, Bristol, United Kingdom

*benjamin.drew@uwe.ac.uk

Abstract

Engineering education at the University of the West of England has traditionally followed a conventional approach of large group lectures. This approach has well-known drawbacks in terms of learning. Research has suggested that the flipped classroom approach can help address the issues associated with the traditional delivery method, encourage active-learning and enhance the student experience. This approach was implemented for a module taught to Mechanical Engineering and Automotive Engineering students. Details of the implementation strategy are provided, including how the pre-study educational resources and virtual learning environment supported the flipped classroom approach and how the re-purposed contact-time became a facilitated active-learning environment involving more discourse, group-working, problem-solving and mastery of the topics.

Evaluation of the implementation was collected via the formal end-of-semester module feedback activity. The results demonstrate a strong preference for this delivery method. In 11 if of the 13 categories assessed with the Likert scale, over 80% of the students either 'Agreed' or 'Strongly agreed' with the statements. The student comments were particularly positive, with students highlighting the various benefits of the delivery approach. In addition, the step-change that has occurred in levels of attainment suggest that the approach is working in terms of students' understanding. This implementation of the flipped classroom approach in engineering education was very successful.

Keywords: *engineering education, flipped classroom, inverted classroom, evaluation, implementation*

Introduction

Engineering education at the University of the West of England has traditionally followed a conventional lecture-based approach, often accompanied by small group unstructured tutorials. The traditional lecture format has drawbacks in terms of learning: it is predominated by one-way delivery of the content to largely passive audience, with the tutor unable to accommodate for the diversity of the student body and the differences in the way students learn. The students are then required to use unfacilitated out-of-class time to master the content.

In order to address these issues, the flipped (or inverse) classroom approach enables active learning to be embedded within the module. The flipped classroom "means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" (Lage et al. 2000, p.32). It is thus an approach whereby students use out-of-class educational resources to obtain the content before the teaching session, and the time in class can then become student-centred, dedicated to active learning activities such as problem solving, experiential activities and group work. By applying the new knowledge, rather than merely taking note of it, students are enabled to develop personal ownership of their learning, where they care more about the material they seek to master, and hence have a vested interest in developing a deeper understanding of the material (Gerstein, 2012). In addition, the approach encourages collaborative and peer-assisted learning within the teaching sessions (Foot and Howe, 1998). Lastly, this less didactic approach encourages students to be actively involved in knowledge acquisition (Abeysekera and Dawson, 2015).

Supported by this evidence, the flipped classroom approach was implemented for a third-year undergraduate mechanical engineering module, 'Vibrational Dynamics'. This paper reports on the method of implementation used, including details of the pre-study material, the use of the virtual learning environment to support this approach, and the structured facilitated sessions. Furthermore, the impact of the approach is illustrated through evaluation conducted as part of the standard formal module feedback activities.

Implementation

Vibrational Dynamics as a 15-credit module (7.5 ECTS) taught over one semester to a cohort of third year students studying Mechanical Engineering and Automotive Engineering. The cohort size for the 2017-2018 academic year was 102 students. It is a highly analytical module, focusing on the theory of vibrating systems, including multi-degree-of-freedom, damped, forced, unforced and non-linear systems, and builds upon the foundations of dynamics taught in the first and second years. In an effort to minimise the impact on timetabling,

the contact time was retained as one two-hour long session per week with the whole cohort, and one one-hour long session per student per week with smaller groups.

The implementation followed the scheme illustrated in Figure 1. Each week, students would conduct independent study on the course content that would be used in the whole cohort teaching session and the small group tutorial sessions; they would then spend time in the facilitated sessions, and follow this up with independent study and the pre-study material for the following week.

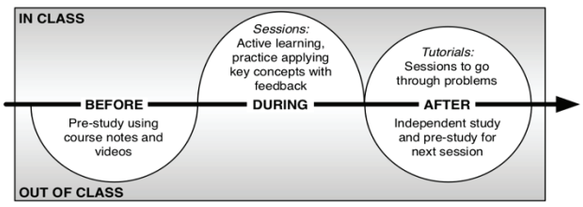

Figure 1: Schemeatic diagram illustrating the implementation approach,

The pre-course educational resources took a number of forms. A full set of course notes were made available to students. These notes contained all assessed content spread over eight chapters. Each content chapter contained a clear set of learning objectives, and interspersed with the content were dedicated spaces for in-class questions. Also aligned with the content are a number of worked examples, and at the end of each chapter are a set of exercises relevant to that content.

Accompanying these notes were video recordings of the lectures from when this module was delivered in a traditional format. The video recordings were re-processed into smaller segments (up to 5–10 minutes, generally), aligned with the content, and the slides were inserted over the top of the raw video of the lecture, cutting back to the raw video when appropriate. The slides used for the lecture were integrated with the notes, so students could easily follow the notes as they watched the videos. There is evidence that video lectures are at least as effective as in person lectures (Zhang et al, 2006; Bishop and Verleger, 2013; Davies, Dean and Ball, 2013) and that technology is an important defining aspect of the flipped classroom, particularly when used for the content delivery aspect of the teaching (Strayer, 2012; Bishop and Verleger, 2013). The videos themselves were optional to watch, as all the content was contained within the notes. They were supportive material, and help address issues associated with a diverse student body, particularly international students and students requiring reasonable adjustments.

The virtual learning environment, Blackboard, was set up to support this delivery approach. The content was broken up by weeks, and each week, a new folder revealed itself to students (using the timed release feature of Blackboard). Within each folder were the educational resources for the pre-study content. This included: the videos for the content; the slides used in the videos; the full-worked solutions to the end of chapter exercises; and a survey which could be used by students to provide feedback on their learning and any particular topics that they would like to cover during the upcoming whole cohort teaching session. Lastly, in an effort to encourage engagement with the content, for the 2017–2018 academic year, an e-assessment test was used on the pre-study content, which was designed to be relatively straight forward to answer correctly had the student engaged with the material. The test was available during the week prior to the associated teaching session, and students had one attempt at answering the question. Marks were given for the correct answer, as well as for engagement with the test. (These ten tests contributed to 20% of the module mark).

The Teaching Sessions

The contact time comprises one two-hour session with the whole cohort, followed by one one-hour session in smaller groups. The two hour-session starts with a quiz using the Turning Point student response system, where multiple choice questions are presented to the class and they participate, anonymously, in answering the questions. This allows both the students and the academic to locate the level of understanding, and potentially highlight any gaps in the knowledge that can be explored during the session. The learning objectives for the topic (as presented in the course notes) are then discussed in more detail, again to help students place their learning and understanding. The session is then facilitated; the academic works through the notes, with the students engaging with the in-class questions, working with each other on the problems, and working through the examples together. The session finishes with a recap of the learning objectives for the topic.

Following the whole cohort session, the group is broken into smaller groups (nominally around 30 students) and the one-hour session takes places in one of the Technology Enhanced Active Learning (TEAL) spaces. These rooms are designed to support active group working, with tables that require students to sit in groups, and each table has a computer terminal on which to use software to support their learning. For this module, the students were all given a question, and the students in these ad-hoc groups work collaboratively on the problem, with the tutor on hand to give advice and provide support as necessary throughout the session. Because this is effectively the third scenario in which the student is experiencing the content, the complexity of the question is at a deep level (i.e. similar to the sort of question they might see in an exam). By visiting the different groups, the tutor gains an insight into the students' level of understanding and mastery of the content. The end of the session is wrapped up by a presentation of the model solution. For groups that completed the question in good time, they are free to make use of Matlab to aid solution visualisation and validation.

Evaluation Methodology

In this paper, the evaluation of this implementation of the flipped classroom approach is based on the formal module evaluation activity that is conducted at the conclusion of the module. This evaluation has two

sections: the first section contains 13 statements with a 5-point Likert scale, with the respondents choosing whether to 'Strongly Agree', 'Agree', 'Neither Agree nor Disagree', 'Disagree' or 'Strongly Disagree' with the statements. The 13 statements are:

1. Module teaching staff are good at explaining things
2. Teaching staff make the module interesting and/or engaging
3. The module has challenged me to produce my best work
4. I knew in advance the criteria my work would be marked against
5. The module assessments and marking are fair
6. I've received timely feedback on my work submitted for the module
7. Feedback on the module has helped me improve my academic performance
8. The Library has enabled me to access the resources on my reading list
9. I've received sufficient advice and support on the module
10. I can contact module staff when I need to
11. I understand how the module fits within, and supports, my wider studies
12. The module is well organised and has run smoothly
13. I am satisfied with the module

The second section of the evaluation form affords the students to provide qualitative comments. The questions for this section are:

- Do you have any other feedback (for example what were the most positive aspects and what would you have changed?)
- Please comment on the flipped delivery approach used in this module.

The module feedback form was made available during the penultimate week of the teaching block in which this module was taught and remained open until after the assessment took place. Of the 102 students registered on the module during the 2017–2018 academic year, 53 responded to the module feedback form, representing a response rate of 52%.

Lastly, whilst no statistical analysis has been conducted, levels of attainment—pass rate and average mark—for the past four years (representing one year of the traditional lecture-based paradigm, and three years of the flipped approach) are presented.

Results and Discussion

For the first section of the feedback form, a positive response is either 'Agree' or 'Strongly Agree', with anything else regarded as negative. (This aligns with the way the National Student Survey rates responses). For this study, there is a very strong positive outcome. 11 of the 13 categories achieve a positive rating of over 80%. The data for all statements is shown in Figure 2.

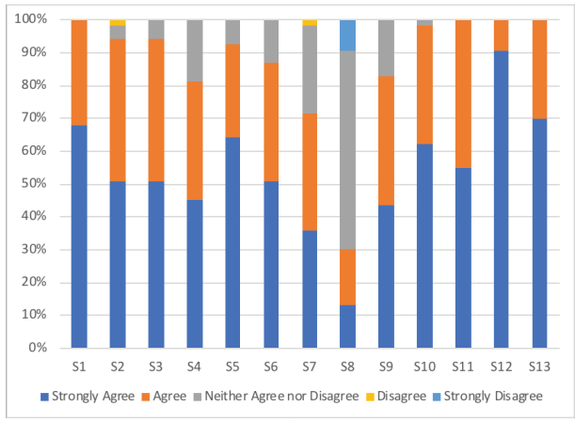

Figure 2: Overall responses for the Likert-scale questions of the module evaluation. (Note: S1 signifies Statement 1, and so on.)

The two categories that failed to meet the 80% threshold where statements 7 (Feedback on the module has helped me improve my academic performance) and 8 (The Library has enabled me to access the resources on my reading list). For statement 7, 71.7% of respondents gave a positive rating. As there is no assignment during the module (apart from the online e-assessments) students would not normally receive feedback tailored to improve performance. For statement 8, 30.2% of respondent gave a positive rating, but the majority of respondents (60.4%) gave a rating of 'Neither Agree nor Disagree'. As all the content is contained within the course notes, a copy of which the students receive at the start of the module, the students' need to access the resources identified on the reading list is not a necessary component of the course.

It is worth highlighting that four of the categories (statements 1, 11, 12 and 13) achieved a positive rating of 100%. With regards to the flipped implementation, statements 11 and 12 are relevant: "I understand how the module fits within, and supports, my wider studies" and "The module is well organised and has run smoothly". It can also be argued that statement 13 (I am satisfied with the module) should carry greater weighting, and achieving a 100% positive response rate for this question is particularly pleasing. Students are clearly satisfied with the module.

For the second section of the feedback form, a full presentation of all the qualitative comments made is not appropriate for this paper. It is possible, however to identify some common themes, with selected quotes to justify these themes.

The first theme is the clear preference to the flipped classroom approach to teaching. It is noteworthy that there was not one negative comment concerning the delivery approach. Quotes supporting this theme include:

- "It's much better and engaging than old method"
- "This delivery approach is by far the best style of teaching so far in my degree."
- "The flipped delivery approach was a great idea."
- "100% preferred the flipped classroom approach compared to conventional style."

- "This was absolutely amazing and I feel like I have really benefitted from this approach."

Somewhat linked to this theme is the second theme, which was a desire to have more modules taught using the flipped classroom approach. Supporting quotes include:

- "I think that the rest of the lecturers in this university should use this module as how they should deliver."
- "[I] firmly believe that other engineering modules could benefit from similar approaches."
- "The reverse [i.e. flipped] teaching method needs to be ran on more modules."
- "I would like to see this style of delivery in more modules."
- "Very well delivered and other modules should include it. It made a difficult module much easier, very happy"
- "I wish that more lecturers would adopt this approach!"
- "more modules should be done this way."

The third identified theme is how the approach made revision for the assessments more straight-forward as they had already 'put in the hard work' during the module. Quotes include:

- "It also made my revision much more effective as I was able to dive straight into past papers and example questions leaving me very confident going into the exam."
- "The tutorials were both helpful for revision and general learning."
- "It gives you more of an incentive to do all of the work for that week there and then rather than leave it till the end of the semester, just before exams."

Lastly, the fourth theme highlights the extreme levels of satisfaction with the module as a whole. The following quotes show high levels of appreciation:

- "By far the most well taught module I've taken."
- "The best module I've experienced in my time at UWE."
- "It has been the best taught module I have had since I have been at UWE."
- "Keep doing your thing! Top lecturer."
- "Keep up the excellent work."

There were a limited number of comments containing constructive criticism. There seems to be a desire to have more worked examples covered in the teaching sessions, and some desire a switch to have a one-hour whole cohort session and two-hours in smaller groups. These comments have been considered in the design of future runs of the module.

The levels of attainment for the past four runs of the module are shown in Table 1. In the 2014–2015 academic year, the module was taught with the traditional approach. The pass rate and average mark for this particular cohort were particularly poor and as such, a mark uplift was applied (with external examiner approval) to bring up the pass rate and average mark. It was these results that motivated the shift in approach. It is clear that in the 2015–2016, 2016–2017 and 2017–2018 academic years, the levels of attainment have shown a significant uplift. Whilst tests of statistical significance have not been conducted, the results suggest that the change of delivery approach to the flipped classroom method has brought about this step change in levels of attainment.

Table 1: Levels of attainment for the most recent four runs of this module.

Academic year	Pass Rate	Average Mark
2014–2015	57.38%	45.98%
2015–2016	85.57%	57.88%
2016–2017	91.80%	69.70%
2017–2018	92.16%	69.60%

Conclusions

In an effort to address the deficiencies of a traditional lecture-based delivery approach and to increase levels of active-learning, the flipped classroom approach was implemented for a third-year engineering module entitled 'Vibrational Dynamics'. Details of the implementation approach are provided, highlighting the pre-study educational resources provided, the use of the virtual learning environment to support the approach, the use of e-assessment to support engagement and the structure of the teaching sessions. To evaluate this implementation, the formal module evaluation activity that takes places at end of the module was used. This formal module evaluation is divided into two sections: the first section provides quantitative data using a Likert-scale against 13 different statements. The second section provides qualitative data, with students able to comment using free text on certain questions provided as part of the evaluation. Attainment levels were also used to compare this approach to the previous approach using the traditional lecture-based delivery.

The results of the evaluation are very positive. In the first section of evaluation, 80% of students either 'Strongly agree' or 'Agree' with 11 of the 13 statements, with four statements achieving 100% positive results. The two categories that did not achieve 80% positive results were not relevant to this module and the approach used to deliver the content. The second section of the evaluation highlighted four themes: a strong preference for the flipped approach, the desire to have other modules use the same or similar approach, the benefits of this approach when it comes to exam revision, and the clear levels of satisfaction with the module. Whilst statistical significance has not been determined, the step-change in levels of attainment following the implementation of the flipped classroom approach suggest that the it can provide benefits in terms of results. In summary, when implemented as described, the flipped classroom approach has been successful for engineering education.

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TEACHING AND LEARNING TOOLS FOR THE E-DUCATION IN MECHANICAL ENGINEERING

I.C. Gruescu[*,a]
[a] University Lille 1 - Sciences and Technologies, IUT "A"/Mechanical Engineering Department (GMP), Rue de la Recherche, BP 90179, 59653, Villeneuve d'Ascq, France

*ion-cosmin.gruescu@univ-lille1.fr

Abstract

The present work addresses the question of the evolution of teaching contents for the mechanical engineering students (Bachelor and Master degrees) by developing an active learning, learner-centered approach, which is based on the use of smart and digitalized academic tools. The Mechanical Engineering Department of the Lille University develops in this context an ambitious project since several years, it consists in the creation of new digital resources and on the development of a technological platform. Several aspects related to our pedagogical approach are discussed in this paper, we propose a method which shows how, step by step, it's possible to transform the classical university in a digitalized one, without losing its essence - our approach is essentially based on meaningful and collaborative learning, case studies or problem solving and critical thinking. To test the proposed approach several pedagogical experiments were conducted on different groups of students, the main idea being to test the feasibility of implementing these concepts (and to link them) in as many as possible classical courses such the materials science, mechanical manufacturing, eco-design, etc. A non-conventional approach (based on the PBL methods) was used, it also deals with organizational learning. The first objective of the paper is to describe the elements guiding the instructional design that contributed to the improvement of students' performance and attitude in training and learning; the second objective of the paper is to illustrate and discuss significant future challenges permitting to other educators to learn and adapt their teaching resources from our experience.

Keywords: *active learning, training, learning, digital resources, learner-centered education, engineering.*

Introduction

A very important number of authors underlined, during the last decades, the need for changes in pedagogical approaches, especially in engineering science. Among the more promoted solutions the active learning occupies an important place. On the other side, the campuses are considered as small cities with both residential/academic areas, where the development of sustainable environments to study, work and live are enhanced through the use of digital technologies and big/open data. An actual challenge of universities is thus to enhance the learning experience of students by providing them smart and digitalized academic tools.

In order to propose to the students of the Mechanical Engineering department of our University new attractive and useful resources for training and learning, several digital resources were recently developed, the followed idea being to give free elements to teachers and trainers, who can directly re-use them in their presentations or for their teaching supports. The provided courses can also be used for self-training, given that the provided media are composed of videos, self-assessment tools and/or practical case studies (which were designed and realised by involving the students).

The digital resources were then used and tested with success in several courses, at the Bachelor level, at the Mechanical Engineering department of the Lille University. The proposed approach is essentially based on collaborative and meaningful learning, case studies or problem solving and critical thinking development. The active learning was introduced also to provide opportunities for learners to think critically about the' course content, through a range of activities that help them to prepare themselves for the challenges of professional situations involving problem solving. The start point was given by observations such those formulated by Huba and Freed (2000) who underlined that those that are learning the most in a classroom are the professors; the professors reserved for themselves conditions promoting learning: actively seeking new information, organizing it in a meaningful way, and having the chance to explain it to others. In this situation, the usual lecture format for most of the courses presents many challenges to both teaching and learning. Even if a traditional lecture allows an efficient presentation for a large body of content to a large number of students, this "one-way transmission of knowledge" often faces superficial learning and do not stimulate the students' motivation. The principal consequence is that a part of the students do not possess important skills for their future integration in the professional life. It is then necessary to find new forms of instruction, by placing the students in the centre of

the approach, in order to allow them to become independent and critical thinkers.

The Mechanical Engineering Department of the Lille University developed the P2NT-GM project (active pedagogy based on digital media and new technologies in mechanical engineering) which consists in the creation of new digital courses and on the construction of a technological innovative platform.

In this paper is presented one of the three digital courses realized between 2011 and 2014 in the framework of the previously cited project. The question of the evolution of the pedagogical content is equally addressed, given that these evolutions aim to propose good quality case studies or courses for the concerned students. Several aspects related to our approach are illustrated by presenting some pedagogical experiments conducted in this period with a group of students.

An educational approach based on active learning and the use of digital resources

Active Learning based pedagogical approaches. Active Learning is actually defined as anything that students can do to learn and train themselves except taking notes and passive listening of an instructor's lecture. Numerous research works proved that such approach helps students improving understanding and retention of information and can be very effective in developing higher order cognitive skills (e.g. critical thinking). However, restructuring a course by using elements of active learning can sometimes seem overwhelming for a faculty, with extensive time commitments in other realms and little or no formal training in pedagogy. In addition, adapting the content and the structure of a teaching resource with respect to the actual standards and regulations or by adapting the treated case studies and the lectures' content with respect to the industrial requests (and reality) are tasks which complicate a lot the preparation work and which request a huge time for the research dedicated to recovering correct and useful information to be used in the teaching activities (especially lectures and demonstrative works). The next section presents the active learning approach developed at the Mechanical Engineering department of the Lille 1 University .

The P2NT-GMP educational project

Context and usefulness . Several reasons pushed the teaching team of the Mechanical Engineering department of the Lille University to develop the P2NT-GM project, which is centered on an active pedagogy. We recall here as examples: the students motivation and attitude, the miss of time and specific tools (for trainers) dedicated to the development of digital resources. Given these reasons and the willingness of the team to help students in improving the success of their education and learning, it was decided to act on two distinct plans : on one side, create an innovative technological platform (financed mostly with our own resources) and on the other side realize new training and learning digital resources by taking advantage of the technical and financial support provided by two French foundations working in the engineering respectively the environmental fields. Note however that the development of these resources is not sufficient to improve the quality and the content of our lectures and resources, this is why it was equally decided to capitalize and to valorise our experience by increasing the number of exchanges with our educational, industrial and institutional partners, in order to get the best feedback possible which can be used for a continuous improvement of our practices and tools.

The main objective of the project is to favourites the students' success by the mean of using digital media and by letting them instruct themselves in working environments such the technological platform that we developed. The learning is mainly based on an inductive method (tutored project) which consists in performing continuously the work by using case studies. This help the development of the technical skills of the students, contributes to the development of their criticism, conceptualisation, and to the improvement of their adaptability. A second objective of the project was to help educators developing and using the technical or digital means previously cited, in our establishment or in those that are our partners.

The technical platform. Our department develops since many years a platform dedicated to innovative technical equipments. In this framework the University financed the acquisition of innovative technical equipments and devices such the 3D measurement device and scanner, some fab lab equipments and 3D printers, industrial vision cameras and devices, foundry furnace or computer numeric control machines. Note that a big majority of these equipments are in free access for students several times a week, in order to let them practice and improve by individual working.

The digital resources. Linking the technical and digital resources (existing ones or to develop in the future) is on the other hand an excellent mean helping in improving the students' success and which allow them to train themselves thanks to the use of pedagogical resources with high level of educational interactivity. We naturally decided then to take advantage of the opportunities provided by the support offered by two foundations (digital universities) and we participated to several call proposals. Three of the proposed projects were approved, this offered to us the opportunity to put in practice our ideas and to develop new digital courses. The design of one of these digital resources will be presented in the next section.

The French digital universities UNIT and UVED. The development and the promotion of active-learning pedagogy is facilitated and supported in France since many years by the 7 digital universities working under the guardianship of the French Ministry of Education. Two of these digital Universities develop activities in the environmental and engineering fields: the digital University of Engineering and Technology (UNIT) respectively the Digital University of the Environment and Sustainability (UVED). These foundations provide support for faculty committed for implementing active-learning strategies in their courses by proposing training

opportunities and by furnishing example teaching resources and materials readily available.

Objectives . The availability of digital courses and the training for the use of innovative tools are factors strongly contributing to the development of autonomy of students in the acquisition of knowledge. The educational level of interactivity of the created resources must be strong; we decided then to realise resources of expository type, with an important use of communication tools with the learner (forum, chat, etc) and a strong presence of exercises, multiple choice questionnaires, case studies and other activities centred especially on the problem based apprenticeship or similar to the serious game activities. Our choice focused then on realizing numerical courses of the form of educational grains designed by addressing several fields of engineering sciences.

The realisation method. The project based approach and the problem based methods (see Barret and Moore, 2011) are inductive unusual methodologies of learning. It was decided to arrange the realised tools and to construct them under the form of educational grains grouped in two categories:
- sequential (the information is detailed in one grain)
- parallel: under the form of worksheets associated to elements giving the "theoretical" information attached to the methodology and the practical information declining its application to the case study.

The grains are imbricate and more other theoretical or practical tools were added: links to other courses, videos, examples of results, etc. The scope is to provide a set of resources conceived under the form of toolboxes or libraries. These boxes are opened by the learner one by one to learn, to self-evaluate or to acquire new knowledge and information. The more he will advance the more he will enter in the methodology details in order to find the right tool or information. The interest of the proposed structure is the fact that the searched information will be find very quickly. The teacher's role and contribution are essentially situated at the case study level and in the project approach. He will help the learner to address the good questions, will encourage him in opening one or another box, to make new researches. The main goal is to bring the learner to an important autonomy level, to help him in the acquirement of the method, and to push him in developing criticism with respect to the collected data or to the obtained results.

The projects' structure. The project is therefore inscribed in an active learning pedagogy and it is divided in three axis. The first one consists in purchasing of new technical innovative means, completed by the realisation of user guides and /or technical worksheets allowing to the learner to self-train. The second action concerns the development of new digital courses and educational kits allowing to other trainers to adapt the proposed media with respect to their needs and practices. Finally, the valuation and the capitalization of the acquired experience and of the developed tools are done by the redaction of a "feedback guide" and by presenting the developed approach at several events: congresses, symposiums, (e.g. Gruescu, 2014 and Gruescu et al., 2014).

Target audience. The digital resources we developed have for target students of licence level (L1, L2, L3) or master (M1, M2). The content was adapted with respect to the public and indications are given to learners in order to guide them to use the information associated to their competences and knowledge. Initial, continuing and apprenticeship training as well can be trained by using the realised resources, since the trainers have in possession an educational kit.

The 3PM - EFAU project for the UNIT digital university

We describe here the development and the implementation of an instructional design that focused on bringing multiple forms of active-learning and learner-centered pedagogies into a traditionally lecture-based introductory engineering course dedicated to mechanical manufacturing. The restructuring of this course was decided by several perceived deficiencies which are common to traditional lecture-based introductory courses. The most important concerns were the poor students' involvement and attitude, feelings that were shared by several faculty involved in the course presentation. Both written or numeric responses on course evaluations indicated in the past that students were not satisfied with it and they did not recognized equally the usefulness of the content to their education and future needs in professional work. Note that even if the students qualified that the lectures and the course materials were boring, they recognized however being more concerned with their test scores than with gaining a thorough understanding of the course material. Poor student attitudes were equally reflected by limited participation in class, poor attendance and almost inexistent individual instructor–student interactions.

Course description and study design. The course restructuring we describe here pertains to the lecture and tutorial classes of a two-semester course that typically enrols annually around 100 students. The course was taught in a standard lecture format in the previous years and redesigned to emphasize active learning and student-centered pedagogy. It proposes a set of activities that aim a progressive simulation of the learner, which is close to industrial reality and thanks to which the learner will acquire and improve his/her technological skills. He will especially be able to know the different production processes, their characteristics and application fields. He will equally use his knowhow to define a production process and to integrate in the production analysis the quality, cost and delay constraints, in order to improve the productivity.

This digital resource (http://www.analyse-fabrication.univ-lille1.fr/co/001_MOG_web.html) is positioned as an application field of the organisation and methods department in a production workshop. Structured in 4 main parts, it is composed of theoretical presentations, videos, exercises and multiple choice questionnaires. It concerns students from higher and vocational education in initial or continuous training.

Any other vocational training can equally be done with the help of this tool. Finally the Master students or engineering students can use it for quick upgrading of their knowledge. Concerning the teaching public this module concern all kind of categories developing their activities in mechanical engineering field. Since it was conceived under the form of educational grains, it can be exploited in totality or partially. Project activities can also be proposed to students on the basis of this module, since the self-evaluation is possible thanks to the solved case studies or to the divers applications proposed under the exercise forms at the end of each chapter. We finally emphasize the remarkable work which was done in order to complete the resource with videos of high technical quality and which were realized based on realistic screenwriting.

The improvements in the course redesign. The first point to emphasize in the redesign of the course is the *reorder of the course content.* The presentation of the course was reordered in four main chapters and enriched in order to teach specific content within the context of broad conceptual themes. For example, a new lecture dedicated to the materials used for the machining tools production was integrated, it was designed to serve as an intellectual bridge between materials science and machining by chip removing. The *active learning and the group problem solving* were introduced in several lectures. Students work now organized in small groups, each case study needs several minutes of discussion in order to correctly state the addressed problem. During this period, the instructor would move from group to group in the classroom to monitor student progress and offer suggestions to the groups that are encountering difficulties. Note equally that we adopted several additional strategies to create a more *learner-centered* learning environment. Every lecture includes a set of learning goals made explicit to students in the lecture PowerPoint slides. The exam are labelled with the corresponding learning goals, in order to emphasize the alignment with assessment. A set of vocabulary terms was also included in the resource to help the students focus on important concepts. As part of the course revision, and based by the use of a moodle platform, we modified the assessment plan to include weekly quizzes. It was also choose to focus on using problem-based learning because these activities tend to be more succinct and less open-ended than the case-based studies; the interest of this approach is also to present the theoretical methodology by using real examples, contrary to many trainings which just present a specific tutorial. The general idea is to give free elements to teachers and trainers, who can directly re-use them in their presentations or teachings supports. It can also be appropriated by self-learning.

It must be finally emphasized that the digital resource that we developed is not only a classical course for students in universities, but also a free-access numerical resource which can be used by everybody in a professional context or for self-training. This resource has been used with a certain success in several departments similar to ours, in the partners' Universities.

Discussion and training experiments

Discussion about the 3PM-EFAU digital resource. A traditional lecture format in a large classroom presents several disadvantages, as was already emphasized previously. There is reason to believe that this deficit diminishes learning outcomes and may contribute to the loss of some of our most talented students, especially at the introductory level. The primary goal of the courses restructuring was to improve student attitudes, motivated by the hypothesis that this would lead to improved learning outcomes. It was then observed that incorporating active-learning and learner-centered pedagogy into the instructional design of our educational approach also lead to increased student attitude and performance. The courses redesign had another unanticipated benefit: it improved not only the students' attitude toward the course but also the professor's enthusiasm and implication. Machining by chip removing has been for a long time a problematic course for our department because of the deficiencies such superficial learning, poor student attitudes or suboptimal performance. As a consequence, educators or instructors often loosed enthusiasm for teaching this course after a few years. It is actually obvious that the interactive pedagogy (based on active learning) and the positive student reactions made this a much more exciting and rewarding course to teach. The changes we implemented also have had an impact at the departmental level. Based in part on the positive student reactions to interactive and student-centered pedagogy in the mechanical engineering courses, other colleagues seriously thing about implementing the use of digital resources in their courses. Since the same author taught the course before and after redesigning, the main outcomes of the new approach are that student attitudes and performance increased in response to the instructional design that we implemented.

Pedagogical and training experiments. We realised some experiments in our department which were used as case studies in the numerical courses that we developed for the French digital universities. We recall that the 3PM-EFAU course proposes an academic presentation of the mechanical manufacturing, and is based on the use of case studies. The general idea was to use a non-conventional approach which is in any way the one which will be discovered in the companies and in the organisations by the students or the auditors as soon as they will start their professional careers. This method is called the Problem-based Learning (PBL) and is described in many works (e.g. Barret and Moore, 2011). This pedagogical method is more interesting for students and auditors because it directly deals with real cases. Besides, the student is no longer a “listener” but becomes an actor of the methodology, which permits him to acquire knowledge and abilities more quickly and more durably. This method also deals with “organisational learning” given the proposed interactions between the working groups and given the time constraints that each team has to face. The students trained in the bachelor’s degree dedicated to mechanical engineering are formed to acquire technical, scientific

and organisational skills required by companies. Within the company, in their future professional life, they will be in charge of improving the products performances: energy consumption, optimal recycling, etc. by seeking innovative and optimised solutions. The tutored-project and all the chapters (e.g, the one related to materials-science) are realized by integrating the "learning by doing" concept (see Gruescu, 2014). The main outcome of this project is that, in addition to the increased interest of the students for the proposed approach, the acquired experience was used for the development of the so called ECO-PEM and ACVBat projects for the UVED University.

The institutional context. The redesigned or newly introduced courses that we implemented in the framework of active learning required significant time investment and consequent financial support. Given the encountered problems it worth capitalizing and valorising the acquired experience and the realized digital resources in order to allow to other colleagues to benefit of our advances and to use at our turn their eventual feedback. Attendance at national and international workshops or symposia, can naturally provide significant background theory and training. It was also possible to organize some regional meetings with colleagues form other universities, these occasions were as well opportunities to improve our practices and experience. These symposiums were particularly useful in providing the opportunity to discuss specific details of course redesign with individuals highly experienced in implementing active-learning and student-centered pedagogical approaches.

Indicators of the objectives' achievement and capitalization

It was established to evaluate in a continuous way the achievement of the proposed objectives (short and mean term) from both quantity and quality points of view. This will permit to adjust and to propose some new actions if necessary. The measurement of the realization process was and will be done by using classical project management tools; concerning the results indicators, we favoured the satisfaction rate of the target audience and the capacity of the tools and engaged means to respond to their needs. An important parameter in this context was the resources' use rate, which can be evaluated by using classical means such the accounting of the connexions number, etc. The main tools permitting to transfer our expertise and recommendations are respectively the educational kit (package) and the feedback guide. The latter can be continuously updated by organizing regularly meetings with partners from universities (initial, continuous or apprenticeship training) in order to share the experience related to the use of the digital resources or technical materials in already finalized or to come projects.

Conclusions

Active learning is a key aspect of the education, it can be applied to any learning environment from online to standard lectures or as a blend of these. The Mechanical Engineering department of the Lille University works since several years in implementing this approach in its educational system. The creation of a technological platform dedicated to innovative technical equipments and the reorganisation of existing courses (or the introduction of new ones) are the main initiatives to be emphasized in this context. The new digital resources were realized with the support of the French digital Universities, this allowed the reorganization of some courses by using active learning and by centring the education process on students. A good feedback and more positive results in students evaluation illustrate how changing the instructional design of a course, without wholesale changes to course content, can lead to improved student attitudes and performance. With respect to the use of the Problem-Based Learning methodology in the development of the resources it was shown that this approach permits in all the cases to train the learners, the results in terms of the appropriation of the subject being better than those which could have been obtained using conventional pedagogical methods.

In summary, we developed and implemented an instructional design that focused on incorporating active-learning and student-centered pedagogy in courses which were previously traditional lecture-based teaching activities. These changes led to sustainable improvements in student attitudes and performance. The course reorganization we described provides not only a model for revision of an individual course but can also be a catalyst for institutional reforms. Note finally that the force of this project lies not only in the interest of the treated themes but equally in its regional and national recognition.

Even if our approach has been applied to technological courses, it is clear that the application field is not at all limited. The second objective of our work was equally attained, the shared expertise and experience permitted to other educators to learn and to adapt their teaching resources and pedagogic approach by learning from our experience.

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HACKATHON TO DEVELOP STUDENTS' GENERIC SKILLS AND COMPETENCIES IN KOSEN

H. Aburatani*, H. Ayano, H. Fukuoka, K. Hoshino, S. Kano, R. Kimura,
R. Komura, Y. Matsumoto, M. Morimoto, K. Moriya, K. Noguchi,
N. Uehara, K. Yajima, and J. Kobayashi
National Institute of Technology Headquarters, Hachioji, Japan

*abura@kct.ac.jp

Abstract

Nowadays, it is important for educational institutes to develop students' generic skills and competencies across the curriculum. National Institute of Technology (NIT) has designed "Model Core Curriculum (MCC)" that provides a framework for learning contents and outcomes levels in specialized fields as a minimum standard for National Colleges of Technology (NIT Colleges: Kosen). It is important to provide students not only with academic knowledge and skills, but also generic skills, such as critical thinking, communication, collaboration and problem-solving skills. Therefore, in MCC, the development of generic skills and competencies are also defined as key components to be developed.

In December 2017, NIT held a "Hackathon" at Hakodate as a nationwide educational event to provide real experience for the students to examine the achievement of the educational goals. Rubrics were employed to assess three major generic skills (i.e. Teamwork, Problem-solving and Communication) and engineering design skills. Peer evaluation as well as pre and post self-evaluation were also carried. The survey results are analysed in comparison to one obtained from an ideathon also held by NIT. It is shown that the Hackathon is a good opportunity to develop students' skills. It is also found that students' prior knowledge and experience relevant to required technical and/or non-technical skills are important to understand their performance and the survey results.

Keywords: *Competency, Rubric, Ideathon, Hackathon, Stakeholder, Regional Problem-Solving, Group work, Facilitation, GIS (Geological Information System) and World café*

Introduction

According to a blueprint for education reform in Japan, globally competitive talent of students has been a top priority on the agendas. To improve the preparation of KOSEN students to meet these high demands in rapidly changing world, we have to improve the curriculum as well as our educational approaches. Generic skills, a set of essential abilities, are what our students need for their future (e.g., Ananiadou, K. & Claro, M., 2009); these skills should be recognized as one of the most important outcomes of teaching and learning through the curriculum. Thus, the curriculum should contain the knowledge, skills as well as competencies that are required for the student's future success.

For these purpose, National Institute of Technology (NIT) has designed "Model Core Curriculum (MCC)" that provides a framework for learning contents and outcomes levels in specialized fields as a minimum standard for National Colleges of Technology (NIT Colleges). Since April 2018, all national Kosen College's syllabus based on MCC are listed and shared on the Kosen Syllabus website (https://syllabus.kosen-k.go.jp/Pages/PublicSchools). It should be noted that each NIT College plans and implements its own distinctive education in addition to MCC, since MCC covers only the core part of curriculum contents (60-70%). Besides the specific engineering skills for each expertise field, the development of Generic Skills and competencies are also defined as key learning components in MCC. In order to achieve these educational goals, Educational Research Office of NIT has been working on several projects to develop educational programs to foster students' competencies.

In this project, "Hackathon" following ideathon in the previous year is held as an educational platform to examine our educational approach. The details of implementation of Hackathon as well as the evaluation and survey result analysis are reported in this paper.

Kosen (National College of Technology) Education

The outstanding characteristic of Kosen education is its 5 years of consistent engineering education starting from age of 15 years. With the additional 2-year advanced course education, up to7 years of consistent engineering education can be conducted through various methods. Another big difference between NIT Colleges and other higher education institutes is its nationwide educational network. At present, there are 51 colleges of technology (55 campuses) under National Institute of Technology in Japan, and approximately 50,000 students from age of 15 to 22 years are enrolled. Figure 1 shows the location of 51 NIT Colleges. As KOSEN colleges were established to respond to a need for well-trained manpower in the rapidly growing industrial sector during

the rapid economic growth in 1960's, each College locates basically at industrial city/zone.

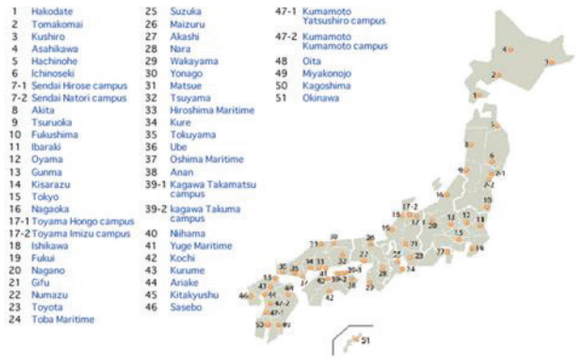


Fig. 1. The location of 51 NIT Colleges.

Over fifty years have passed since the first Kosen colleges were established and the social demands for KOSEN education have changed. For the improvement of education, NIT has designed "Model Core Curriculum (MCC)." In the MCC, the attainment targets of each subject area are determined basing on Bloom's Taxonomy. Table 1 shows the relationship between the attainment target levels and the corresponding education program (fields). The MCC provides a framework for learning contents and outcomes levels in specialized fields as a minimum standard for NIT Colleges education.

Table 1. Attainment targets for each category and corresponding program in MCC.

Skills required for engineers	Attainment Target					
	1 Knowledge and Memory Level	2 Comprehension Level	3 Application Level	4 Analysis Level	5 Evaluation Level	6 Creation Level
Basic skills that engineers in any field should acquire						
I Mathematics	K	K	K	A	S	S
II Natural Science	K	K	K	A	S	S
III Humanities and Social Sciences	K	K	K	A	S	S
IV Engineering Basics	K	K	K	A	S	S
Specialized skills that engineers should acquire in their areas of expertise						
V Special Engineering by Field	K	K	K	K	A	S
VI Engineering Experiments and Workshops by Field	K	K	K	K	A	S
VII Substantiation of Specialized Skills	K	K	K	K	A	S
Cross-sectoral skills required for engineers						
VIII Application Skills	K	K	K	A	S	S
IX Attitudes and Orientation (Personal Qualities)	K	K	K	A	S	S
X Comprehensive Learning Experience and Creative Cogitations	K	K	K	A	S	S

(K: Kosen regular (College) course, A: Advanced course, and S: Higher-level qualification such as professional engineer) .
Note: These English translation of MCC is not the final version to be released.

Thus, the MCC is a fundamental part of NIT College education to ensure its levels and quality assurance. In order to implement the education based on MCC, it is necessary to adopt and develop new educational approaches. Although typical lecture plays an important role, the generic skills should be also fostered effectively through a variety of educational approaches (e.g. Active Learning). Figure 2 shows the scheme for the implementation of MCC. As the preparatory phase, Faculty Development (FD)/Training, Sharing Teaching Materials, Development of Portfolio System, and Fostering Generic Skills have been executed. This project is a part of "Competency Evaluation" in the implementation phase in which Development of educational environment and Student Projects are also being proceeded.

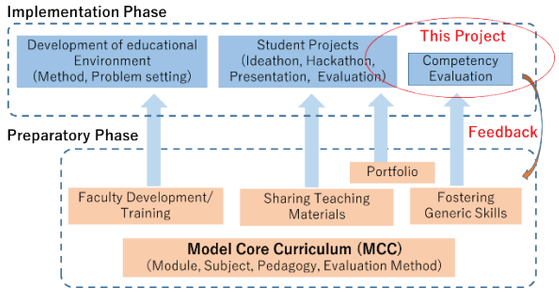


Fig. 2. Preparatory and Implementation phases of MCC

KOSEN Hackathon

For Competency Evaluation, "Ideathon" and "Hackathon" have been employed as practical educational platforms in this projects to provide real experience and tangible results for the students and to evaluate their development of competencies. The Hackathon, is an intensive and workshop-like activity in which students discuss in small groups and collaboratively develop ideas and prototypes for problem-solving. In this project, three major Generic Skills (Cross-sectoral Skills), Teamwork skills, Problem-Solving Skills, and Communication Skills, as well as Engineering Design Skills are mainly focused (Figure 3). Teamwork skills are subdivided into Teamwork (interpersonal) and Independence/ability to perform actions (intrapersonal). Problem-solving Skills are also divided into Logical thinking/Problem Solving skills and Ethics/Social responsibility and action. A rubric for the Hackathon which is similar to one for the Ideathon was designed to evaluate these five competencies and engineering design skill.

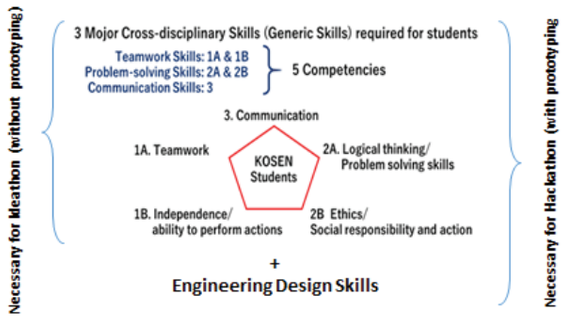


Fig. 3. A comparison of necessary skills for Ideathon and Hackathon.

KOSEN Hackathon

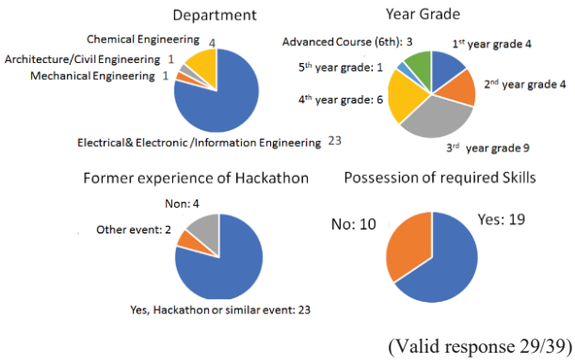
The main theme of Hackathon, schedule, and programme are following:

Hackathon@Hakodate (10th -12th Nov. 2017)
Main theme: Regional revitalization through Monozukuri (Innovation)
Student Participants：39 (18 Colleges)
Supporting Companies: 6

Programme:
Day 1: Ice-breaking, Ideathon and team formation
Day 2: Idea Presentation and Hackathon
Day 3: Outcome presentations, Judging, and Winner announcement

This Hackathon ran for three days. On the first day, World Café was chosen to conduct group discussion as the ideathon part at the beginning of hackathon, and regional problems were addressed from the viewpoint of Kosen students. World Cafe is a structured conversational process in which groups of people discuss a topic at several tables, simultaneously. Basing on the discussion results through the World Café, issues of concern to be addressed are shared among the students and they choose their own problems/challenges to tackle. The students then break into small groups for further discussion, delve into the problem and prototype: developing the solution using Information Communication Technology (ICT). As the goal of this hackathon is to create usable software, it includes programming, applications, APIs, and/or interface hardware parts. For their prototyping, supporting companies' staffs and Kosen faculties provide technical advices and mentoring for the students.

At the final presentation, each team pitch and demonstrate their solution and receive appropriate feedback from the judges. The students evaluate their performance using the rubric (e.g., Jonsson, A. & Svingby, G. 2007) and the self & peer evaluation sheet are carried out after the Hackathon. The participant's info are shown in Figure 4.



(Valid response 29/39)

Fig. 4. The participant's information









Fig. 5. Scenes of the Hackathon: ideathon (upper), team presentation, hackathon, and final presentation & demonstration (bottom).

In order to promote prior knowledge and experiential leaning of a topic, a pre-assignment of investigating local facts and information as well as pre-reading materials were given to the students. A geographic information system (GIS) is also suggested to be used. GIS (Maurya, S. P. et al. 2015) is a system designed to capture, manipulate, analyze, and present spatial or geographic data. GIS enable the students to visualize, analyze, and interpret data to understand relationships, patterns, and trends. The student brought their reports and shared their findings with others for discussion.

Results and Discussion

In this project, two different surveys were conducted to measure students' skill development and behaviours: a simple 5-level rating for 6 competencies and a rubric evaluation. Figure 6 shows the result (average) of self, peer and faculty 5-level rating during the event. It is confirmed that students tend to underestimate her/his outcomes, meanwhile peer members and faculties rate them higher. This tendency is also observed in the former Ideathon events. It seems that those highly motivated students set their attainment goals higher than we expected, resulting in lower self-evaluation rates. This assumption is also supported by the results that Engineering Design Skills and Logical thinking Skills/Problem Solving Skills show smaller improvements through the Hackathon than those for other skills, except ethics and social responsibility. From these results, it is suggested that the students did not satisfy with their performance in the development of solutions/prototype and found difficulties to link ethics and social responsibility to their solution/idea. This observed students tendency should be also taken into account in the implementation of Hackathon/Ideathon to guide the students properly.

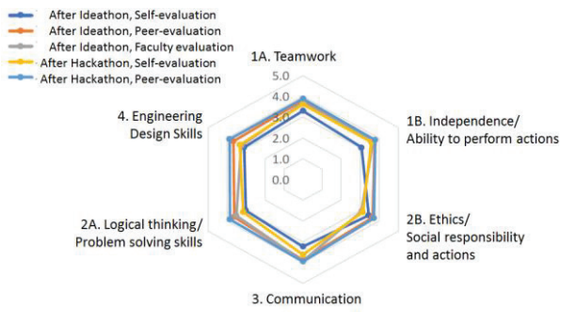


Fig. 6. Self, Peer and Faculty 5-level rating results

Table 2 shows the rubric for Teamwork Skills (1B) as an example. It should be noted that the students can check their performance at each attainment target using 3-star rating. This rating system allows us to examine the details of their performance. In order to examine students' performance in Hackathon, the result is compared with those obtained from the ideathon which was held in 2016 with the main theme of Problem solving for local community and region. The results of students' rubric evaluation of 5 competencies are shown in Figure 7.

Table 2. The rubric for Teamwork Skills (1B)

		Basic	Proficient	Advanced
Teamwork skills	1B. Independence/ability to perform actions	Be willing to participate in discussion and also be capable of doing so.	Observing team activity, be able to exprees an opinion according to circumstances to support and /or encourage discussion	In addition to the active participation as an individual member, be able to contribute to team discussion basing on the understanding of each mamber's role and function.
		☆ ☆ ☆	☆ ☆ ☆	☆ ☆ ☆
1	2nd Year Female	3	2	2
2	2nd Year Female	3	3	2
3	1st Year 3組Male	3	2	2

The details of Ideathon are following:

Ideathon@Hakodate College (2days)

Topic: Regional revitalization and Promoting tourism in Hakodate

Student Participants：51 (15 Colleges)

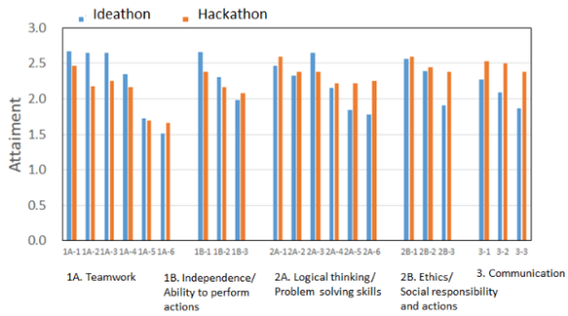


Fig. 7. Results of rubric evaluation for 5 skills.

It is shown that the students' performance decreases with the attainment level as general tendency for both ideathon and hackathon. However, it should be noticed that the result of communication skills for hackathon is found to higher than that for the ideathon. It seems that the prototyping activity promotes more communication and collaborative work among students in the hackathon. Figure 8 shows the standard deviations of students' rating for the ideathon and hackathon. It is found that the standard deviation of students' rating for the hackathon tends to be higher than those obtained in the ideathon, except ethics and social responsibility. Especially for Teamwork skills of 1A-4 to 1A-6 which relate to the implementation of idea, it exhibits higher standard deviation than others. Table 3 shows the average values and standard deviation for each competency category obtained from the results in Figure 8. Different from the result shown in Figure 9, the standard deviation for the hackathon are found to be lower than those of the ideathon. From these results, it is assumed that there are two types of student participants: well experienced students with programing/technical skills and students without enough skills.

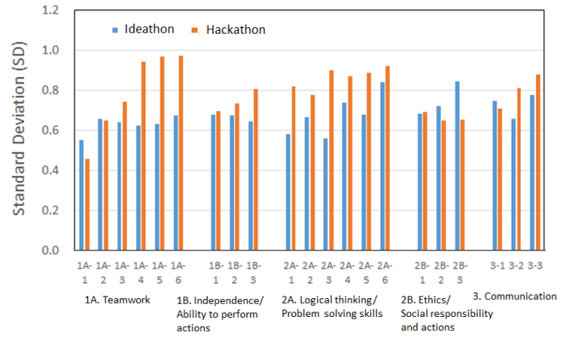


Fig. 8. Standard deviations of students' rating for the ideathon and hackathon.

The former students are capable of managing group work and implementing their ideas through the hackathon. However, due to the lack of skills on programming and others, the latter students are supposed to behave passively. This assumption is supported by the result of rubric evaluation for the Engineering Design Skills shown in Figure 9. For six levels from the beginning to exemplary one, the obtained average values are found to be less fluctuated than other skills and be around two with a small standard deviation of 0.08 among the levels. However, standard deviations relatively larger than 0.7 for the average values of about 2 are obtained for each level. This result indicates that there are two types of students mentioned above: polarization of students' attainments due to their pre-developed skills. It seems that, in the hackathon, prototyping and implementation of ideas are key ingredients for the problem solving; it is important to consider the students' pre-developed skills to form the group and implement the hackathon effectively.

Table 3. Average values and standard deviation for each competency category obtained from the results in Fig. 8.

	1. Skills for Teamwork				2. Skills for Practical Problem Solving				3. Communication	
	1-A		1-B		2-A		2-B		3	
	Teamwork		Independence/ Ability to actions		Logical Thinking /Problem solving		Ethics/Socail responsibility		Communication	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Ideathon	2.26	0.51	2.32	0.34	2.21	0.35	2.29	0.34	2.08	0.20
Hackathon	2.07	0.32	2.21	0.15	2.34	0.14	2.47	0.11	2.47	0.08

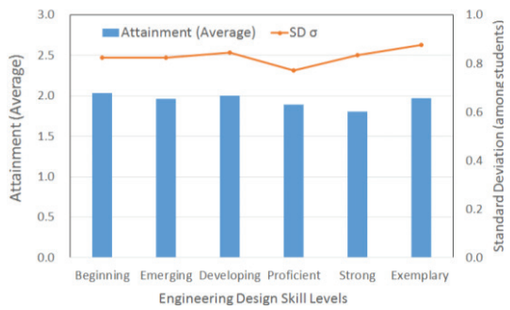


Fig. 9. Rubric evaluation results for the Engineering Design Skills: Average values and Standard deviation.

This result should be considered for implementation and management of Hakcathon /Ideathon held as educational opportunities for developing students' skills. From the comments, it is shown that the hackathon is very effective way to gain and to build students' confidence towards tackling next problems collaboratively. In addition to these results, from the student comments and observation, it is also shown that the hackathon among NIT Colleges provide the students opportunities to form their network as future collaborators and share the views of Kosen education reflecting their regional characteristics.

Conclusions

In this project, "Hackathon" was chosen as an educational platform to provide the students real experience of collaborative problem solving to foster their generic skills and engineering design skills as a part of implementation phase of MCC defined by NIT. It is shown that the students recognise their generic skills and engineering skills are improved through the Hackathon. However, the self-evaluation for ethics and social responsibility exhibits decrease after the hackathon. It seems that the students recognise the difficulty for problem-solving taking into account ethics and social responsibility, because those are not usually covered by lectures. This result suggests that faculties need to give them proper feedback to the students through the Hackathon activity. It is also noted that Engineering Design Skills and Logical thinking Skills/Problem Solving Skills show smaller improvements through the Hackathon. It seems that the students did not satisfy with her/his performance in the development of solutions/prototype. From the average and standard deviation analysis of the rubric evaluation results, it is shown that there are two types of student participants: well experienced students with required technical and/or non-technical skills (e.g. programing/technical skills) and students without enough skills. The polarization of students' attainments due to their pre-developed skills should be considered for improvement.

It seems that the Hackathon is very effective way to foster students' generic skills. However, it is very important to consider the students' pre-developed skills to implement the hackathon effectively.

It is shown that the Hackathon is a good opportunity to develop students' skills. Basing on the obtained results from this study, further international collaborations among partner institutes (e.g. International Hackathon) is also suggested to be promoted for the development of students' global and intercultural competencies.

Acknowledgements

The authors acknowledge all colleges and students as who participated in this project. We would also like to show our gratitude to supporting companies for their technical support and mentoring.

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STEM CO-LEARNING BRINGS CROSS-GENERATION LEARNING

A. Kong*,a and T.C. Fu**,b

[a] Department of Communication Design and Digital Media, Hong Kong Design Institute, Hong Kong SAR
[b] Department of Information Technology, Hong Kong Institution of Vocational Education (Shatin), Hong Kong SAR

*anthonykong@vtc.edu.hk, **cstcfu@vtc.edu.hk

Abstract

This study explores collaborative synergistic learning on elderlies and kids and provides empirical insights for STEM (Science, Technology, Engineering and Mathematics) education in Hong Kong. Experiment on elderly and kid to complete a STEM challenge for measurement. The result shows elderly performs well in STEM areas. Elderlies and kids learning together is significantly more effective, also benefit on both sides.

Keywords: *cross generation, collaborative learning, elderly and kid, STEM education*

Introduction

The promotion of STEM education in Hong Kong was first proposed in the 2015 Policy Address and further supported in the Policy Address (2016), aim to nurture a versatile pool of talents with different sets and levels of skills to enhance the competitiveness of Hong Kong. Technology is growing rapidly, cause to increasing the gap of digital divide between older and younger generations.

Digital Divide

Technology is growing rapidly, cause to increasing the gap of digital divide between older and younger generations (Holmes, 2012). The baby boomers generation, born between the years of 1946 and 1964, they are not big fans of technology and hard to catch up the latest technological trend, due to resist to learn (Loges, W. & Jung, J., 2001). Therefore, the generations divide is formed.

According to Table 1, in 2064, the elder population will be increased to 33% of the entire population in Hong Kong. It will cause a serious impact to the society because of this digital divide.

Table 1. Characteristics of the HK population (Projections).

	Percentage of population		
	Mid-2014	Mid-2034	Mid-2064
Aged 0 – 14	11%	10%	9%
Aged 15– 64	74%	62%	58%
Aged 65 & over	15%	28%	33%

(Source: Census and Statistics Department, Hong Kong Population Projections 2015–2064)

Leisure Time

Ibrahimov (2015) finds the leisure activities and spending time are in similar pattern between teens and elderlies, watching Television or Video time is 1100-1200 hour per year, shown in Table 2. That implies they have plenty of leisure time to spend.

Table 2. Hour of leisure time per year.

	Teens	30s/40s	70s
Watching TV/Videos	1200	450	1100
Socializing with 3 or less people	150	275	200
Socializing with 4 or more people	350	50	25
Individual exercise (Sport)	150	200	150
Group exercise (Sport)	450	175	0
Cinema	100	37	75

(Source: Ibrahimov, 2015)

The Experiment

This study explores collaborative synergistic insights on elderly and kid to learn in STEM areas. Experiment on assess STEM aptitude test for solving the types of problems that arise in science, technology, engineering and mathematics. The participants were grouping in pair

into 3 categories: 1. Elderly-elderly, 2. Kid-kid and 3. Elderly-kid. Arranged as Table 3. The selected elderly aged from 66 to 73 and kid aged from 4 to 8, total 20 persons (10 pair group). The test required the participants to complete 10 problems in 20 minutes.

Table 3. Groupings

G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
EM	EF	EM	EF	EM	EF	EM	KM	KF	KM
KM	KF	KF	KM	EM	EF	EF	KM	KF	KF

Notations: Elderly Male – EM Elderly Female – EF
Kid Male – KM Kid Female – KF

Result and Discussion

The experiment result was measured by the answer accuracy and finishing time as shown as Table 4.

Table 4. Result

	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
%	100	80	100	70	100	80	100	50	70	60
Time	F	F	F	M	M	F	F	S	M	M

Notations: F – Fast M – Moderate S – Slow

Finding1: The elderly and kid pairing groups were significantly more effective than the others.

Finding2: The elderly pairing groups were also performing well in STEM area.

Finding3: Indicating elderlies enjoyed more to learn and play with kids in observations.

Conclusions

Bring the cross generation collbrative learning (co-learning) is significantly benefit for both generations, not only the acquire for knowledge but also to build emotional attachment for active living. However, the motive for learning of elderlies is still in low, collaboration with the kids may be one of the motives to commence. The findings also reveal STEM knowledge of elderlies is high, through co-learning with kids can effectively transfer to kids.

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TEACHING ETHICAL REASONING TO ENGINEERING STUDENTS

Sin-Moh CHEAH & Hui-Bee LEE

School of Chemical & Life Sciences, Singapore Polytechnic, Singapore

CHEAH_Sin_Moh@sp.edu.sg

Abstract

Engineering ethics is an important component of engineering education. Yet the topic is seldom covered in mainstream engineering education, partly due to the wide-ranging nature of ethical issues. Especially of concern is the rapid advancement of technology, in particular in the advent of Internet of Things, while bringing about greater convenience and availability of information, also threatens personal and data privacy. This paper presents an initial effort by a team of lecturers from the Diploma in Chemical Engineering to teach ethical reasoning to its students. While not directly related to addressing the ethical issues related to technologies per se, we believe this is an important first step towards greater coverage of engineering ethics in education. Due to an already packed curriculum, the topic is introduced as part of the study of chemical process plant safety, a 60-hour core module in Year 3 titled *Plant Safety and Loss Prevention*. The paper starts with a brief introduction to engineering ethics, and shares various ways – based on a survey of the literature – how engineering ethics can be integrated into the curriculum. Then, after a brief introduction to the module, the paper presents the work done by the team, which involved the use of the DVD *Incident at Morales*, a professionally-produced teaching aid, as an assessable assignment. The objectives are to introduce our students to potential ethical issues related to engineering work, heighten their awareness in recognizing them, and how they can reason through possible resolutions using the engineering profession's code of practice. Essentially the work done is via facilitated classroom discussion, where scenes from the DVD are identified as posing potential ethical issues, and how these can be addressed, with students putting themselves in the shoes of the main actors. Students are assessed through a presentation in MP4 format. The paper then shares the finding of students' learning experience via surveys, which include questions that are part of the DVD package, as well as additional questions posed by the teaching team. The paper concludes with some ideas to further improve the teaching of engineering ethics.

Keywords: *CDIO, Chemical Engineering, Ethical Reasoning, Code of Ethics*

Introduction: Importance of Engineering Ethics

Being able to practice is an ethical manner is expected of engineers. Therefore, the teaching of ethics should be an important component of all engineering education. Colby & Sullivan (2008) suggested that training of professionals in all fields can be designated as 3 formative apprenticeships as follows:

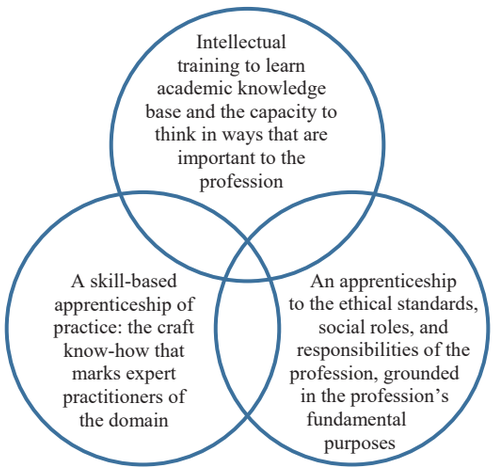

Figure 1. Apprenticeship of Professional Training

However, the teaching of ethics in engineering profession as currently practiced is still inadequate (Herkert, 2010; Colby & Sullivan, 2008). The rapid progress in technology development, in particular Internet of Things, had raised concerns (Waddell, 2017). For example, Stahl et al (2017) probed the social and ethical implications of research and innovations in emerging technologies such as artificial intelligence, cloud computing and robotics. Wadhwa (2014) went further and noted that technological progress is moving further ahead than the legal and moral frameworks needed to manage it. From a different perspective, several authors had also argued that teaching of ethics is important for the development of professional identity in one's chosen field (e.g. Stappenbelt, 2012; Loui, 2005)

Sternberg (2012) argued that ethical reasoning can be taught, and best with the case study approach. Ethical reason is distinct from ethics – the former is how to think about issues of right or wrong, whereas the latter comprises a set of principles for what constitute right and wrong behaviour (Sternberg, 2012). Also, as noted by

Adamson (2017), while ethical behaviour is about doing the right thing, it doesn't follow that the right thing is intuitively obvious. Just as engineers and technologists learn to assess risks in their work, they need to learn how to identify ethically challenging circumstances.

Integrate Engineering Ethics into Curriculum

There is clearly an increasing need for educational institutions to teach ethics to better prepare students for today's workplace (Frisque et. al, 2004). However, there is no one consistent, widely agreed-upon method of teaching ethics to undergraduates, and literature indicates disagreement about approaches to teaching ethical practice (Baker, et al, 2012). Various approaches had been suggested to integrate engineering ethics into a curriculum. Some of these are 'standalone' approaches (e.g. Hornsby, 2007), where a separate module is introduced, and the teaching may not be directly related to any core modules and often taught by faculty not belonging to the engineering profession. Others tend to link teaching of engineering ethics with the execution of capstone projects (e.g. Jiménez, et al, 2006; Leone & Isaacs, 2001). Our approach in the Diploma in Chemical Engineering (DCHE) is based on what Davis & Riley (2008) termed "insertion", which involved the inclusion of ethics instruction into technical modules resulting in a dozen or so "ethics mini-lessons". A micro-insertion is one that is small-scale, each lasting only a few minutes. The work described here is one that is significantly longer, as presented next. In this case, we use the video Incident at Morales and integrate it into the module *Plant Safety and Loss Prevention.*

The video is a product of the combined efforts of a team with representation from several universities and individuals with experience in various engineering disciplines and philosophy. It was developed by The National Institute for Engineering Ethics (NIEE), Murdough Centre for Engineering Professionalism, Texas Tech University, with a grant from the National Science Foundation.

This video is chosen because it provides the suitable context for the chemical engineering discipline. It involves a variety of ethical issues faced by a company that wants to quickly build a chemical plant in order to develop a new chemical product to gain a competitive edge over the competition. Potential technical and ethical issues arise from choices of designs, including valves, piping, chemicals, etc. The process involves high temperatures and pressures and requires the use of chemicals that need special handling. The plant is designed to be automated and controlled using computer software. Because of cost factors, the company decides to construct their plant in Mexico and uses cheaper parts and components (Smith & Nichols, 2004). Various problems of different nature (technical, environmental, financial, and safety) arisen that involve ethical issues. The movie emphasized 3 aspects:

- Ethical considerations are an integral part of making engineering decisions.
- Although legal requirements may vary among states and nations, ethical obligations do not stop at state or national borders.
- Wherever engineer practice, they should strive to protect the health, safety, and welfare of the public.

Description of Work Done

Plant Safety and Loss Prevention is a core module taught to all 120 DCHE students in Year 3. It is non-examinable, i.e. it is 100% based on in-course assessment, as shown in Table 1.

Table 1. Module Assessment Plan

Code	Description	Type	Percentage
CA1	Assignment: HAZOP Report	Group	20
MST	Mid-Semester Test	Individual	20
CA2	Case Study: Singapore Standards	Group	15
	Assignment: *Incident at Morales*	Group	15
EST	End-of-Semester Test	Individual	30

The module was taught in semester 1, with 4 hours contact time per week, over 2 terms for a total of 15 weeks, not including the 3-week term break in-between. The lesson on teaching ethical reasoning was conducted over Weeks 16 and 17 (total 8 hours) as follows. Students are first reminded (i.e. to activate their prior knowledge) of their Year 1 study in the module *Introduction to Chemical Engineering* where the Bhopal Gas Disaster and ethical issues were first introduced. The class then goes on with more in-depth discussion such as identifying key stakeholders and their perspectives. This sets the stage for exploring potential ethical issues and ethical reasoning using the *Incident at Morales* video.

The video is about 35 minutes long. It was played in class and paused at appropriate intervals whereby he lecturer then initiated classroom discussion to clarify scenes in the video, and to engage students in identifying potential ethical issues. Collectively, the class (comprising 20-24 students, working in groups of 4-5 students per group) record the discussions into Google Doc (see Table 2). At this point, any group can help with the recording. The purpose is to capture the key points of the discussion. Later, students were given time to watch the video again to better understand the entire storyline. Students were then informed that each group is to select one ethical issue of technical nature and another ethical issue of non-technical nature for their assignment; and no groups can work on the same issues. Each group recorded its choice with an "X" in Table 2 for all to see. Selection is on a first-come-first serve basis.

Students are also briefed on the assessment requirement of the assignment, which is worth 15% of the overall assessment (see Table 1). It requires students to prepare a presentation in-class or via a video. Specific details of this assessment are shown in Table 3. Lesson then continues with the lecturer facilitating the discussion on ethical reasoning. Students were given up to one week to complete the assignment.

Table 2. Google Doc for Recording Discussion Outome

			Class:		Group:		
	S/N	Brief Description of Issues	A	B	C	D	E
Technical	T1						
	T2						
	T3						
	T4						
	T5						
	T6						
Non-technical	N1						
	N2						
	N3						
	N4						
	N5						
	N6						

Table 3. Assessment for *Incident at Morales*

Assessment Component (Group)	Percentage
• Analysis of Ethical Issues: 1 Technical, 1 Non-Tech	40
• "If You Were In-Charge"	20
• Creativity / Presentation Skills	20
Assessment Component (Individual)	Percentage
• Class Participation, Completion of Surveys	20

A total of 3 surveys were carried out. The first two surveys use the same set of 5 questions devised by Loui (2006), who used the video to investigate students' learning of engineering ethics; but adapted them to Singapore's context for one of the questions. His study showed that the video is an effective approach to teach engineering ethics. One survey was administered before students watch the video, and another survey after they watched the video and classroom discussion. The 5 questions are:

S1. The first obligation of an engineer is to fulfil an assignment from the employer, or a contract of a client
S2. When working in a foreign country, a Singaporean engineer should comply with local regulations and should avoid imposing more stringent Singapore standards for safety
S3. Ethics consideration are an integral part of making engineering decisions
S4. A code of ethics can provide guidance in making engineering decisions
S5. Many ethical problems encountered by engineers have technical solutions

For each question, students are to indicate on a Likert Scale their responses: from 1 for "Strongly Disagree" to 5 for "Strongly Agree". The third survey is prepared by the author to learn about the students' learning experience in engineering ethics based on an active learning approach used in classroom. There are 10 question with a Likert Scale ranging from 1 "Strong Disagree" to 5 "Strongly Agree":

Q1. I find that the lessons from "*Incident at Morales*" had provided me with new understanding of the role and responsibilities (i.e. that of ethics) of a chemical engineer.
Q2. I have developed greater awareness of potential ethical issues that may arise from the conduct of a chemical engineer in the workplace.
Q3. I believe that having a good understanding of ethical principles is important for the professional identity of a chemical engineer.
Q4. I find the approach used in class (use of probing questions, reminder of selected scenes, or words spoken) useful in helping me identifying potential ethical issues in "Incident at Morales".
Q5. I enjoy participating in my group discussion analyzing ethical issues in "Incident at Morales".
Q6. I have learnt to analyze a technical issue for its potential ethical implications.
Q7. I have learnt where to obtain more resources and some tools needed to help me resolve an ethical dilemma that I may face.
Q8. I find that including learning of ethics in the chemical engineering curriculum is beneficial to me.
Q9. I find that working collaboratively in Google Doc is a useful way to identify as many ethical issues as possible in "Incident at Morales".
Q10. Overall, I benefitted from the lessons in analyzing ethical issues covered in "*Incident at Morales*".

Results and Discussions

We will first discuss the results from the 5-question Pre- and Post-video surveys, shown in Figures 1 to 5 as obtained from 2 cohorts of students in 2 semesters. The results in Figure 1 is encouraging, as it showed that there is an increased awareness that the obligation of an engineer went beyond that of employers or clients. There is a shift in the numbers of responses that indicated "Agree" or "Strongly agree" towards "Strongly disagree". This showed that the broad intended learning outcome had been achieved, i.e. the commitment that an engineer should have is towards health society and welfare of the public.

Likewise, Figures 3 to 5 represented changes in students perceptions that were not unexpected. Students recognized that ethical considerations is part of engineering decision-making; and felt that having a code of ethics is useful. In Figure 3 there is a significant increase in responses towards "Strongly agree" that ethics consideration are an integral part of engineering decision-making, confirming the shift noted in Figure 1. There is minimal change seen in Figure 4: we take it that all along students opined that a code of ethics is useful in guiding their decision-making. As for Figure 5, it showed a shift in students' belief that many ethical problems can have engineering solutions.

An interesting situation came from Figure 2, which suggests that when in a foreign country, an engineer should comply with local regulations and should avoid imposing more-stringent Singapore standards for safety. Here there is negligible change overall, due to 'cancellation' effect as shown in Table 4.

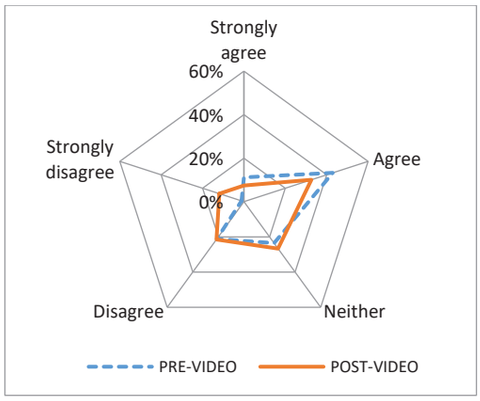

Figure 1. Response to Pre- and Post-Video Survey S1.

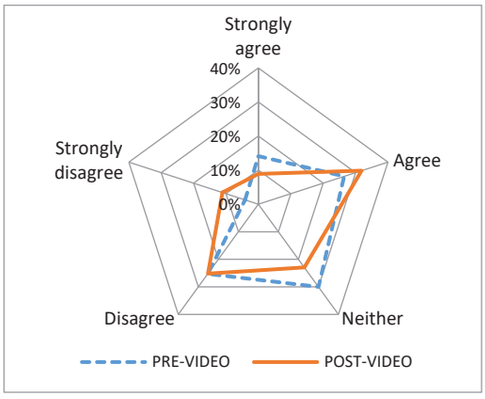

Figure 2. Response to Pre- and Post-Video Survey S2.

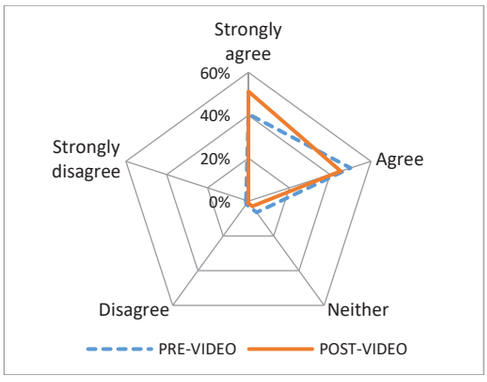

Figure 3. Response to Pre- and Post-Video Survey S3.

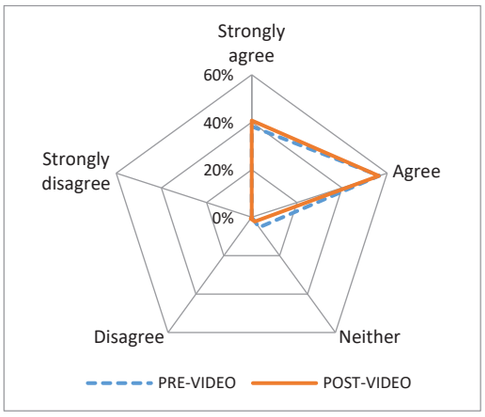

Figure 4. Response to Pre- and Post-Video Survey S4.

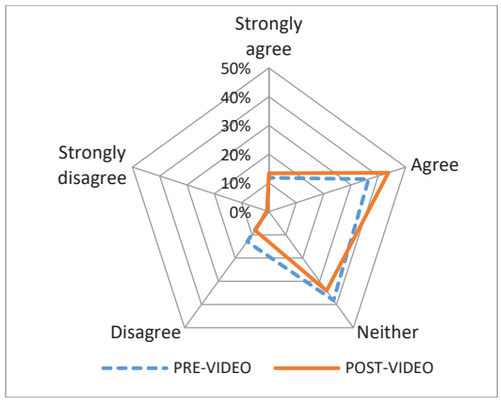

Figure 5. Response to Pre- and Post-Video Survey S5.

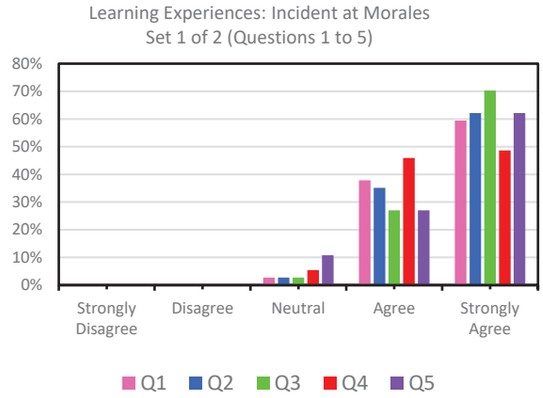

Figure 6. Response to Learning Experience Survey Set 1

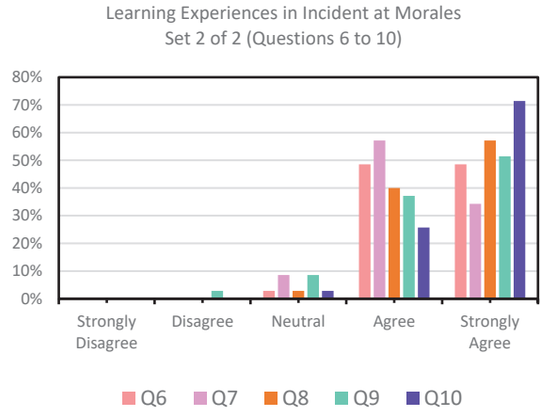

Figure 7. Response to Learning Experience Survey Set 2

Table 4. Results from Figure 2.

	% Response				
Video	S Agree	Agree	Neither	Disagree	S Disagree
Post-	9	32	23	25	11
Pre-	14	26	30	25	4
Change	–5	+6	–7	0	+7

The pattern of the shift indicates that there seem to be confusion among students on which country takes precedence on ethical matters – his/her home country or the country he/she is working in. This means that we

should spend a bit more time during the lesson debrief to address the issue. Timing-wise this can be challenging because the post-survey can only be done after students watched the video and class discussions completed. At this point students tend to be more interested in continuing with the assignment than completing this post-video survey, even if we stop conducting the third survey.

Next, we look at the students' learning experiences in the topic by examining the results from the third survey. Responses to Questions 1, 2 and 3 as captured in Figure 6 showed that students can readily identify with the need for chemical engineers to conduct themselves in an ethical manner. Most students also reported that they felt engaged by the approach used in teaching the subject, as shown by responses to Questions 4 and 5 in Figure 6. This is again reaffirmed by the students in their response to Question 9 in Figure 7, on the use of Google Doc. Based on the authors' experience, students often came up with more numbers of ethical issues (both of technical and non-technical nature) than required. As mentioned in earlier paragraph, the requirement is that no group should work on the same issues; i.e. if there are 5 groups, then there should be 5 different technical and 5 different non-technical ethical issues identified. However, in all instances, the students usually came up with 6 or 7 different issues for each category.

On their skills development, students generally reported that they had improved in the ability to analyse a potential ethical issue (Question 6), and be more resourceful when seeking more information (Question 7). Overall, they believed that learning about ethics is a useful endeavour (Questions 8 and 10).

Due to time constraint, we are not able to allocate as much time needed for classroom discussion using the approach suggested in the training guide. Another challenge faced is the need to invest some time to explain some of the scenes, for example, how a multi-national corporation operates (for example as in the *Incident at Morales* case, which involve a parent company in France, with the subsidiary in the U.S., building a new plant in Mexico), or the terminologies used in the dialogues among the actors due to the students's lack of real-world working experience.

An interesting finding though, was the preference shown by students for sharing their work, which contributed to 15% of total module assessment. This was in fact a chance encounter: for Academic Year 2017, due to clashing of class schedule with national public holiday, students were given options to either send in a video submission of Week 17, or do a classroom presentation to the lecturer on Week 18. The latter had been the traditonal approach of assessment used in previous years. All except one group opted for the video presentation. As can be seen from Table 3, use of creativity in presenting the materials is one of the assessment criteria.

As things turned out, students handed in more interesting work based on their video submissions. There were much creativity displayed in presenting the assignment, in terms of analysis of ethical issues, and the segment on "If You Were In-Charge" (Table 3) using a wide range of media such as PowToon, VideoScribe, or they simply just film themselves in role play. For the author, this outcome is much more desirable than sitting in class going through one PowerPoint presentation after another.

Ideas for Future Work

The survey results are very encouraging to the team, which prompted us to think of ways to build on what we had done thus far, to further deepen the students' engagement in learning about engineering ethics. We come up some ideas for future work:

(a) We can consider consolidating the separate cases of ethical issues currently integrated in various core chemical modules under a common theme, such as using a spiral curriculum (Whysong, et al, 2007). An opportunity to do so now available, as the course is now undergoing a revamp to align itself with the requirement of a national-level initiative (Cheah & Yang, 2018).

(b) Introduce a systematic process for ethical reasoning, to help students analyse ethical issues. An example is the Sternberg's 8-step process (Sternberg, 2012):
   1. Recognize that there is an event to which to react
   2. Define the event as having an ethical dimension
   3. Decide that the ethical dimension is significant.
   4. Take personal responsibility for generating an ethical solution to the problem.
   5. Figure out what abstract ethical rule(s) might apply to the problem.
   6. Decide how these abstract ethical rules actually apply to the problem so as to suggest a concrete solution.
   7. Prepare to counteract contextual forces that might lead one not to act in an ethical manner.
   8. Act

(c) The logical next step after students had acquired the ethical reasoning skills is for us to assess how well they are able to use it in various situations. In this case, we can refer to the works of Self & Ellison (1998) who investigated the use of Defining Issues Test (DIT), which is based on cognitive moral development theory, as the instrument of assessment of moral reasoning skills. They found that the teaching of ethics in engineering can be rigorously measured, tested and analysed and can have a significant positive influence on the moral reasoning skills of the students.

Strategy (a) can and should rightfully be implemented within the DCHE curriculum itself, as this can best provide the right context of learning about ethical issues in chemical engineering setting. This approach can also support a longitudinal study to track students' skills in handling ethical issues over the duration of their study. Students can be taught to recognize potential ethical issues early in their study, right in Year 1. They can then learn the systematic way to deal with such issues via Strategy (b) for example in Year 2. Evaluation of their competency in ethical reasoning can be carried out in Year 3 using Strategy (c).

The challenge here is for the team to figure out how best to do this in a curriculum that is already packed. Where can Strategies (b) and (c) best incorporated is not immediately clear at this point. The Year 2 curriculum is particularly congested. An althernative may be to explore this as an elective module offered in Year 3, combining both Strategies (b) and (c). The on-going revamp effort may help to inspire some new creative ways.

Conclusions

This paper shared the work done to develop in students skills in ethical reasoning. From the results obtained, we can conclude that students had gained greater awareness of potential ethical issues in engineering, but still need practices to hone the skills required. We had acquired new understanding from this effort, and come up with new ideas of improving the teaching. Although we are still far away from addressing the concerns of technology as mentioned in the beginning of the paper, the author believed the effort made thus far is one that is pointing in the right direction.

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INNOVATIVE LEARNING AND TEACHING IN JOB REDESIGN FOR WORKPLACE SAFETY AND PRODUCTIVITY: NURTURING PROFESSIONALS FOR SMART CITIES

C.K. Leo[a*] and Rowena. Koh[b]

[a] Republic Polytechnic, School of Engineering, Senior Lecturer, Singapore
[b] Republic Polytechnic, School of Engineering, Assistant Director, Singapore

* leo_chin_khim@rp.edu.sg

Abstract

Job design is an integral component in an organization. The way a job is designed affects a worker's motivation and performance. A poorly designed job may inadvertently lead to issues with workplace safety and lost productivity. It is imperative that the organization develops an environment where workers feel motivated in their jobs and at the same time their work meets the goals of the organization. Well-designed jobs can have a positive effect on workers' performance, motivation, satisfaction and safety on the job. Properly designed jobs and where necessary, redesign are crucial to effectively match the job to a worker's strengths and abilities. This is of added importance especially in aging populations where increasingly elderly workers are reemployed to the workforce to keep the economy going.

A new methodology, the 4E Job Redesign Methodology, was developed and applied to the Human Factors Engineering (HFE) module via Project-Based Learning (PjBL) to provide a holistic and systematic framework for job analysis and improvement studies. Through a team project, students applied concepts of HFE and the 4E Job Redesign Methodology to redesign jobs for canteen cleaning assistant, laboratory assistant, librarian, goods receiving assistant, gym assistant and area cleaning assistant. Innovative and useful ideas were generated and made into prototypes for team discussions and evaluations. Positive feedbacks from students who have taken this PjBL module will encourage more adoption of the Project-Based Learning approach.

Keywords: *productivity, job redesign, workplace safety, motivation, aging workforce, project-based learning*

Introduction

RP's unique 4E methodology – Explore, Establish, Evaluate and Enhance shown in Figure 1, employs a systematic yet holistic approach to job redesign. The 4E methodology strives to understand and grow an enterprise's bottom-line in a sustainable manner by providing measurable and quantifiable results,

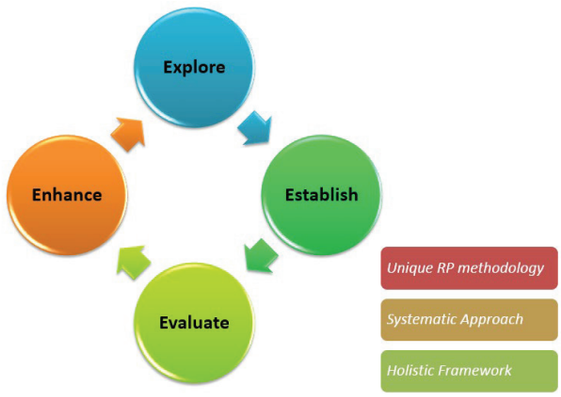


Figure 1 – 4E Job Redesign Methodology

"By eliminating non Value-Added activities and streamlining work flows, 4E methodology improves process cycle-time, reduces workplace accidents and injuries while enhancing overall motivation and well-being of the worker." (C.K. Leo and Rowena. Koh, 2017)

Method and Discussion

The Human Factors Engineering module was revamped and delivered via Project-Based Learning from 2017, in order to provide ample learning opportunities for students to relate the theoretical concepts of ergonomics to practical applications in the area of job redesign through a semester-long project. Job redesign focuses on improving workplace safety, productivity and employability for all workers. Many aspects of job redesign hinge on worker, ergonomics and environment which are already covered in the existing curriculum.

The proposed project requires student to analyse a chosen job or task holistically and make recommendations for improvement. Through laboratory observations, experiments and prototyping, they consider both environmental factors and human anthropometry, and in the process appreciate the potential difference they may make in enhancing the ease and value of the job they study.

The module is divided into 4 learning packages. A 4E Job Redesign Methodology – *Explore, Establish, Evaluate and Enhance* (C.K. Leo and Rowena. Koh, 2017) is used to trigger and organize the learning. The 4

learning packages will have equal weight corresponding to 4 assessment points for Continuous Assessment (CA). The knowledge and skills acquired in the learning packages will be applied to the team project. Students have been briefed at the beginning of the module on the required deliverables and expectations of the project.

A breakdown of the activities for the learning phases in each lesson is as shown in Table 1.

Table 1: Learning Phases in each lesson

Learning phase	Key Attributes	Proposed Activities
1	Theoretical Concepts and skills demonstration	• A series of mini-lectures and student activities will be used to introduce the learning objectives of the lesson and allow students to understand how the learning acquired will be useful for their project. • The lecturer will cover key concepts required to handle the week's tasks with activities to understand the concepts.
2	Practical applications and activities	• Students will conduct research, and consult lecturer to clarify the content for their learning package tasks. • They will participate in hands-on activities to apply techniques and to practice their skills.
3	Project Discussion and Implementation	• Time will be allocated for students to provide an update on their project progress, highlighting difficulties that they face and knowledge gaps that should be addressed in order to complete the project. • Student and lecturer will provide feedback on learning and the effectiveness of their inquiry and project activities. • The teams will continue to work on their project by applying new techniques and knowledge they have acquired during the lesson.

Every CA grade is made up of a team-based component and an individual component. The Module Grade (MG) is calculated based on four CA grades and two Summative Assessment (SA) grades.

In week 13, students were assessed by a panel of lecturers. A poster based on 4E methodology and prototype such as physical model or simulation form part of the assessment criteria during presentation.

Results

A total of 120 students took the module in 2017. From week 1, the students form their own team of 4 or 5 and brainstormed on the job redesign project they wish to embark on. They were given 6 jobs to choose from:

a) Canteen cleaning assistant
b) Laboratory assistant
c) Librarian
d) Goods receiving assistant
e) Gym assistant
f) Area cleaning assistant (e.g. classroom/toilet)

By the end of week 2, each project team is required to submit their chosen job and they can kick-start their project initiation and ideation using the first E - Explore. Figure 2 shows some of the project teams during project discussions and initial prototyping phase.



Figure 2 - Project Teams in Discussion and Ideation

During the Explore phase, the project teams seek to understand the work environment and work flow processes of the chosen job. They also need to recognise basic human sensory anatomies employed to carry out the tasks and apply basic research methodology, for example, conduct survey and interview the worker to find out the job requirements.

The Explore phase will last 3 weeks and at the end, the students will have a basic understanding of the job being studied.

During the next phase, Establish, environmental parameters related to the chosen job, including physical distances/lengths, noise, lighting, temperature and humidity were measured. These formed the baseline environment which the worker is performing in. Measurement tools including light level meter, sound level meter and Wet Bulb Globe Thermometer were provided to the students. Figure 3 shows some of the tools provided to the students.



Figure 3 – Environment Measurement Tools

The Establish phase will last 3 weeks during which the measured data were referenced to known standards to determine whether the baseline environment is suitable for the job. For example, light level results from one particular project team showed the laboratory assistant is working in an environment < 100 lux. This may be too low for comfortable and accurate work requiring performance of visual tasks of medium contrast or small size like reading off equipment or tool readings.

The next phase, Evaluate, is where the project teams analyse the worker's anthropometry, work parameters and risk factors for injury and fatigue. Current work practice and work-rest schedule were also evaluated to sieve out infringements to recommended work duration. Finally the students inspect the workplace for likelihood

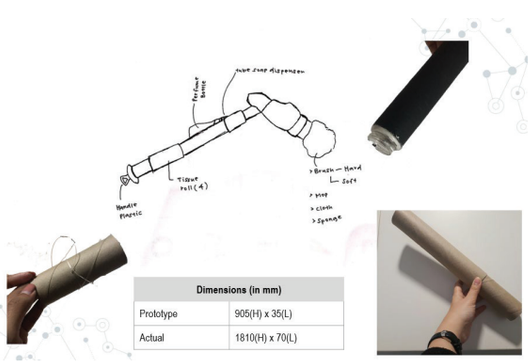
of human error and perform risk assessment for the workplace. Figure 4 shows the risk assessment conducted by a project team working on an area cleaning assistant job.

Hazard Identification			
No.	**Activity**	**Hazard**	**Possible Adverse Consequence**
1	Too much soap dispensed	Work Environment – Slippery floor Human Performance – People will slip and fall	Sprain ankle, Spine, Backache
2	Janitor need to bend down often as the product is short	Ergonomics – User might have backache from repetitive bending motion	Backache
3	Faulty Product	Design Factors – Faulty soap dispenser	Product unable to work
4	Material not durable	Design Factors - The stick might break	Injure the user
5	Faulty Product	Technical - Handle must be forcefully extended	Users would hurt themselves

Risk Control			
Severity (Consequences)	**Likelihood**	**Risk Level**	**Risk Control Measure**
8	5	13	Remind user to be careful while dispensing the soap
6	6	12	Extend the extender stick to its maximum
5	3	8	Regular checks on faulty products
4	2	6	Find better materials eg. acrylic or stainless steel
5	2	7	Have a manual for users to read before using product

Figure 4 – Risk Assessment for Area Cleaning Assistant

In the final phase, Enhance, the project team make recommendations to improve the job by proposing improved hand tool design, improved work flow or enhanced physical workspace. They also rate the effectiveness of their recommended solution. Figure 5 shows the efforts of a team and the stages they went through in designing a 4-in-1 cleaning tool for janitors.



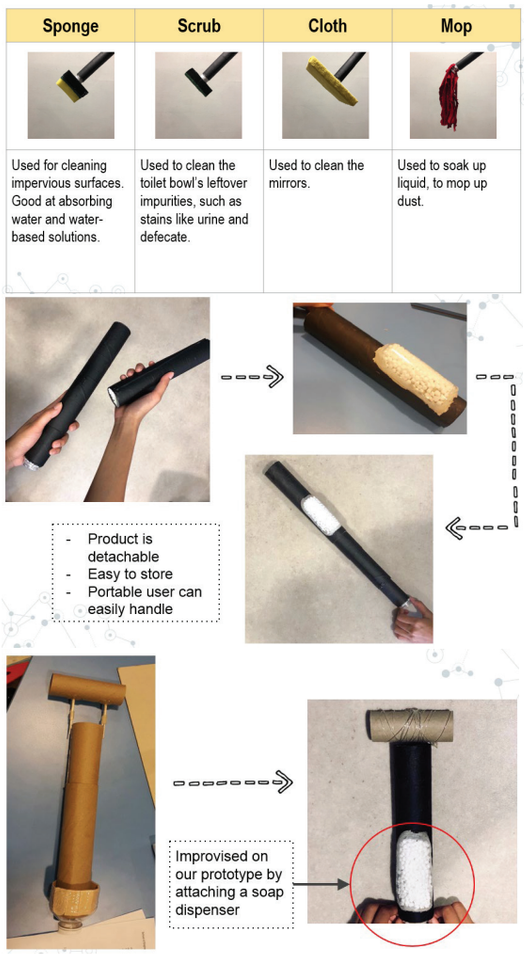


Figure 5 – Students project to design a novel 4-in-1 cleaning tool for janitors

During week 13, the 24 project teams were then assessed by a panel comprising of the students' project supervisor (40% weightage) and two independent assessors (30% weightage each) in a 30 minute presentation. The project teams were required to showcase their physical prototype and project poster, and defend their recommended solution using PowerPoint slides, team report and a Question and Answer session from the panel. Figure 6 shows some of the teams' project presentation during week 13.



Figure 6 – Project Presentation in Week 13

After the project presentation and prototype showcase, the student teams participated in a gallery-style walk to view and understand what other teams have done. This encourages peer learning from one another and gathering of feedbacks for future improvements. Figure 7 shows the gallery walks conducted after teams' presentations.



Figure 7 – Gallery walks sharing to promote peer and collaborative learning across student teams

At the end of the semester, students' feedbacks were gathered to find out if PjBL has helped them to learn and apply HFE concepts and tools to real life scenarios, in particular job redesign. Figure 8 shows the graphical representations of the students' feedbacks for PjBL in the module.

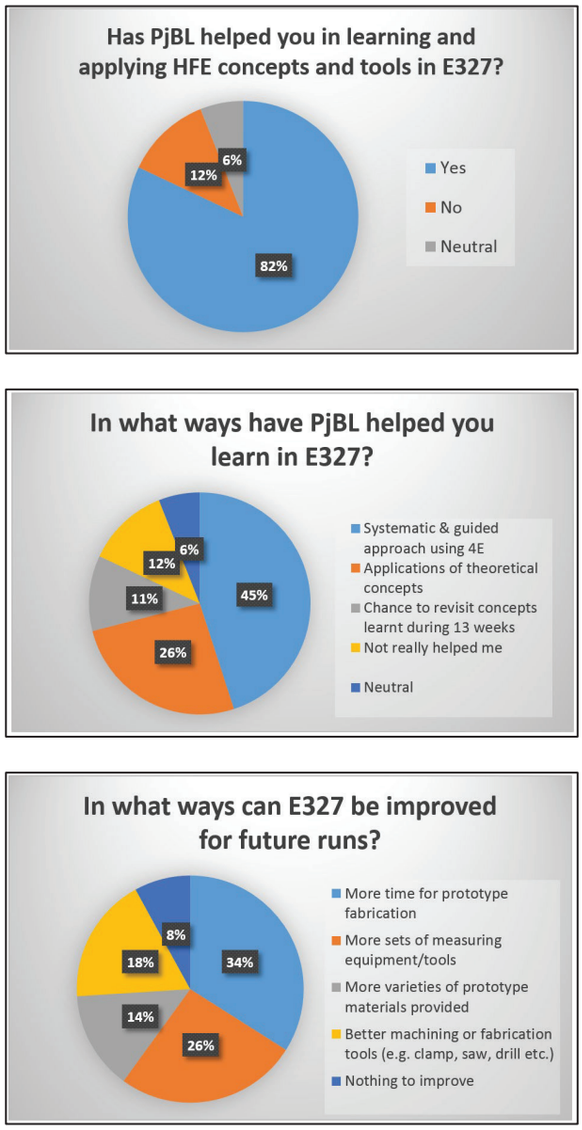


Figure 8 - Graphical representations of students' feedbacks for PjBL in the module

Samples of students' feedbacks from their Reflection Journals are captured here:

"PjBL has allowed us to apply what we have learnt throughout the semester as we are tasked to select a project at the start of the semester. Lesson by lesson, we slowly apply what was taught to our selected project and through that we also understand the concepts better."

"I appreciate that the Human Factors Engineering adopts PjBL because I believe that one will learn best by applying what one have learnt. Which PjBL gave us the opportunity to grow in that particular aspect. Not only applying what we have learnt, but also the time allocated to apply what we have learnt. Especially for my team, on the problem itself, we applied what we have learnt in Learning Phase 1 & 2 immediately and presented to our lecturer even though it was not required for certain problems. Reason for that is to keep

track of what we have learnt and not to miss out anything when week 13 comes… In summary, I am extremely satisfied with PjBL."

"The PjBL in the module has helped me in understanding and applying the concepts by knowing which concepts to apply and how to apply them. This is because throughout the project, my teammates and I have identified and use the concepts into our prototype. For example, when putting the markings on the laptop stand, we calculated and decided that the font size of the markings should be 0.48cm so that the library officers can see the markings easily from their desk. Therefore, throughout this project, I can apply the concepts to the prototype. The PjBL in the module has helped me in understanding and applying the concepts by using the concepts of human factors in real- life. This is because in this project, my team choose to improve the working conditions of the library officers. Hence, we interviewed them to find out the problems that they are facing. From there, we decided to create a laptop stand for them and applying the concepts we have learnt into the prototype. Therefore, by doing this project, I can have a better understanding of the concepts taught."

"When developing our project prototype, proposal and PowerPoint presentation, we applied HFE knowledge to help us generate the different requirements. We applied our weeks 1-3 knowledge to develop our prototype solution such as the poster to know what type of font size is needed to make reading easy. Our weeks 4-6 knowledge help us examine the physical environment such as heat, light and noise. Weeks 8-9 helps us to understand the work physiology and human error and violation within the Lab. Week 11 helps us to draft out questionnaire to make it reliable, valid and sufficiently sensitive. Week 12 helps us understand work safety. All these knowledge eventually was translated to generate the various requirement, thus making our project complete by identifying the different issues that we need to consider in order to perform job redesign. I personally feel that PjBL indeed is beneficial in our learning of HFE in a more practical and realistic manner."

Conclusion

Project based learning (PjBL) was adopted for the teaching of Human Factors Engineering (HFE) module in Republic Polytechnic, Singapore. Using a real-life scenario of Job Redesign for common jobs around us, students taking the HFE module has ample opportunities to relate and apply HFE concepts and tools learnt to redesign their selected job to make them safer, more comfortable and more productive. Peer and collaborative learning among students was enhanced along the journey to conceptualise and materialise their prototype for job redesign. Positive feedbacks from students who have taken this PjBL module will encourage more adoption of this learning approach.

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EVALUATING EFFECTIVENESS OF INTERVENTIONS TO IMPROVE STUDENTS' LEARNING IN ENGINEERING MATHEMATICS

P.E. Janice Lim*[,a], H.H. Wilbur Tan [b]

[a,b] Republic Polytechnic/ School of Engineering, Lecturer, Singapore

*janice_lim@rp.edu.sg

Abstract

This study aims to examine students' learning experiences and the effectiveness of their learning in a classroom learning environment with interventions introduced to the module - Engineering Mathematics. The interventions involve two parts, (i) instructional design of the learning activities in the lesson packages and (ii) study skills of students. Feedback was gathered from 500 students through administering a survey questionnaire and a self-reflection checklist. To examine students' learning experiences and the effectiveness of their learning, there are 3 main areas of consideration in this research: (i) students' perception of the interventions made to lesson packages (ii) the level of effectiveness of these interventions on students' learning (iii) the impact of students' self-reflection checklist on their study skills.

This paper describes different methods and interventions that were introduced in the curriculum design of a polytechnic diploma first year math module for one semester - Engineering Mathematics. The interventions to the lesson packages include the introduction of digital interactive platform, Kahoot!, games and hands-on activities, Kahoot! was rated the highest for level of enjoyment by the students and is consequently perceived as the most important intervention amongst those introduced. Furthermore, its effectiveness to promote learning can be gauged. A strong relationship between the students' level of enjoyment and students' learning is observed. Among all these interventions, Kahoot! is the only digital interactive platform whilst the other interventions belong to the traditional non-digital hands-on activities. The findings of this research indicate that these interventions, especially those involving digital interactive platform, are able to promote learning effectively as they created more opportunities for the students to practise and demonstrate understanding.

Introduction and Background

Many believe that Mathematics is mainly about computations which is a common misconception. In application, these theories are used to create solutions for real life situations. In our current world, powered with advanced technologies, artificial intelligence and information predication, it has become an absolute necessity for people to be able to understand, analyse and apply appropriate mathematical knowledge. As learning and practicing students, it is necessary to be equipped with higher-order math knowledge to be successful in the engineering world.

The importance of adopting instructional design techniques by educators to obtain higher success math rates of students, in the aspect of higher achievement scores, is becoming significantly necessary. Rasmussen and Marrongell (2006) have also showed that it is important for educators to adopt instructional design techniques. They stated that after aligning students' needs in obtaining higher-order math knowledge and abilities, instructional design can be used to provide a structural process and framework. Various studies indicate that instructional design is one of the more effective ways to remove challenges for a student in order to achieve math success. Saritas (2004) has indicated that instructional design is an effective way to alleviate many pressing problems in education, while Reigeluth (1983) shared that instructional design is a linking science – a body of knowledge that prescribes instructional actions to optimise desired instructional outcomes, such as achievement and effect.

However, instructional design per se cannot produce the other variables mentioned in this paper – including better learning and math achievements of students. The person designing the instructions (instructional designer) must possess clear understanding of crucial factors that affects students' learning and build a bridge between the students' achievement goals and their performance. Libienski & Gutierrez (2008) on the other hand stated that identifying these factors will help to utilise limited resources including financial resources and time more effectively. Once these factors are identified, there can be optimisation of financial and time resources.

In addition, students' learning effectiveness is also dependent on their study skills. This is evident in a book titled "Conquering Math Anxiety" by Arem (2003). She has presented a comprehensive, multifaceted treatment approach to reduce math anxiety and help learner succeed in math.

In view of the above, this study explores the relationship between students' learning experiences of

the introduced interventions, and the effectiveness of their learning in a classroom learning environment for the module - Engineering Mathematics. The interventions involve two parts: (i) instructional design of the learning activities in the lesson packages and (ii) study skills of students.

Three main research questions of this study follows:

(i) What are the students' perception on the interventions made to the lesson packages?

(ii) What is the level of effectiveness of these interventions on students' learning?

(iii) What is the impact that students' self-reflection checklist have on their study skills?

This action research study involved 1007 students of a polytechnic diploma taking first year math module for one semester - Engineering Mathematics over a semester - a total of 13 weeks at tertiary level. Students were exposed to the newly design activities in every lesson over a period of 13 weeks. At week 6, a reflection checklist exercise was given to the students so as to evaluate their own study habits. They were given another 6 weeks to work on their study habits based on the checklist. Thereafter, they were given another round of this exercise at week 12 for them to assess their own progress. At week 7, the students were given a survey questionnaire to collect feedback on the interventions made to the lesson packages. These quantitative data points were examined and changes were made to the interventions if required. At week 13, feedback was collected from the students through the survey questionnaire again. Selection and recruitment of subjects for student participants were conducted via online invitation. A link to the survey was sent to these students and they were informed about the purpose of the survey.

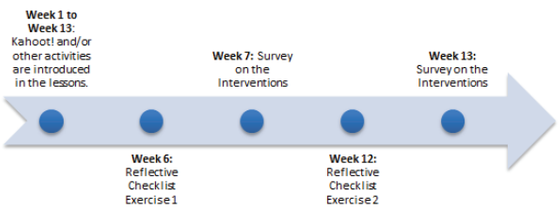

Figure 1: Timeline

The 2 main interventions can be described as follows:

i. introduced activities in the lesson packages
ii. introduced reflection checklist exercises on students' study habits

Literature Review

Instructional Design

Merrill (2002) discussed the first principles of instructions and how these principles are elaborated to promote learning, the five main principles stating where learning is promoted: when learners are engaged in solving real-world problems; existing knowledge is activated as a foundation for new knowledge; new knowledge is demonstrated to the learner and new knowledge is applied by the learner. To understand the effective instruction, Merrill (2002) has also elaborated the phases for effective instruction further. They are activation phase, demonstration phase, application phase and lastly integration phase. In view of the above, an overlapping method of demonstration and application phase was proposed as intervention, by having demonstration before practices, and also having more opportunities for students to practice and perform after demonstrating examples.

On the other hand, students' learning effectiveness is also dependent on their study skills. This is evident in te work of Arem, her book titled "Conquering Math Anxiety" (Arem, 2003). She has presented a comprehensive, multifaceted treatment approach to reduce math anxiety and help learner succeed in math. Her approach to conquer Math anxiety involves: anxiety management and reduction, confidence building, success in math visualizations, learning-style enhancement, problem-solving strategies, effective math study skills and winning strategies for overcoming math test anxiety.

Under one particular aspect of her approach - effective math study skills, learners are to evaluate their own study skills using the self-reflection checklist. Thereafter, learners are required to streamline the strategies which they would like to improve upon, as stated within the checklist. This approach is proven effective as learners can always refer back to the checklist to see if they have made improvements in their study skills.

Introducing Interventions in Lesson Packages

Incorporating the ideas abovementioned, a series of interventions were introduced to the 13 lesson packages:

a) Having students demonstrate their learning and also have more questions creating more opportunity for the students to practise and perform using the interactive media: Kahoot! This is a platform whereby students come together to do questions in the same online platform.
b) Having extra questions through crossword puzzle and mini-game.
c) Presenting hands-on activities as a problem for the students to solve collaboratively.

Achieving Effective Math Study Skills through Self-Reflection Checklist

Arem (2003) came up with a self-reflection checklist on study skills in order to help learners to obtain effective learning of Mathematics. This checklist involves studying techniques that work best for math, and she shared that by mastering these techniques, it will breed success. This self-reflection checklist

exercises aims to help students to reflect on their study skills and to work on how to improve them so that learners are less anxious and can eventually learn better in class.

Methodology

The effectiveness of these interventions was measured by:

(i) The effectiveness of these interventions is underpinned by both quantitative and qualitative data points collected under consensus of the students. Student's feedback on each aspect of the intervention within the lesson packages will be collected quantitatively through online survey questionnaire. The rating was based on a 5-point Likert Scale: 1 = Poor and 5 = Excellent. Feedback on the students' perception on each aspect of the intervention was examined, together with their feedback on the effectiveness of their learning with the interventions. Meanwhile, students' inputs on what can motivate them to learn and also other possible platforms to bring about more effective learning in their lessons were also collected.

(ii) To understand what impact the self-checklist exercise has on the students' study skills, analyses was done on the students' checklist scores - before and after, and reviewed if they have made any improvements in their score. Data on the usefulness of the checklist and if it has helped them to improve their study skills, were also be collected.

Data Collection

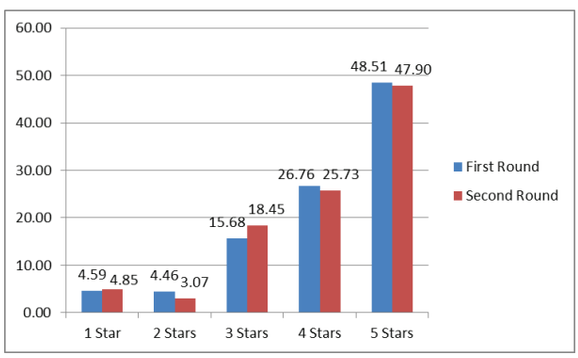

Figure 2: Interactive online tool Kahoot! (in percentage)

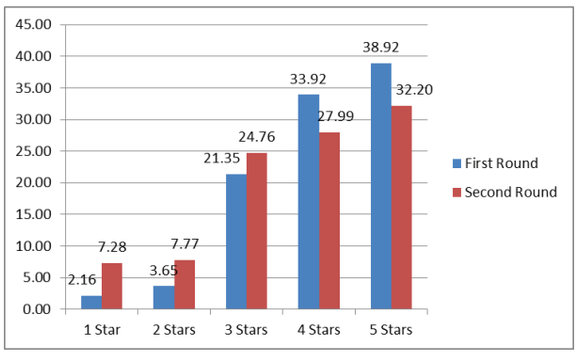

Figure 3: Hands-on activities (in percentage)

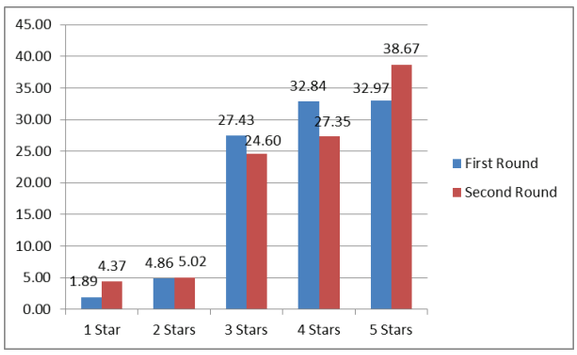

Figure 4: Brain warm-up exercise (in percentage)

Feedback was also collected on their learning and motivation through these interventions:

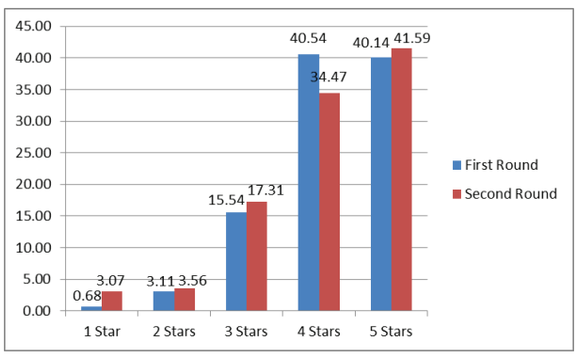

Figure 5: How much do all these activities help you to learn better in general? (in percentage)

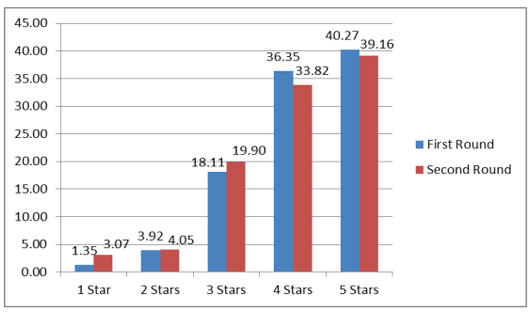

Figure 6: How much do all these activities motivate you to learn the concepts for that day? (in percentage)

Also, feedback on the usefulness of the self-reflection checklist and exam strategies in preparing them for their mid-semester assessment was collected and as shown:

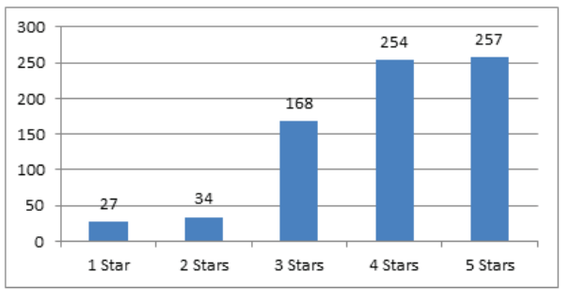

Figure 7: How useful did you find the timetable planning helps in your revision in preparation for mid-semester assessment?

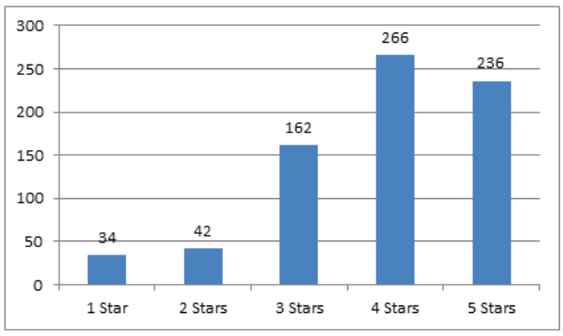

Figure 8: How useful did you find the self-reflection checklist helps you to reflect on your study skill for this module?

In both data collections, Kahoot! has the highest rating in its association to create an enjoyable learning environment for the students based on the feedback. For the first round of data collection, 80.68% of the students have given positive feedback that these interventions have helped them to learn better in general and 76.62% of them felt that these interventions in the lesson packages have also helped to learn the concepts for the day. 69.05% of the students have found the timetable planning useful in helping in their revision in preparation for mid-semester assessment. In addition, 67.84% of the students have found the self-reflection checklist useful in helping them to reflect on their study skills.

Actions taken after first round of data collection:

From the first round of data collection, the interventions have received positive feedbacks, thus these existing interventions were continued for the remaining 6 weeks. These interventions include: having Kahoot! for every lesson, re-assessing the students' study skills through reflection checklist, sharing of strategies on how to cope with exam, sharing of brain warm-up exercise video and incorporating hands-on activities and mini-games in the remaining lessons.

In addition, in view of the students' perspectives based on the feedback survey, it was noted that the lecturer also plays an important role in their motivation level to learn. Hence after, the lecturers introduced the sharing of motivational videos with the students on top of the usual guidance, and also more peer coaching and collaboratively learning in class when applicable.

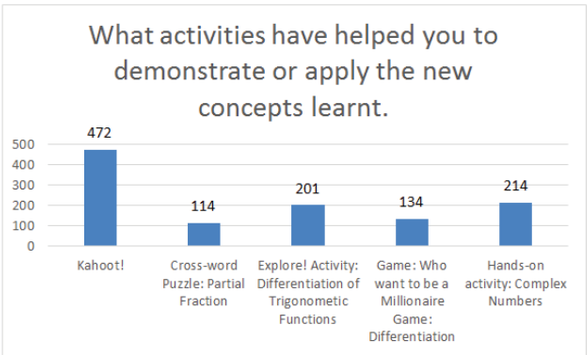

Figure 9: Select the activities which have helped you to demonstrate or apply the new concepts learnt. You can tick more than 1 option.

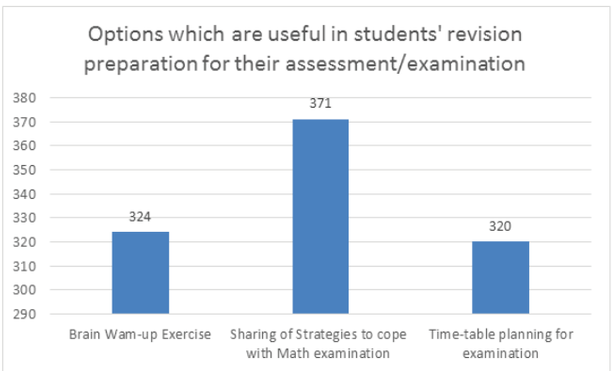

Figure 10: Which options which you find useful in your revision preparation for your assessment/examination? You can tick more than 1 option.

Table 1: Data collected based on self-reflection checklist

Students who have made:	**Percentages**
Improvements in their study skills after the self-reflection checklists	81.23
No changes in their study skilss after the self-reflection checklists	18.77
Improvement in their scores	44.31
Drop in their scores	48.69
No changes in their scores	7.01

In the second round of data collection, Kahoot! has the highest rating to create an enjoyable learning environment for the students based on the feedback and it is also rated the highest among all the activities in the effectiveness of learning.76.06% of the students have given positive feedback that these interventions have helped them in their learning and 72.98% of them felt that these interventions in the lesson packages have also helped to motivate them to learn the concepts during lessons. In addition, 81.23% of the students feedback that the self-reflection checklist have helped to improve their study habit, however, when comparison was made between the students' scores between their two self-reflection checklist exercise, only 44.31% of the students have improvements in their scores. There was observation made from the data that the students did make attempts to improve their study skills but it was not significant enough to result in an improvement in the score. On the other hand, more than 50% of the surveyed students found the interventions useful in helping them for their examination preparation with the strategies on how to cope with Math examination being ranked the highest.

In addition, feedback was collected on the reasons for their motivations and also their sharing of activities which they viewed is able to help them to learn better:
Lists of reasons that will motivate the students to learn better for both rounds of data collection are (in no particular order): good grades, lecturers, interactive activities such as Kahoot!, games, friends and peer supports, more given examples and questions, prizes and rewards, and individual goals.

List of activities which the students suggested to have to promote learning from both rounds of data collection (in no particular order): more brain exercises, videos about the topic being taught, interactive games, Kahoot!, e-learning lesson, real life scenarios to relate their problem, stress-relief activities so that they can concentrate better when studying, peer-to-peer guidance, hands-on activities and lastly, different learning environments.

The list of activities suggested by them and also the reasons for them to be motivated to learn are quite similar in both rounds of data collections. The top factors for the students to learn are good grades, lecturers and peers, and challenging questions. On the other hand, the top suggestions proposed by them which they think can help them in promoting their learning are to have more math games and activities, more questions or quizzes and also more Kahoot! and hands-on activities.

Through the qualitative feedback, one observation made was that the interventions have made an impression on the students as many of the interventions are being raised up as part of their suggestions for further improvements to promote their learning.

Conclusions

In this paper, different methods were explored and interventions were introduced in the curriculum design for Engineering Mathematics. Kahoot! is being perceived as the most successfully implemented intervention as it was rated the highest for level of enjoyment by the students and also its effectiveness to promote learning. A strong relationship between the students' level of enjoyment and students' learning is observed. Among all these interventions, Kahoot! is the only digital interactive platform as compared to the other interventions which belonged to traditional non-digital hands-on activities. The findings of this research indicate that these interventions, especially those involving digital interactive platform, are able to promote learning effectively as they created more opportunities for the students to practise and demonstrate their understanding after given examples as emphasised by Gardner (2009), and Perkins and Unger (1999).

From the data collected, the self-reflection checklist on study skills was able to help students reflect on their study skills and got them to continually work on improving their study habits. However, the efforts put in to improve their study skills are not significant enough to be reflected as an improvement in the checklist scores during the second round of exercises. This study can probably be improved if there is more monitoring and follow up on the students' study skills by their lecturers in between the two rounds of self-reflection checklist exercises.

Through the qualitative feedback, the most cited reasons for students' motivation are good grades, lesson activities, lecturers and friends. For this action research, the study focused more on instructional design of the lesson packages to promote learning. For further studies, more interventions can be explored to work on how to improve the students' motivations and learning in Engineering Mathematics.

Acknowledgements

Special thanks to the School of Engineering and Centre for Educational Development, Republic Polytechnic Singapore for the resources and information provided in this paper.

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Annex A: Self-Reflection Checklist on Study Skill

How Good Are Your Study Skills?	Usually (3 points)	Sometimes (2 points)	Rarely (1point)
1. I attend all my Engineering Mathematics classes.			
2. In class, I mentally follow all explanations, trying to understand concepts and formulas.			
3. In class, I write down main points, steps in explanations, definitions, examples, solutions, and proofs.			
4. I review my Math class notes again 2 to 3 hours later or definitely the same day.			
5. I do weekly and monthly reviews of all my Math class notes.			
6. I work on at least ten new questions and five reviewed questions during each study session.			
7. In reviewing, I use all methods, such as reciting aloud, writing, practising questions, picturing the material, etc.			
8. When I read, I say aloud and write out important points for a particular Math concept.			
9. I underline, outline, or label the key procedures, concepts, and formulas in my text.			
10. I take notes on my text and review them often.			
11. I work to complete my difficult Math quizzes/exercises in several small blocks of time.			
12. I complete all my Math quizzes/exercises and keep up with my class.			
13. I work to "overlearn" and thoroughly master my Math material.			
14. I retest myself often to solve the question in memory.			
15. I work to understand all formulas, terms, rules, and concepts before I memorise them.			
16. I use a variety of checking procedures when solving Math questions.			
17. I study with two or more different Math sources for references.			
18. I take small breaks every 20 to 40 minutes when I study Math.			
19. I study Math before other subjects when I'm most alert.			
20. I reward myself for having studied and concentrated.			
Totals:			
My Grand Total is:			

THE ATTEMPT TO APPLY LITERAL TEXTS AS TEACHING MATERIALS OF ACTIVE LEARNING FOR COMMUNICATION AND CULTURE SUBJECTS: THE CASE OF THE REPRESENTATIONS OF THE REGIONS IN JAPAN

Akio Kikuchi*[a]

[a] Department of Liberal Arts and Engineering Sciences, National Institute of Technology, Hachinohe College, Hachinohe, JAPAN

*akikuchi-g@hachinohe.kosen-ac.jp

Abstract

It has been seldom considered that literal texts are a useful medium for engineering students, who have little interest in culture and communication. Although few national colleges of technology (Kosen) in Japan have subjects for literature itself and the literary texts have been used mainly as linguistic materials, the subject has the possibility to give a chance for the students not only to learn regional or global cultures but also to develop their communication skills if we use them from different viewpoints. This presentation will try to show how effective literary texts can be materials for promoting Kosen students' communication skills in terms of active learning.

Keywords: *literary texts, interpretation, cultures, communication skills, active learning*

Introduction

It has been seldom considered that literal texts are a useful medium for engineering students, who have little interest in culture and communication. Although few national colleges of technology (Kosen) in Japan have subjects for literature itself and the literary texts have been used mainly as linguistic materials, the subject has the possibility to give a chance for the students not only to learn regional or global cultures but also to develop their communication skills if we use them from different viewpoints. This presentation will try to show how effective literary texts can be materials for promoting Kosen students' communication skills in terms of active learning.

Background

It is true that some of the students are interested in reading books or novels (as written in their curriculum vitae), not a few are less interested in reading classic texts or authorized texts. It can be said that the time for reading has been decreasing. It might be necessary for us to detect how exactly the situation is since the skill of interpretation is indispensable for engineering students who have to face the unknown texts when they work.

However, it is not easy to build the skill of reading. In not a few classes concerning languages such as Japanese or English, the literary texts, including novels, poems, dramas or essays, are being used as teaching materials. In this case, one of the main targets for using the material is to analyse the structure in various levels; word, idiom, sentence or paragraph. In other words, the material is linguistically treated, and as the text is the final target, it is difficult to go over the text and to, put it more precisely, utilize the material for other purposes. Students can understand how to read, but they can seldom get the idea of 'why they read'.

For engineering students, the main texts will be machine manuals or operations. They are written with clear aims. Literary texts, by contrast, often having deep and ambiguous meanings, are difficult for students who tend to search for one clear-cut meaning. The dichotomy between the simple reading tendency and the complex texts needs to be more focused since it dramatically illustrates the students' situation. They have to be accustomed to deep and complex reading, but in order to do that, it is necessary to enable us to make them involved into reading experiences.

To meet this demand, I carried out the 'reading' class in a class for tourism in 5th year students at NIT, Hachinohe College (hereafter Hachinohe Kosen). The class is called as 'Tourism and Culture', which is opened as one of the selective classes for 5th year students. In the classes.

Since it started in 2013, 'Tourism and Culture' has been working on lectures on histories of tourism, tourist sites, tourism resources. In 2018, in addition to the other subjects, travel writing was more focused than previous years. In 2017, the text materials of travel wrings have been included so that students can visualize the image of local communities through reading the descriptions in each text like *Unbeaten Tracks in Japan* by Isabella Lucy Bird, a famous English female traveller, and "Tsugaru" by Alan Booth. Compared with 2017 version, Bird's *Unbeaten Tracks in Japan* was more focused in 2018 version of 'Tourism and Culture'. By picking up her passage to Aomori, students are expected not only to read and interpret the content but also to make a travel plan.

Task (1) Make a travel plan for Isabella Bird in 1878
Task (2) Make a travel plan for Isabella Bird in 2018

Through these activities, the students are expected to not only come to know about historical situations in the time of the beginning of Meiji period but also try to think about inbound tourism through the text.

Results and Discussion

By giving a questionnaire, the students' motivation and their attitudes toward cultural material was examined in addition to their recognition about their own reading skills. The answers were given back from almost all the students.

2018 Tourism and Culture questionnaire

Class: No: Name:
Please mark each answer.
(1) Are you interested in knowing the culture of your area?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(2) Are you interested in knowing the culture of other areas?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(3) Are you interested in literature?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(4) Are you interested in history?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(5) Are you interested in geography?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(6) Do you know well about your hometown?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(7) Are you interested in enriching your knowledge on the culture of various areas including their history, geography, literature?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(8) Are you interested in travel or tourism?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(9) Are you interested in reading?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(10) How do you often read books?
1 More than five in a month 2 Four 3 Three 4 Two 5 One (Or none)
(11) What kind of books do you read?
1 Mystery 2 History 3 Love story 4 Fantasy 5 Biography 6 Travel Writing
7 Others [ ]
(12) How do you often read COMIC books?
1 More than five in a month 2 Four 3 Three 4 Two 5 One (Or none)
(13) Do you use E-books such as KINDLE?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(14) Do you think you often have difficulty in reading texts or books?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(15) As for question 14, what kind of difficulty is that?
1 Unknown vocabulary 2 Following the plot 3 grasp the relationship of the characters
4 Other [ ]
(16) Do you have confidence in understanding texts or books?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not

Thank you very much for cooperation.

Figure 1. The questionnaire on the students' attitude toward culture understanding (before TC).

The next data shows the result of the questionnaire.

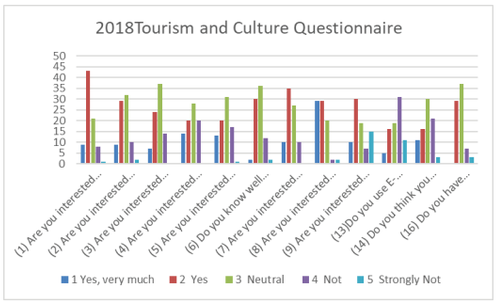

Figure 2. The questionnaire on the students' attitude toward culture understanding (abridged; before TC).

The data exhibits how the students think about learning cultures. As for question (9), which focus on the students' interest in reading, nearly fifty percent answer Strongly Yes / Yes. Concerning (14), which asks their confidence in reading, 40 percent answer Yes while 12 percent answer Not / Strongly Not (There is no answer of Strongly Yes). From these answers, it can be said that the students are not so much disinterested in reading. However, it should be not overlooked that 27 percent answer Not / Strongly Not, which indicates some students have seriously negative attitudes toward reading. How the students' attitudes have changed will be shown with reference to the result of the following questionnaire after the class.

2018 Tourism and Culture questionnaire2

Class: No: Name:
Please mark each answer.
(1) Are you come to be more interested in knowing the culture of your area after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(2) Are you come to be more interested in knowing the culture of other areas after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(3) Are you come to be more interested in literature after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(4) Are you come to be more interested in history after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(5) Have you come to be more interested in geography after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(6) Do you know well about your hometown after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(7) Are you come to be you more interested in enriching your knowledge on the culture of various areas including their history, geography, literature after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(8) Are you come to be you more interested in travel or tourism after the lecture?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(9) Have you enjoyed learning culture through tourism?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(10) Are you interested in reading after this class?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(11) Do you think you often have difficulty in reading texts or books after this class?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
(12) As for question 14, what kind of difficulty is that after this class?
1 Unknown vocabulary 2 Following the plot 3 grasp the relationship of the characters
4 Other [ ]
(13) Do you have confidence in understanding texts or books after this class?
1 Yes, very much 2 Yes 3 Neutral 4 Not 5 Strongly Not
Thank you very much for cooperation.

Figure 3. The questionnaire on the students' attitude toward culture understanding (after TC).

Conclusions

In this study how texts are useful as a platform for communication and learning culture through the active learning based on Isabella Bird's travel writing. Althouth the research is being continued and not finished, this study introduces how the class working on the application of travel writing for planning travel plans can change the students' attitude toward reading. With the change in their attitude toward reading and texts, it can be estimated that it will have an influence on the students' mindset for cultural understanding. While this presentation mainly treats how to 'interpret' the text, so it will be needed to investigate the relationship between communication skills and cultural understanding through

travel writing from other perspectives such as vocabulary building, geographical mapping, or comparing with other texts or their own experiences. These will be the subjects for following reasearches.

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ANALYSIS ON THE EFFECTIVENESS OF RAISING STUDENTS' ENERGY SAVING AWARENESS THROUGH ACTIVITY-BASED LEARNING

T.W. NG*,[a], W.W. KWAN[a] and K.W. LEUNG[a]

[a] Department of Engineering, Institute of Vocational Education (Chai Wan), 30, Shing Tai Road, Chai Wan, Hong Kong

*eetwng@vtc.edu.hk

Abstract

The Hong Kong Government has introduced the combination of educational, social, economic and regulatory means in the policies in order to drive energy saving. Substantively practicing energy saving can reduce cost, improve air quality and protect our environment. In this paper, a 1-year government-funded community project is introduced to gain the awareness and improve the behaviour of Hong Kong secondary school students on energy saving issues. The programme aims to nurture secondary school students' energy saving sense through a series of interactive activities, including training courses, games, experiment and seminars with proper use of energy. About 500 students from 12 schools in Hong Kong participated in this programme and data is collected by questionnaires and analysed by pre-test and post-test. The students who participated in the project activities were measured on their environmental conservation knowledge and behaviours before and after participation. The results indicate that the participants not only showed gains in their energy-saving knowledge but also reported an improvement in their behaviours of energy-saving.

Keywords: *Activities-based learning, Energy-saving, Pre-test Post-test Analysis, Environmental conservation, Secondary school education*

Introduction

This Government-funded community project is a pilot plan to promote domestic energy saving extensively and raise the public concerns and awareness on the proper use of energy through students' peer effects. Secondary-school students in Hong Kong are invited to participate in the pilot programme to broaden their knowledge of energy and the ways to quantify energy saving. Selected students after completing training would become ambassadors and help in promoting energy saving message to the public. Meanwhile, the ambassadors would be responsible to bring the concept of energy saving back to secondary schools and suggest feasible solutions in domestic energy saving to their peers.

Programme Structure

The 1-year programme is divided into 4 stages: Stage 1 is the pre-test questionnaire. Participants from secondary schools are requested to complete a questionnaire with an aim to investigate students' awareness on energy saving and STEM education, which also included students' expectations on the stage 2 activities. Students' level of education, gender, age, district of accommodation will be recorded for evaluation. Stage 2 consists of a 3-hour activity-based learning with a class size of 30. The 3-hour learning section includes energy generation and conservation, the importance of energy saving and a carbon emission audit. A survey with the same questions as the pre-test questionnaire will be conducted right after the training to verify the effectiveness of stage 2 activities. In stage 3, a 15-hour training to 40 selected students from 11 secondary schools are provided to nurture them as energy saving ambassadors. The final stage covers the promotion and energy-saving message spreading in schools and projects evaluation.

Learning outcomes

Energy saving is the effort made to reduce the consumption of energy by using less of an energy service which is a part of the concept of environmental conservation for sustainable development. In this project, students should be able to address what is energy, how energy affects our daily life, what if our life be without energy, why energy saving is important, etc. in order to achieve a high degree of awareness in energy saving, we had designed an interactive training course with applied activity-based learning strategy, to teach students the skills of energy saving, the importance of environmental conservation, the relationship between people and energy, and what will happen if they applied energy saving in their daily life.

Methodology

A pre-test consists of 15-20 questions for assessing students' knowledge on energy and energy saving was conducted. The questionnaire was distributed to 500 secondary 3 to 5 students who aged from fifteen to

seventeen at the beginning of academic year. All respondents from 12 secondary schools are expected to participate in Stage 2 training section and complete the post-test on site after the training was finished.

Table 1 showed the first 10 questions students to be completed in the questionnaire. Students were required to answer all of the questions by selecting the appropriate degree of consent to each statement listed on the questionnaire. A 4-point scale was designed to illustrate the degree of consent and no 'neutral standpoint' would be given which allows the results obtained to be more significant. Options available are i) totally agree; ii) agree; iii) disagree; and iv) totally disagree respectively.

Collected data from survey will be regarded as reference to verify the effectiveness of the training section in Stage 2 which is a 3-hour workshop in selected dates during the first semester.

Q.1	I agree the Earth is now in sick, I have to do something for environmental conservation.
Q.2	I switch off any electrical appliances when not in use.
Q.3	I am aware of the household electricity consumption.
Q.4	I understand the concept of energy saving.
Q.5	I am familiarized with the energy consumption unit kWh (Kilo-Watt Hour),.
Q.6	I know the energy consumption of each household electrical appliance.
Q.7	I know how much I should pay for the electricity bill of each month.
Q.8	I am familiar with the EMSD's energy label.
Q.9	I know what carbon footprint is and I can reduce carbon emission as much as I can.
Q.10	I had been aware of the reading on electrical energy meter in the past 2 months.

Table 1: First 10 statements in the questionnaire

In Stage 2, each secondary school was given an identical 3-hour training section. The topics conducted in the courses were the extension of the energy-saving knowledge they had learned or they had ignored in their daily life. The training content covers the topic of i) energy generation, ii) energy saving, and iii) carbon audit in a class size of 25-30. Splitting classes were applied when the class size is larger than 30 for effective learning in accordance with Koc, N. & Celik, B. (2015) finding. The teaching package was designed based on students' foundation knowledge learnt in school and the convenience students may apply in their daily life. After the training section participants were invited to complete the identical survey as post-test that they have completed in Stage 1, together with an event evaluation form before they leave the venue. The data would be compared with the result of Stage 1 and feedbacks from participants had also been collected with a purpose of Stage 3 planning.

The significance of the course is then verified by ANOVA with a null hypothesis of the 3-hour training course will not lead to a better understanding in energy saving. Two groups of 61 candidates' data are selected by random, one group with 3-hour training and the other group as control will be selected from population of the 500 secondary school students to evaluate the significance of the training.

Project on-going

A total of 40 shortlisted students will be selected as energy saving ambassadors and received further training in Stage 3. The ambassador selection criteria are based on students' eagerness and participation in stage 2 training section together with school teachers' or Institute trainers' recommendations.

In Stage 3, energy saving ambassadors will receive further training in the following areas: i) electrical quantities measurement with tools, equipment and apparatus; ii) various forms of energy conversions; iii) cautions on using new electrical appliances; iv) operating principles on renewable energy sources; and v) presentation skills.

In final stage, energy saving ambassadors will spread the energy saving awareness to the public, through their peers as secondary audience. To start with, student ambassadors after participating in the training will have a sharing on what they have worked in the training and how they implement the energy saving concept in school to teachers and schoolmates with a total number of over 4000 audiences in 11 secondary schools.

Results and Findings

Figure 2 illustrates the pre-test result after the survey conducted in Stage 1. The result showed that most students know they should conserve the environment by reducing energy consumption but more than half of students are not familiar the way to quantify household energy consumption as well as the electrical energy consumption unit.

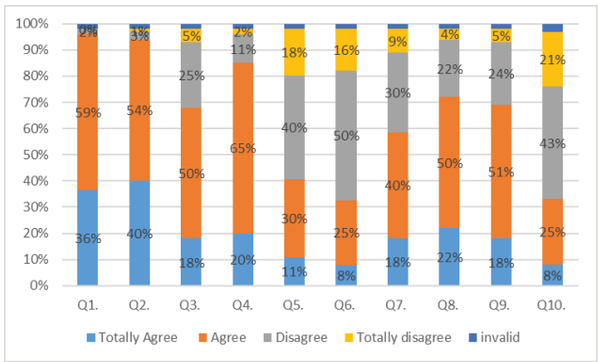

Figure 2: Questionnaire Pre-test Result

Figure 3 illustrates the post-test survey result after the training conducted in Stage 2. The result has recorded the percentage of students who 'totally agree' with the statements in the questionnaire has been raised. It should also be addressed that in question Q1, Q2, Q3, Q4 and Q8, 'totally disagree' percentage has increased slightly. Possible reason for the polarization is the training did help students to enrich knowledge and identified they did not acquire a complete understanding. The change in percentage of each statement in the questionnaire is tabulated in Table 4.

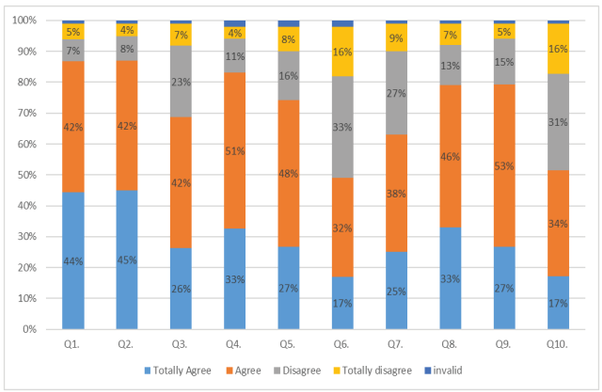

Figure 3: Questionnaire Post-test Result

Change in % (Post-test – Pre-test)	Totally Agree	Agree	Disagree	Totally disagree
Q1.	7%	-18%	5%	5%
Q2.	4%	-13%	5%	3%
Q3.	7%	-8%	-2%	2%
Q4.	13%	-15%	-1%	2%
Q5.	16%	18%	-25%	-10%
Q6.	9%	7%	-18%	0%
Q7.	7%	-3%	-4%	-1%
Q8.	11%	-6%	-9%	3%
Q9.	9%	1%	-9%	0%
Q10.	9%	8%	-13%	-5%

Table 4: Change in percentage of response in pre-test and post-test

Apart from the 4-point scale questions, 2 open-ended questions are extracted from the questionnaire and illustrate the findings. The survey had found out students recognized how to reduce energy usage from daily life, such as turn off all unused household appliances, half of the students would start with turning off unused lighting and air conditioning first. For instance, (1) turn off the light/air-conditioner while no one using, (2) reduce to use light/air-conditioner, (3) use fan to replace air-conditioner. Only a small number of students know to adjust the temperature to 25°C or turn off the appliances with standby state.

It is also found that after the training in Stage 2, more students reflected they obtained environmental friendly and energy saving information through different sources of media than pre-test as shown in Table 5. The training may either raised students' interests or nurtured them to identify information relating to environmental friendly or energy-saving. It is also noticeable that most students receive the information of energy saving were from school (73%) and from TV programs (55%).

Source of Media that students obtain environmental friendly and energy saving information:	Pre-test	Post-test
TV	55%	62%
School	73%	82%
Book/magazine	24%	34%
Online media	48%	54%

Table 5: Students feedback from pre-test and post-test

Table 6 illustrates the result of the single factor ANOVA. From the result obtained a low p-value (0.021) has been acquired which the null hypothesis can be rejected. The negative value in Sum and Average refer to better acceptance/a higher degree of consent to the statements in the questionnaire after the post-test. From the comparison among sample respondents who had taken the training course and the control sample, a significant difference of -16.6 (with course) and -0.2 (no course) has been recorded. The 3-hour training course is found effective in terms of the acceptance of environmental conservation and energy saving. During the course, students could experience how much effort they had to pay to generate electricity and had seen the actual profit of energy saving on the electricity bill through activities. Such learning experience allows students to quantify energy and explore ways to reduce losses during energy conversion.

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
(With Course)	61	-16.6	-0.2721	0.39171
(No Course)	61	-0.2	-0.0033	0.42266

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.20459	1	2.20459	5.41425	0.02165	3.92012
Within Groups	48.862	120	0.40718			
Total	51.0666	121				

Table 6: ANOVA result

Discussion on Activity-Based Learning

The Activity-Based Learning (ABL) helps students to develop their knowledge and ideas through

interactive actions and experience. The interaction is the main key for the successful learning. Suydam, M. N., & Higgins, J. L. (1977) and Çelik, H. C. (2018) expressed their views on interactive resources and environment are critical tools for helping learners to get more interest in learning. R. Ravi and Xavier P (2007) also stated activity-based learning is a method that teaches students to think against the problems, motivate them to explore possibilities for them in the learning period.

The project team does implement a number of activities-based elements such as laboratory work, quiz contest, professional talks, sharing, etc. to the teaching. The involvement is the most important element of ABL. Students are given chance to raise questions actively which motivate a bi-directional communication. Meanwhile, short lectures were included for traditional teaching. Such mixed arrangement allows students to adapt the learning environment smoothly.

Conclusion

From the comparison of pre-test and pro-test result shown, the activity-based-learning adopted in the training sections demonstrated the effectiveness in the promotion of energy saving. The questionnaires result reflected a significant improvement of participants' energy saving knowledge and energy saving awareness. It is very impressive that participants considered they had gained a certain degree of energy saving knowledge. Significant improvements in terms of depth are also recorded from survey result such as the energy consumption of different electric appliances, electric bill, proper use of energy, etc. and students' skills on energy saving were also improved.

According to the students' feedback in an evaluation after Stage 3 training, it is concluded that ABL achieved an improvement in learning energy saving concept and students found the training content is useful. The programme provided opportunities to students whom may experience and learn through activities other than vision and hearing. It is believed that activity-based learning stimulated students' motivation and interest. From the visits at Stage 4, it is observed that students are able to make good use the activities' content to explore their own learning pace and relate them to daily life in spreading the energy saving message in stage presentation.

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FROM BUSINESS ACADEMY TO BUSINESS AND ENGINEERING ACADEMY

J.M.A. Kallio-Gerlander[*, a] and A.E.E. Norström[a]

[a] Turku University of Applied Sciences, Faculty of Technology and Business, Lemminkäisenkatu 30, FI-20520 Turku, Finland

*jaana.kallio-gerlander@turkuamk.fi

Abstract

Future professionals in all fields need entrepreneurial mindset and innovation competences. Entrepreneurship goes hand-in-hand with innovation – the ability to produce new ideas and to provide better solutions. A fruitful environment for innovation consists of individuals with different backgrounds working together on the same real life problems. Business Academy and the future Engineering Academy consist of students representing business, chemical engineering as well as industrial engineering and management.

Business Academy is a multidisciplinary learning environment where active learning standards in the form of real working life assignments, innovation pedagogy approach of Turku University of Applied Sciences and student centered learning environment meet.

The Business Academy program gives a great opportunity for the students to work together in order to learn about modern team entrepreneurship but at the same time to focus on their own field of specialization.

Business Academy is a learning environment, where students can reach entrepreneurial and teamwork capabilities by actually doing business in a co-operative. Research and development activities are done with visionary local companies.

Learning program creates Synergy between Practice and Theory

Academic studies in the Business Academy model are based on active learning process as individual and as part of a team. The elements of the learning process are intertwined, i.e. both theory and tools are learned by activating methods in training sessions and reading circles. The theories are put in immediate action in each co-operative's business. The reflections of business, continuous feedback and development enhance deeper learning and bring up new needs for further theoretical learning. Positive cycle and the flow-feeling of doing business yield more knowledge, skills and competences. In Business Academy model learning is both theoretical and practical. This model is going to be applied to the engineering education in order to provide an alternative to the traditional engineering syllabus.

Keywords: *Business Academy, engineers, chemical engineering, students, companies, multi-disciplinary, collaborations, entrepreneurial*

Introduction

The importance of entrepreneurship in society is growing constantly. As many as 80% of new jobs are created in the small and medium enterprises, SME-sector, so it can be stated that the burden and responsibility of Finnish employment now lies with the SME-sector. This trend will continue and grow stronger in the coming years. Entrepreneurship is needed to secure economic growth and to keep the welfare economy alive. The number of companies in Finland in 2013 was 266 909. The so called micro-companies (employing less than 10 people) are dominant and represent over 93% of all companies. SMEs employing less than 250 people are in total 99%. The turnover of all Finnish companies in 2012 was about 389 billion euro. The percentage of this in micro-companies was 17% and in the total SME-sector 53%. (Elinkeinopoliittinen mittaristo 2016)

Most recent employment statistics from Finnish companies (revenue producing companies) are from the year 2014. The total number of full-time employed was 1 408 353 persons. Micro-companies formed 25% of this and the whole SME-sector 63%. (Elinkeinopoliittinen mittaristo 2016).

From the perspective of the European Union there are several documents that highlight the importance of entrepreneurship for the area. For example, the Entrepreneurship Action Plan (European Commission Entrepreneurship 2020 Action Plan - Reigniting the entrepreneurial spirit in Europe, 2013) is a blueprint "for decisive action to unleash Europe's entrepreneurial potential, to remove existing obstacles and to revolutionize the culture of entrepreneurship in Europe". Investments in changing the public perception of entrepreneurs, in entrepreneurship education and to support groups that are underrepresented among entrepreneurs are indispensable if a lasting change is to be created. Only if a large number of the Europeans recognize an entrepreneurial career as a rewarding and

attractive option, can entrepreneurial activity in Europe thrive in the long term.

The Entrepreneurship 2020 Action Plan, referred earlier, is built on three main pillars:

1. Entrepreneurial education and training
2. Creation of an environment where entrepreneurs can flourish and grow
3. Developing role models and reaching out to specific groups whose entrepreneurial potential is not being tapped to its fullest extent or who are not reached by traditional outreach for business support.

The European Commission will through the competitiveness and industrial policy follow up the Action Plan and its crucial pillars. A document called Small Business Act. The European Commission analyses the current situation of entrepreneurs in the EU and spots the obstacles and attitudes as well as the policy of each EU country, which may hinder the entrepreneurial activities not only in businesses but for example in education. Small and medium sized companies depend on entrepreneurs - the individuals who have the ideas and are willing to take the risks necessary to get a firm off the ground. Europe needs more entrepreneurs and the Commission is looking for ways in which potential entrepreneurs may be encouraged to establish firms. Other forms of enterprise, such as co-operatives, can play a crucial role in economic growth and they are often underestimated or thought to be "not so real companies". However, these types of company forms can encourage people in all kinds of professions to test their business ideas. (European Commission 2009a)

Beliefs hampering the entrepreneurship and tools to disperse the apprehensions

First, there are cultural factors discouraging too many people from starting a business. In the Higher Education Institutions (HEI) it is a necessity to develop a more entrepreneurial culture, starting with young people and students on each level in an educational system. Institutions of higher education should foster students creativity and teach them the ability to think "out of the box", innovation, self-efficacy, self-confidence, problem solving and, in general, how to manage complexity and unpredictability. Interestingly, when it comes to substance knowledge, it is often stated that "basic business and financial skills" must be covered. However, the importance of a learning environment in which learning takes place is considered very important, too. (See for example European Commission 2009b; Richardson and Hynes 2008; 2014)

Being an entrepreneur involves always an economical risk. There is too often a stigma attached to this risk and a possible failure. The attitude towards becoming and being an entrepreneur must be fostered and changed. Moreover, the total image of the entrepreneurship must be renewed: "You are either born an entrepreneur or you will never become one" – types of myths and beliefs are dangerous. Thus, facta based information is needed. (European Commission-Enterprise and Industry 2013)

Second, the administrative requirements are often the major reason hindering entrepreneurial activities. And third, entrepreneurs need to find it easier to attract investors. (European Commission 2014)

Furthermore, considering the entrepreneurial culture and entrepreneurial development from both individual and collective perspectives visions must be developed, as Koiranen and Ruohotie (2001), Kyrö and Ripatti (2006) and Henry (2013) suggest. They state that learning entrepreneurship takes place in four paths.

The paths are;

a) About entrepreneurship, which highlights rational thinking and theory,

b) For entrepreneurship, which presses the will and skill to start one´s own business,

c) Through entrepreneurship, which supports developing of gathering and using information and moreover creating actions for starting a business and finally,

d) Acting in a real company-like environment, in which one enjoys the freedom and uncertainty and the possibilities they give and, at the same time, develops the skills of sensing possibilities and creating those possibilities and opportunities oneself.

e) The last but not the least, is the fear, which comes up from time to time when entrepreneurial activities are added into the curriculum and the hard scientific substance seems to disappear. However, these topics should be seen as complementary to each other.

Pedagogical concept of Business Academy

The cooperative or limited company form of studying is nowadays an essential part of HEIs. In Turku University of Applied Sciences at the faculty of Engineering and Business, all the business, media and some ICT students have the possibility to join or establish a company during their studies. These students own and conduct companies in which real-life assignments are implemented with local SMEs, bigger companies and other organizations in growing numbers. Especially local SMES´s are favoured partners for student-owned companies for multiple reasons. For example, their needs are typically smaller and easily manageable.

Students invest 30-50 euros in the companies; they run their firm and at the same time study towards their degree. Students study in their co-operative teams of 15 to 20 persons, doing real life projects. On the other hand, they are also obliged to run their business and take care of the paper work of the company such as establishing papers, tax notes, salary issues etc. The payments of the projects go directly to students, not to the university.

Today, we combine business and Media production students in the Business Academy concept. In the future chemical engineering as well as industrial engineering and management are joining the BA concept.

The study plan consists reading materials, group discussion, and real-life projects targeted at the curriculum competencies of a certain level as well as

personal objectives of the student. Classical lecturing can be taken as a part of the study plan but is not, however, the most important sector. Identifying and recognizing the learning in various situations, also outside the university, is a key part of studying in the company. Reflections and evaluations are made by the coach, but also by the students themselves, by clients in projects as well as by fellow students.

The Business Academy Model is presented in Figure 1.

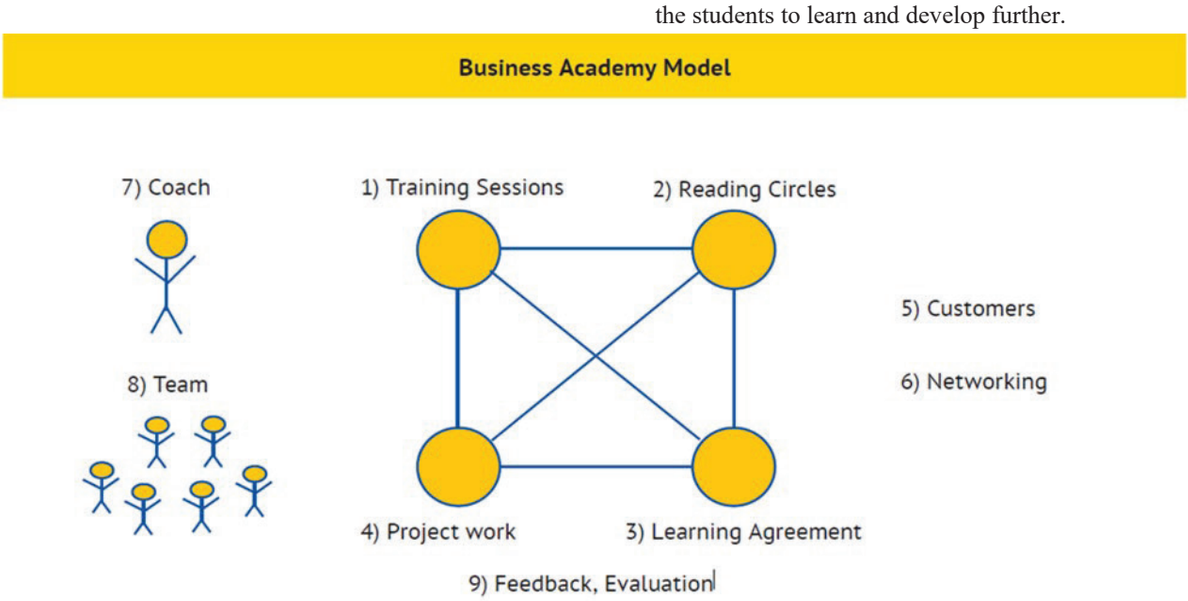

Figure 1. Business Academy Model

The Business Academy Model or concept typically consists of the following nine elements:

1. Training Sessions
Each team has training sessions twice a week. The contents and topics of the sessions come from the team's own business and learning goals. Training sessions are students' active learning by innovative methods. The planning, preparing and implementation of the sessions are the students' responsibility.
The coach supports and enhances the learning in the training sessions, in which knowledge is shared, built and deepened. The requirement level in training sessions grows as the learning progresses.

2. Reading Circles
Every student prepares for the Reading Circle by choosing the topic area as well as a book that boosts both the business and the learning. The book should be red and the relevant tasks should be made before the Reading Circle meets. In the Reading Circle are the lessons learnt deeper discussed and shared. Also the personal reflections are elaborated further and a common product that summarizes and supports the learning is produced.

3. Learning Agreement
The Learning Agreement crystalizes student's prior experience, current state, goals and ways to measure the progress. The students strive to actively reach the set goals and develop themselves towards the chosen career.

4. Project Work/Running Business
The student team sets up a co-operative company and develop the business according to their own plan. Knowledge and skills are put to direct and immediate action. Continuous feedback from the stakeholders help the students to learn and develop further.

5. Markets/Customers
Student-teams operate in open business markets. Genuine customer contacts and co-operations with companies make it possible to apply the theories in action.

6. Networking
Students have excellent opportunities to build relationships and networks with business decision-makers, stakeholders and partners during their Business Academy studies.

7. Coach
The students are by their team coach supported in finding their best way to learn. The basic role of the team coach is to support the team and its individual members to learn and develop themselves, so that everyone can find their own way of learning. Hence the concept: guided self-organized learning. The team coach has the most important role in the educational program.

8. Team
The team is the most important learning unit. Team-learning provides possibilities to become a versatile business expert. The team starts a company, creates its own business and is responsible for the theoretical learning process. The coach supports and challenges the team which co-works with other teams.

9. Feedback, Evaluation and Continuous Development. Continuous feedback is a part of the Business Academy best practices. Each project and learning situation is analysed by using a four-square model. Based on the feedback and assessment the learning is summarized and adjustment of actions points and /or development ideas are agreed.

The Entrepreneurial Engineer

During the past decades engineering education has been widely criticized as the focus in the various degree programs has mostly been on theoretical studies instead of practical work. The traditional engineering curriculum is no longer sufficient to address the contemporary industry concerns for improved graduate competency. The curriculums have been fragmented and concentrated on specific subjects rather than larger entities developing holistic views, mind-set and skills enabling the students to create and realize new value for people and organizations needed in the companies. The need for improved professional skills such as critical thinking, problem solving and interpersonal skills have widely been addressed.

Business creation and business development competences are keys to the global business arena of the future. Furthermore, such competences are generally a requisite for a range of knowledge-based organisations, from large to small and medium-sized private companies, start-up companies, as well as public services. Through a combined study programme both Business Academy students and Engineering students have the opportunity to acquire tools, methods, knowledge of processes, as well as an organisational and managerial understanding of innovation and entrepreneurship that will allow the youngsters to make a difference.

The teaching in the programme is research based. This means that the lecturers are doing research within the same academic field as they are teaching. This gives the students as well as the collaborating companies the access to the latest knowledge and dedicated personnel who are passionate about their subject. The teaching material not only includes books but may also consist of, for example, current academic articles from journals.

Engineering is combined with practical hands-on activities. A large part of the company assignments for the engineers take place in various laboratories where i.e. customer product development assignments are performed. The laboratories are of the highest standard, and they play an important role in teaching. Students in the programme will work under the best laboratory conditions with access to the latest technology, which is vital for benefiting from the teaching in their future companies.

Results and Discussion

The philosophy, how future business people and engineers as well as entrepreneurs should be educated, has changed during the last decade. In addition, the idea of what kind of mind-set and skills education providers should produce and promote among young people has moved from closed classroom based learning environments to open and company like concepts.

The word development also stands for important milestones such as building new curriculums together with local companies, real company work while studying, cross- and multidisciplinary student and staff teams working together etc.

In addition, the fear that when so-called generic, soft or human skills are added to the learning curricula, the scientific hard substance of the subjects will become less important has diminished. The attitude of both staff and students in HEIs must change towards more modern, educational environment, open up the faculty and welcome a dialog with the outside world. Naturally, this will demand a clear concept, in which roles, responsibilities and goals of the stakeholders (students, academia staff and industry) are well defined. The demand for a strict model is constant but also flexibility and openness for possible new elements must be kept in mind.

Preliminary practical results among business students based on the 12 years' experience are as follows:

- Graduation time for Business Academy students became shorter than for average business students (3.4.years compared to 4.2. years)
- Satisfaction of the student is higher than an average student (4.6 compared to 3.8, the scale 1 the lowest and 5 the highest))
- 16 certified coaches
- 32 teams graduated → 500 business professionals
- 89 % after graduation are in business life and/or acting as entrepreneurs
- 92 % of the alumni would recommend the Business Academy

These numbers have been collected from the university student databases VIRTA and the questionnaire for graduating students AVOP. Also an alumni survey was conducted.

Conclusions

Business Academy model contributes to existing academic knowledge of learning by suggesting broader connections to local companies, not only in the field of research but in implementation and prosecution of the projects. The learning concept postulated in this paper provides an additional step for development of learning environments in different fields, to enhance both substance and other skillset such as entrepreneurship.

From the more practical point of view, the case Business Academy has value for practitioners operating within education industry. The experience suggest that in the early phase of studies, here in the 2nd year, students must be put in contact with the industry. Moreover, the forming theory and practical project work can be together, not only in causal order (first the theory and then the implementation) compared to classical learning approach. Different parties can do the assessment along the learning process, also the student him/herself. There are basically two options to change learning approaches in academia and industry 1) promote the learning pedagogy as itself as a solutions or 2) change the learning environment structure combining various learning elements and put people to operate there. The second option is usually the more difficult and expensive one since academia typically resist attempts to change their opinion and behaviour in learning: the environment must be very different, not only simulating real world but to be the real world – act as an entrepreneur.

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HOW TO EDUCATE BETTER ENGINEERS?

J. Kontio*

Faculty of Engineering and Business, Turku University of Applied Sciences, Turku, Finland

juha.kontio@turkuamk.fi

Abstract

The Innovation pedagogy and the CDIO approach are the key elements in engineering education in the Turku University of Applied Sciences. Based on these approaches four main goal categories have been defined: structures, learner, teacher and culture. These categories are further described with concrete goals for the engineering education. For example, structures are described with words such as flexibility, learning with the industry, projects and multidisciplinary. In general, the acquisition of knowledge and development of skills go hand in hand in our programs. In curricula, there are faculty wide agreement that each program has certain elements raising from the Innovation Pedagogy, CDIO approach and the detailed goals we have defined. There are for example Project Hatchery, Introduction to your own study field – module and Innovation Project. In general, the basic elements of our education are in good condition. At the same time, the economy of the region is booming and there is a high demand of skilled engineers. The engineering faculty realized that we have to do better to answer the needs in the region and in the working life. Therefore, we organized a series of workshops to discuss how we could do better. Altogether 66 staff joined the workshops in spring 2018. First part of the workshops focused on the current challenges and the second part on finding answers and solutions to these challenges. The findings emphasized supporting students' intrinsic motivation and importance of teachers' pedagogical and coaching skills among others. In this paper, the pedagogical playground of our programs is described as well as the challenges and the proposed solutions from the workshops.

Keywords: *Innovation Pedagogy, CDIO approach, Engineering education, Challenges*

Introduction

Turku University of Applied Sciences (TUAS) is an inspiring community of 10,000 members – an innovative and multidisciplinary higher education institution, which creates international competitiveness and well-being for Southwest Finland. Our graduates are practice-oriented professionals with top competencies. Turku University of Applied Sciences has three faculties of which the Faculty of Engineering and Business is the biggest with 5800 students. In the field of applied research, Turku University of Applied Sciences represents the top tier in the country. TUAS coordinates or acts as a partner in over 200 RDI projects yearly. Studies at TUAS are working life-oriented, combining theoretical studies with professional skills. At the core of our teaching is Innovation Pedagogy, a new approach to learning developed at TUAS. Innovation Pedagogy emphasizes the viewpoints of RDI and working life, making our graduates independently minded professionals with excellent international and communication skills. In the approach, learning and teaching methods are applied creatively and, in a value-adding way, so that the students take responsibility for their learning and actively strive to reach their learning goals (Konst & Scheinin, 2018). Innovation pedagogy has a key role in the TUAS strategy and CDIO approach links very well with it (Penttilä & Kontio, 2014, 2016; Penttilä, Kontio, Kairisto-Mertanen, & Mertanen, 2013). Turku University of Applied Sciences (TUAS) has been a member of international CDIO initiative since 2007. The Faculty of Engineering and Business uses the CDIO approach together with Innovation Pedagogy to respond to the needs of the industry.

The goal of CDIO approach (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014) is to (a) educate students that have deep working knowledge of the technical fundaments, (b) are able to lead in the creation and operation of new products and system and (c) are able to understand the importance and strategic value of their work. The CDIO approach is adaptable to all engineering schools, but other fields of education can learn from CDIO approach too. The key elements of teaching and learning in CDIO are the connection to the working life and real engineering practices and active involvement of students in their learning. The CDIO approach supports universities and programs in education development by offering tools (CDIO standards and CDIO syllabus) for continuous improvement. The 12 CDIO Standards address program philosophy (Standard 1), curriculum development (Standards 2, 3 and 4), design-implement experiences and workspaces (Standards 5 and 6), methods of teaching and learning (Standards 7 and 8), faculty development (Standards 9 and 10), and assessment and evaluation (Standards 11 and 12) (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014). The CDIO syllabus provides key competences for engineering programs

besides the core technical topics. The general objective of the CDIO Syllabus is to describe a set of knowledge, skills and attitudes desired in a future generation of young engineers. It offers rational, complete, universal and generalizable goals for undergraduate engineering education.

Following the ideas of the Innovation pedagogy and the CDIO approach we have defined four main goal categories (Figure 1): structures, learner, teacher and culture. The work of Goldberg and Somerville (2014) has influenced on the categories broadly too.

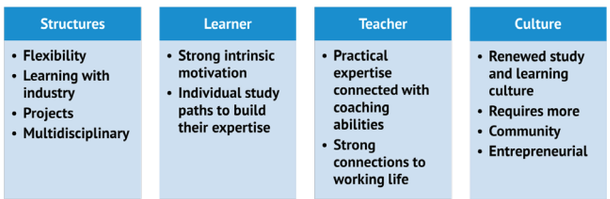

Figure 1. Key goals in education

Each of these categories are further described with more concrete goals for our degree programs and the faculty operations altogether. Structures describe the key ideas on how we organize our teaching and learning. The curricula are flexible. They define the overall competences for the degree, but allow flexibility on the modules and courses our students do. Teaching and learning is done together and in the industry. The teaching and learning is filled with projects and multidisciplinary activities. The Learner category has two key elements. First, we have to enable the learners' intrinsic motivation to get them wholly engaged resulting to deeper and more effective learning. Second, we have to allow student to make individual study choices and paths to build their expertise. Giving students the power of controlling the elements of their education they feel the trust and are motivated on their learning. Third, our teachers have strong practical experience from the industry and we want them to be able to support the learning of our students with coaching capabilities. The teaching follow the principles of experiential and active learning where student has the key role in learning process and our lectures coach them in their learning process. The teachers need good connections to the working life and these connections has be maintained. Finally, all the above has impact on the culture of the faculty. The teaching, learning and working environment and atmosphere need to change. We are requiring more, we are working as a community and entrepreneurial activity is increased. In general, the acquisition of knowledge and development of skills go hand in hand in our programs. In curricula, there are faculty wide agreement that each program has certain elements raising from the Innovation Pedagogy, CDIO approach and the detailed goals we have defined. There are for example Project Hatchery (Kumpula, 2014), Introduction to your own study field – module and Innovation Project (Kulmala, Luimula, & Roslöf, 2014).

In general, when HEIs want to develop their education and aim for better graduates they can identify three questions that a higher education institutes has to think (Crawley et al., 2014). First, they have to be aware of the need of their graduates - *What is the professional role and practical context of the profession(al)?* Second, the learning outcomes of their program has to be defined in relation with the needs in the industry - *What knowledge, skills and attitudes should students possess as they graduate from our programs?* And third, there is always room for improvement in the producing of the learning. It is possible to reconsider the curriculum, teaching and learning activities, assessment and workspaces and learning environments - *How can we do better at ensuring that students learn these skills?* Kamp (2014) encourages higher education to make fundamental changes, to take the benefits of the pedagogical and technological innovations, and better prepare graduates for the increasing and different demands of the new world of work.

The recent report (Graham, 2018) aimed to look the global state of the art in engineering undergraduate education. She tried to identify the current and emerging leaders in engineering education and their distinctive features. Finally, the study reported the key challenges that are likely to constrain the progress of engineering education. Graham's report lists several distinctive pedagogical features that the recognized current leaders in engineering education share. First, the students must have opportunities to engage with the university's research activities often building on applied teaching in the engineering fundamentals. Second, there are wide range of technology-based extra-curricular activities and experiences available to students and many of them are student-led. Third, there are multiple opportunities for hands-on, experiential learning throughout the curriculum. These learning experiences cover often both problem identification and problem solution and they are supported by state of the art engineering workspaces. Fourth, user-centric design is used throughout the curriculum enhancing students' entrepreneurial capabilities. Fifth, the leading universities provide emerging capabilities in online learning and blended learning. Finally, the collaboration and partnership with industry in education and in research is longstanding.

In Southwest Finland the economy is booming and there is a high demand of skilled engineers. The marine, medical, automotive and other fields of technology industries are all growing rapidly. This positive structural change sets pressure to our university too. We are actively building a technical innovation university of the future. We are investing in new research and development infrastructure to support the structural change in the region. Our communication and collaboration with the industry is active. We work together in research and development projects, they participate as visiting lectures in teaching and our advisory boards provide a forum to discuss the future trends and the needs in industry. Thus we have the understanding of the professional role and practical context of our professionals. The learning outcomes are discussed constantly with the industry representatives as well. We are constantly working on to ensure that our students have the needed knowledge and skills when they

graduate. We have approached this demand from different viewpoints such the curriculum structure and content, teaching and learning methods in use, hands-on experiential learning experiences, level of engineering workspaces and faculty competence. Despite all the activities we still have the feeling that we can do better to answer the needs in the region and in the working life. Therefore, we organized a series of workshops to discuss how we could do better. This paper presents the work and results focused on this regional demand.

Research

The idea of having How to do better –workshops was introduced in a faculty meeting in February 2018. An open invitation to join was presented in the meeting to all faculty members. Participation into the workshop was voluntary and everyone was free to join.

Altogether five workshops were organized in the beginning of March 2018. Each workshop followed the same procedure and lasted two hours. A total of 62 teachers (30% of the faculty) and 4 student representatives joined the workshops. In the workshops the participants worked in randomly created groups of around 5 to 6 persons.

The workshops covered two themes: Current challenges and Solutions to the selected challenges. The beginning of the workshop was dedicated to identify the challenges in our activities that hinder us from not reaching the best results. After listing randomly the challenges, the workshop participants were asked to select the challenges that they would like to present some solutions. The second part of the workshop focused on creating possible solutions to the selected challenges and finally closing the workshop on a common discussion.

Every workshop was documented and after all five workshops the author summarized the results using content analysis. Content analysis is a research technique for systematically analysing written communication such as the workshops reports in this paper (Weber, 1990). Content analysis allows the researcher to analyze relatively unstructured data in view of the meanings, symbolic qualities, and expressive content (Krippendorff, 2012). In content analysis all answers are processed and interesting and relevant information is collected. Once all answers are processed major themes and categories are identified.

Identified challenges

In the workshops 73 single challenges were identified. These challenges were grouped into 10 groups that are not totally distinctive rather have some overlap. These ten groups correspond well with the key goals of our education (see Figure 2). The challenges dealing with the structures were *tutoring and guidance*, *multidisciplinary*, *student enrolment* and *curricula related structures*.

The workshops participants provided following challenges in tutoring and guidance:

- Are we focusing our guidance and tutoring to right students?,
- We are not able to keep the level of learning, because we are focusing too much on the low motivated students
- There are not enough support for the teacher to succeed in tutoring and
- The competence levels in a student cohort are very broad and far away – according which level we go?

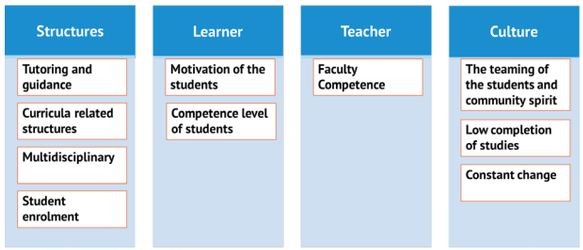

Figure 2. Challenges.

The structural challenges with multidisciplinary said that we can use the multidisciplinary structure of our faculty better and provide studies to our students more broadly. Workshop participants wanted to keep the study options open and not to restrict student alternative, but at the same time, they expressed a worry about balancing expertise and wide mixture of studies. Challenges recognized in student enrolment structures said that our marketing should address more the youngsters and we should get more applicant per study place. It was also seen important that we should persuade the right students to us and once students are with us, it should be easier to change their major. Most challenges were named in curricula related structures. The workshop participants were critical with curricula content vs. learning outcomes asking for example is it possible to reach the learning outcomes with the way of teaching is at the moment? They criticised too few contact hours in teaching, too few time to prepare courses and too little time to seize the opportunities of online learning. In addition, the coherence of the curricula was questioned and the prerequisites of the modules were said to be unclear. Furthermore, the participants were not convinced how we make sure that knowledge and skills develop gradually.

The challenges focusing on the students were *motivation of the students* and *competence level of students*. The motivation of students was discussed in each of the five workshops. The participants wished more students' own initiative and more enthusiasm to learning. They also talked how we challenge students to learn more and how we get them to work for their learning and not take the easy way out. The participants also talked about the teacher's role in creating the student motivation – maybe teachers have to look at the mirror too.

The competence level of students was seen challenging too. It seems that some students lack necessary life management skills and have low skills on basic topics such as mathematics and languages. This means that there is a need to fix these lacks and therefore there is a feeling that we have set the learning outcomes too high. In big cohorts the skill level of students is very broad. In master level there are situations where the competence lack needs to be fixed before focusing master level studying.

Only one group of challenges was identified for the teacher: *faculty competence*. First, the participants expressed their worry that our personnel doesn't share the overall understanding of the education focus and context. Second, the world is changing so quickly that our teachers' competences need updating too. Third, the motivation of teachers is as important as students – how we keep up the working capacity and enthusiasm?

Finally, there were three challenge groups addressing the culture. These were *the teaming of the students and community spirit*, *constant change* and *low completion of studies*. The participants of the workshops discussed much about the teaming of the students and how important that is. They shared the idea that there might be too many teams and groups a student has to cope with. Can we create teams or groups that encourage studying and commitment to studies? The teaming of the students could help community building too, but how to support community spirit in online learning? A question was raised whether our tutor groups are too large thus not serving the teaming and commitment. We are building a new campus and it was seen as a challenge and a possibility at the same time to build community spirit.

Another challenge with the culture was the feeling of constant change. The workshops discussed that we have had too many changes and we have been too innovative – are they actually slowing down our development. They expressed a worry that maybe with the changes we are losing the characteristics of the programs. The participants asked for better use of existing information and regional economy forecasts.

One big challenge that is not unique to our faculty is long graduation times. For example, students in engineering should graduate in four years, but the norm is closer to five years. Another challenge here is that the number of students that eventually graduate is much fewer than the number of students that started the studies. A more positive challenge is that students are hired to industry before they graduate which is not the optimal situation either.

Suggested solutions

Based on the challenges each workshops produced they continued to propose solutions too. Solutions were proposed for motivation of students, student competences, guidance and tutoring, beginning of studies, structures, enrolment, pedagogy and master studies.

The motivation of the students can strengthen with following actions and ideas. We invest in the learning environment and make it more attractive – there are cafeterias and maybe there is even free coffee available. We collaborate more with our alumni and connect them with our current students. We organize large projects and events that support community spirit and motivation. And we need to communicate more on the future job opportunities and requirements.

The competence level of students is partly not good enough in basic mathematics and physics. It is proposed that we offer an extra course for students having low skills on basic natural sciences. In addition, we have to find a way to differentiate study groups based on the skill level. This enables to support the students with low skills more and on the other hand speed up studying with the others.

There was several ideas how to do better in tutoring and student guidance. One possible solution could be that students from the older cohort work together with students in younger cohorts. We could define clearly how the older ones support and assist the students in the younger cohorts. Furthermore, we have to think about groups sizes in tutoring and in teaching and learning too. Maybe there is room for prioritizing the tutoring and guidance resources to students that are more like to graduate. Altogether, tutoring should build the path to the profession better.

The beginning of studies is usually very important to learn the right way to work and study as well as team up with the fellow students. The workshops propose that we start with real projects from the day one. We should place more effort on making the first year. We should have the first year students more tightly in our control and let them gradually learn the freedom of the studies. In addition, students should have the feeling of their own expertise very early on their studies.

We have developed our curricula continuously and the workshops encourage us to continue that work. The workshops identified certain very concrete proposals to curricula development. For example, we should get rid of the mandatory 5-credit size of courses. We should also provide more study-field specific elective modules. A big possibility is to utilize summer semester more efficiently.

The improvements to student enrolment asked for better profiles of the programmes and their specialisations. We have to make sure that the language is correct for the young generation thinking about applying to us. Another interesting idea was to establish a summer academy together with selected industry partners. All students who pass the summer academy will granted a study place. The summer academy will be planned together with selected industry partners and the projects and topics could even continue after the summer as normal first study year parts of the degree program. The summer academy could even lead to summer employment or internship in the company.

The workshop proposed number of improvement activities in our pedagogy too. Each teacher should reflect his/her teaching methods and think about the appropriateness of them to the defined learning outcomes. As valuable is to reflect the assessment practices with the teaching and learning activities. Basically the workshops reminded the constructive alignment concept (Biggs, 2003), which connects the intended learning outcomes, teaching and learning activities, and assessment of student learning. Furthermore, the workshops required that we emphasise more on giving feedback. The feedback should be more versatile and timed better as well as it should focus on improving the skills of the student.

The workshops focused more on Bachelor level issues, but some ideas we proposed for master studies too. As part of their challenge of long graduation times, the master thesis is usually the most typical reason for not graduation on time. Therefore is was proposed that the

thesis should be started much earlier, it should be guided and checked more often and there could be peer thesis groups. Regarding the student enrolment challenge, we have to market the different study possibilities better. In addition to traditional master programs we have master studies in our research groups. There are differences on applying the programs, on the study format and on the timing of the studies. These differences should be explained better for the possible master student candidates.

Discussion

The five How to do better – workshop offered a very good platform for open discussion on our way of teaching and learning. The challenges that the workshops identified corresponded quite well with the goals that we have defined. The four goals of structures – flexibility, learning with the industry, projects and multidisciplinary – were partly identified as challenges still. We could do better with the flexibility and multidisciplinary. On the other hand, learning with industry and projects were not mentioned suggesting that these elements are all right. The key goal of the learner category is to enable the students' intrinsic motivation. Unfortunately, the workshops suggest that we still have a way to go here. For the teachers we have defined two goals: they have strong practical experience from the industry and they are able to support the learning of our students with coaching capabilities. The workshops emphasized that we need to update the practical experiences of our faculty and support their pedagogical skills and understanding of the programs. Our fourth category of goals is about the culture. The way we operate in our daily teaching and learning, how we work as a community with entrepreneurial activities present. Based on the workshops our efforts on building a community and team spirit have not been enough, neither have we succeeded in communicating the development actions and their rationale.

Based on the challenges the workshops proposed possible solutions to do better. Some of the proposed solutions are such that we are already working with, but there were very concrete and new ideas presented too. The proposals are discussed in below:

1. Learning environments
   - New campus in process and to be ready 2020
   - New investments (7 million euros) on laboratory infrastructures is decided
2. Alumni activities
   - Some programs have active alumni network already, but this is not a faculty wide habit at the moment
3. Large projects and events that support community spirit and motivation
   - Several large projects and events are already organised annually and we will continue this and maybe introduce new events too
4. Extra support for natural sciences
   - This needs to be further discussed and planned
5. Tutoring and guidance changes
   - We can use students from the older cohorts to guide students in the younger cohort more than we currently do.
   - Use of students might help with the group size challenges too.
   - We have decided that we renew our tutoring model in 2019 and move tutoring closer to daily teaching and learning.
6. Real projects from the beginning of studies
   - The curricula 2019 of the faculty will have project hatchery –module in the first semester.
7. Own expertise from the beginning
   - The curricula 2019 of the faculty will provide Introduction to you own study field as a project module in the first study year.
   - This follows the CDIO standard 4.
8. First year more controlled
   - Both above mentioned project modules will support a more controlled first year studying.
9. Summer semester
   - The responsibility of summer semester content has moved to the faculties and summer 2019 is the first where faculties can create a summer semester answering better to their program requirements.
10. Summer academy
    - This proposal is very interesting and we need to discuss more about this.
11. Marketing of our programs
    - We have changed the way our program descriptions are produced. We have standardized key elements of our teaching and learning descriptions and make sure that our texts address possible students better.
    - Enrolment is changing nationwide too. More emphasis will be given to the matriculation exam results and traditional entrance exams will mostly be removed.
12. Pedagogical support
    - Our university provides trainings on Innovation pedagogy and online learning. Faculty members are encouraged to join these.
13. Focus on feedback
    - This is an activity for each faculty member to reflect their own way of teaching and learning.
14. Master studies
    - We reorganize our master education in new Master School of Engineering and Business in the beginning of 2019. This new organization will work on the identified challenges and the proposed solutions

The discussion we had in our workshops provided us good understanding on our challenges and ideas on how to do better. It is interesting to notice that our discussions, our goals and our activities have many similarities with the distinctive features of the engineering education leaders as presented in the Graham's (2018) report. As a leading university of applied sciences in Finland our applied research provide plentiful opportunities to our students to engage real research activities connected with their learning. Our curricula are filled with multiple

opportunities for hands-on, experiental learning and with the new investments and new campus our workspaces and infrastructure support these activities. Our partnership with the industry is strong both in education and in applied research. We do have elements supporting entrepreneurial capabilities too, but there we still have more work to do. Use of online learning and blended learning is starting and we have good examples of successful programs utilizing these, but this is not the main stream and our university supports this with the pedagogical trainings offered. Most work is needed to get a range of student-led technology-based extra-curricular activities and experiences available.

Still, we can argue whether the steps we are taking are enough to take the benefits of the pedagogical and technological innovations, and better prepare graduates for the increasing and different demands of the new world of work like Kamp (2014) proposes. Anyway, we answer quite well with the future direction of engineering education (Graham, 2018). Our curricula are flexible and provide possibilities for students to build their own expertise, there are many possibilities for multidisciplinary learning, and learning is supposed to happen outside the classrooms too.

Conclusions

Our activities supported with the Innovation pedagogy and CDIO approach have taken us into right direction. The elements of Innovation pedagogy and CDIO approach are visible in our curricula and in our teaching and learning. Both have given us a structure and support to proceed in our development activities. Still, we are not there yet as our workshops showed. There are several challenges and suggested actions how to do better. We have processed there results further in a faculty wide workshop together with 250 faculty members. Our faculty management team will continue processing the original results and the follow-up workshop results in autumn 2018.

The possibility to discuss freely about our challenges and provide suggestions to answer these challenges was very positive experience and we can recommend this to other institutions too. Our faculty will continue discussions/workshops in the autumn with no-agenda format.

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ENHANCE LEARNING BY USING USER EXPERIENCE DESIGN

C. Jinjakam*

*King Mongkut's Institute of Technology Ladkrabang/Department of Computer Engineering, Faculty of Engineering, Chalongkrung Road, Lamplathew, Ladkrabang, Bangkok, THAILAND

*chompoonuch.ji@kmitl.ac.th

Abstract

Only theory lecture in the class makes students feel boring and sluggish in learning. Although the theory is very important. But doing activities together while learning will make better understand for the students. Therefore, not only theory that students learned, but also activities and assignments they did in Human Computer Interaction class. They have to design and test their interesting interaction types in assignments. Anyway, the results can show only the user interface of the interaction design. It might or might not match the user's need. Accordingly, this paper implemented the activity in Human Computer Interaction class by using User Experience design, in order to enhance interaction designed that support the user's need.

At the beginning, students learn HCI theory along with the basic UX process. They practice a few activities with every learning lecture for enhancing their understanding. After students learn persona, empathy map and user journey, those are basic of fundamental UX designs. They will set their user of the assigned topic. Their user is not only "who", but they have to imagine - "what" user wants, including scenario "when" user use their work at "where", and "how". Their new focus topic is how their work can solve user problems. Students will set problem by themselves and create their own work in order to support the user requirement and action. Results are Mockup prototype that every group will help to test and evaluate each other, including checked by the teacher. The goal is not a perfect finished result of the assignment, but it is how to improve for better results. The subject evaluation at the end of semester shown, students feel fun to learn by using UX to design their works. They can learn user viewpoint and better understand the user. Moreover, they know the advantage and disadvantage of their works and can give suggestions for the other group's work. This learning style is not only brainstorming in the group, but also enhance learning when evaluated and get ideas from the other group. Furthermore, students can apply UX design with any topics of their future works for better results.

Keywords: *Active learning, problem based problem, project based learning, user experience, teamwork, brainstorming*

Introduction

The interaction design term was invented by Bill Moggridge (Giuseppe & Giancarlo (2007)). It was adapted to user interface design that is understand user's need's and goals, designing tools with consider the limitation of the user's environment and technology. Human computer interaction is a subset of interaction design that HCI involves the study, planning and design of the interaction between user and computer (Wikipedia, 2018). The interaction design needs to meet the user's need, that is why user center design has entered a high role. User center design is a procedure to design software or system based on the user requirements. (Hugh and Karen, 1997) wrote a book that provides step by step guidance for user center design. In order to discover the system for the user, the simplest way is an interview with the user. Interview have to plan carefully for the effective action in proper time. And the user is needed for taking care to encourage cooperation until finishing the interview. After the system was built, the next process is testing. The testing is a procedure of finding and fixing usability problems (Steve, 2009). Finally, the figured problems were solved in the improved version of the system. These processes are looped to continuously improve the system. (Steve, 2014) wrote 'Don't make me think' book from his experienced of effective designing website that help to understand the principles of intuitive navigation and information design. Moreover, (Don, 2012) provide the fundamental principles of great and meaningful design that is applicable to any user. Anyway, user is different and is changed over time. It takes time and cost for the interview, built prototypes, testing and improving processes in each design. Therefore, user experience design has come to overwhelm this problem. In addition, the process of design Splint (Apirak, 2018) is an important role to speed up the process of system establishing and improving.

Material and pedagogy

Previous class of human computer interaction (HCI) in a few years ago, the closed Facebook group was used to contact or announce within this class. Students had submitted their works via Google Classroom, and comments were given back to the students. Normally, their assigned topics were testing, designing, or comparison between the interactive techniques. Students had at least one week to do the experiment. They discussed and chose their interested topic, started the process, tested by the other groups and concluded results. Even the evaluation of the assignment results were interesting, but it cannot show that the user like to use their interaction design or not. It is better to design to support user center, thereby the user experience (UX) design is combined with interaction design in the class.

One interesting assignment in HCI class is designing the application or website. The procedure and results of designing interaction and designing interaction by using UX are shown in the following topics *A* and *B*.

A. Interactive UI Designing

An assignment in the last year class was designed user interface (UI) of website or application. They were assigned to use proper interaction styles by rational and full functionality to design their interesting website or application.

After students formed their group, they brainstormed ideas about what website that they like to design. Then draw the draft of UI design, as shown in figure 1.

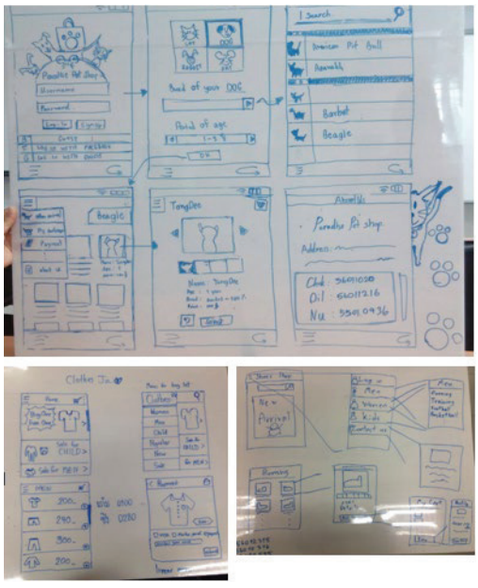

Figure 1. Draft UI design.

Students had one week to modify their draft for Mockup UI website. It had just prototyped UI on each page. Students can use supported tools to generate this prototype, no need to do real programming to establish it. This prototype can be clicked to change to the next page, but it cannot process in reality. The reason to design just UI prototype in the assignment is if they have to make a real website or application, they will need more time and skill. And the purpose of this assignment is just want to discuss the proper of interaction designing. The example of a UI prototype website is shown in figure 2.

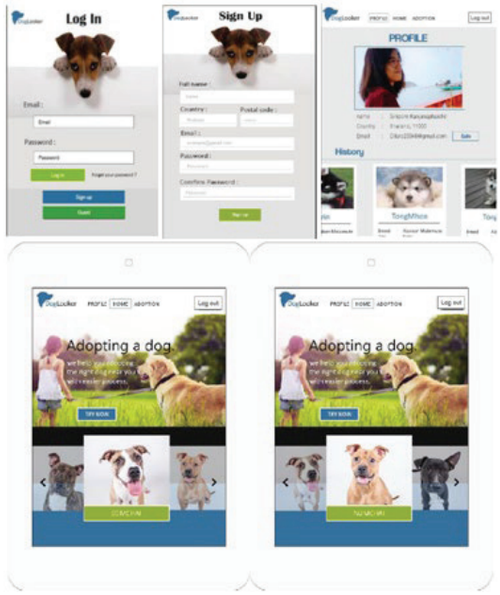

Figure 2. UI prototype.

In the class, we were discussing about functionality and proper interaction type of each group's designing. Students judgement was from their previous experience. Most of the UI design seemed functional and beautiful design. But we did not discuss and did not know that design is proper for the user or not. Therefore, the next year HCI class was included basic UX to design the UI prototype.

B. Interactive UI by using UX Designing

At the beginning of the class, students were taught about their user. They learnt to set their focused user and wrote down their user characteristics, called Persona. Persona consisted of user's name, picture, quote, story and key goal, as shown in figure 3.



Figure 3. Persona of UX design.

Persona details gave information about the focused user. How about user spent their daily life, what was Pain and Gain. And indicated the most important thing for the user, for example, time, money, convenience, luxury, etc. Then, each group designed their user's empathy, as shown in figure 4.

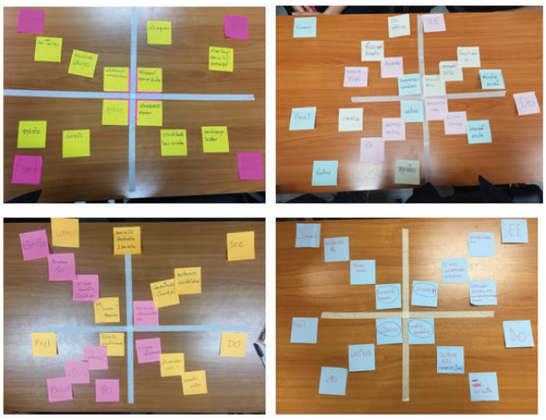

Figure 4. Empathy map.

Students were discussing what happened with their user for the situation that their application is needed. Empathy map were set the scenario that happens to the user, what user do, feel and commit. Then they figured the most significant problem to choose and solve in their application. Post-it that easy to re-arrange the situation was used. After that, the user journey was created. User journey gave details about the events - before, on service and after using an application in short details of touch point, user action and emotion, as shown in figure 5. Finally, the UI prototype of the application was created in the week after, as shown in figure 6.



Figure 5. User Journey.

The prototype design programs, eg. Marvel, Adobe XD, etc., was used. This program support to create the UI easily on a mobile phone, tablet or PC. The clicking area can be set to change to the next require page without needing any programming skill. After UI Mockup was created, the last step was testing. Students were volunteering for the other group testing, as shown in figure 7.

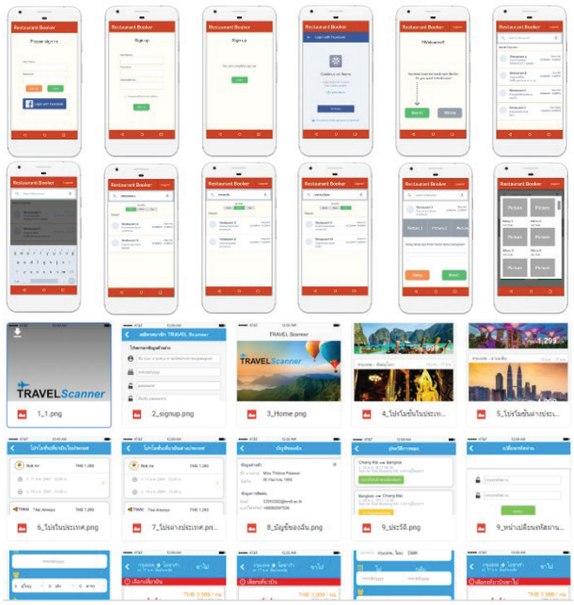

Figure 6. UI prototype.



Figure 7. Testing of interactive UI design.

In this year, 32 students were in HCI class. They were divided for 4 people in each group. When they started testing, two students sat stationary to brief the usability of their application and take note. The other two students walked around the class to test the other group application and gave suggestions for the improvement. From this setting, each group had comments and suggestions from the other 7 groups. And also they can see the weak point and learn how to improve their own application. Finally, they were figured out and concluded the things they do to improve their application efficiency, as shown in figure 8.



Figure 8. Example of application improvement.

Results and Discussion

When students design the application or website, they are known well about what they did. Even they had created the most important options that needed, but still something lost. Because if students just design and create an application by only themselves, they were clearly understood how to use, where to press, and what they want. But when they learned UX design to set Persona, empathy map and user journey before create their application. These processes are very useful to understand better about their user. Moreover, the testing helped them to see that some people doubt with their designed and can figure out what they should improve for the better application.

Conclusions

Regarding to the previous HCI class, students chose their freestyle topic, within teacher assignment topic. They usually created a topic related to their group member interesting. But the details might not be required or appropriated by the user. However, UX design can help to overcome this problem in current class.

Students that learned UX process were understood their user better. And the testing helped them to figure out that what they should do to improve the design. The results needed is not a perfect design application. But it is what they can do to improve for the better application.

UX design can be used to enhance the learning efficiency of students in HCI class. Moreover, these processes are also useful with the other designing in the future.

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Sub Theme 2

Technology Enhanced Learning



THE KEY FACTORS OF CONSIDERATION WHEN INTRODUCING PUBLIC INSTANT MESSAGING IN HIGHER EDUCATION

Benson K.H. Hung

Department of Construction,
Hong Kong Institute of Vocational Education (Tsing Yi),
Vocational Training Council, HKSAR, China

bensonhung@vtc.edu.hk

Abstract

Today's students are more technology literate. Instant Messaging (IM), as one of the use of learning technologies, has had a significant impact in education and has brought amazing changes to pedagogies. However, many of the public IM tools are primarily used for non-academic discourse, and if they are used in academic contexts, it requires not only well-understanding of student-centred learning and teaching approach but also good instructional design and online facilitation skills.

Two cohorts of students using public and private IM tools from the same module named Highway Engineering (CON4381) of Higher Diploma in Civil Engineering at the Hong Kong Institute of Vocational Education (Tsing Yi) were selected for a case study. A comparative method was used to find out why the cases are different and to discuss such a variation. A descriptive comparison was made to describe and explain the invariances about such application of IM tools. With an approximate class size of 300 students for each cohort, the research in this paper focuses on the teachers' perceptions of the IM and answers the following questions:

- **What are the advantages and disadvantages of both public and private IM tools in educational contexts?**
- **What are the key factors of consideration when introducing a public IM tool for Technology Enhanced Learning?**

The results revealed that significant differences were found across the applications of public and private IM tools in education both positively and negatively. Being exploited as a social rather than an academic medium, this research has a significant implication on how these public tools can be more effectively incorporated into the educational experience and fosters an effective learning environment through three key factors of consideration: usability, innovation and security.

Keywords: *Instant messaging, public and private, Telegram, VTC@HK IM, usability, innovation, security.*

Introduction

The rapid growth in the number of students who use Instant Messaging (IM), as well as the amount of the time students spend on it, opens opportunities and creates challenges for higher education institutions. IM, in general terms, enables individuals to easily communicate with families and friends in real time and is primarily used for non-academic discourse. However, for educational purposes, using IM in education requires not only well-understanding of student-centred learning and teaching approach but also good instructional design and online facilitation skills. This may not be an easy task for teachers.

In previous researches, a particular focus on the educational impact of public IM tools has rarely been examined. Being exploited as a social rather than an academic medium, it is important to better understand how these public tools can be incorporated into the educational experience.

This paper illustrates the application of IM in a case study on Telegram (a public one) vs. VTC@HK IM (a private one). The advantages and disadvantages of both public and private IM tools are discussed. By comparing with a private IM tool, the purpose of this study is to identify the key factors of consideration when introducing a public IM tool for conducting effective communication and fostering students' self-paced learning in an online setting.

Literature Reviews

The use of IM is pervasive as 42% of Internet users report using IM and 63% of those users indicate that they use IM several times during any given week (Shiu & Lenhart, 2004). Given its pervasiveness, it is natural that IM has also found its way into educational settings. Farmer (2005) suggests that since many students are already familiar with instant messaging, it can be used as a tool to foster an engaging learning environment. In addition, IM can also foster community between learners. Nicholson (2002) found that students who utilized instant messaging were "more likely to agree with the statement that they felt a sense of community with classmates" than those who did not utilize instant messaging. Within the literature, the benefits of IM in the development of community within educational contexts appear to be greater for student-to-student conversations than student-to-teacher conversations, and more notable in distance education courses.

Academic vs. Social Uses of Instant Messaging

IM, which sends messages in real time, has become one of the most popular applications of the internet to stay people connected. Apart from the most common use for social purposes (Pew Research Center, 2015), various public IM tools such as Telegram, WhatsApp, Line, WeChat, Twitter and Skype have been employed to facilitate student learning and to provide a variety of opportunities in academic contexts (Bakker *et al.*, 2007; Brett, 2008; Lauricella & Kay, 2013; Quan-Haase, 2008). The tremendous potential of this technology to activate deep student engagement and to support collaborative learning has been widely acknowledged by many scholars (Tinto, 2003; Ng'ambi & Brown, 2009; Cifuentes & Lents, 2010; Echeverría *et al.*, 2011; Timmis, 2012; Kim *et al.*, 2013).

Instant Messaging in Educational Environments

Lauricella *et al.* (2013) praise instant messaging as a useful and viable tool for augmenting student's communication among peers and faculty in higher education. Litchfield *et al.* (2007) found that students are positive about using mobile devices in education and hence suggest that mobile learning has a high potential to be utilised in teaching and learning. In higher education, mobile devices have remarkable features which can create more effective learning environments for traditional classes (Kert, 2013). Kim et al. (2013) also praise the development of mobile technologies has enabled educators to send instructional messages in flexible ways. However, instructional decisions have been shown to influence the quality of student-to-student online discussions, with lack of teacher guidance and intervention having a negative effect (Hou, Chang, & Sung, 2007).

Methods

An action research was done to describe the situation. Two cohorts of students who were studying the same module named Highway Engineering (CON4381) of Higher Diploma in Civil Engineering at the Hong Kong Institute of Vocational Education (Tsing Yi) were selected for study. Students of cohort 2016/17 and cohort 2017/18 use Telegram (public IM tool) and VTC@HK IM (private IM tool) respectively in assisting teaching and learning. Brief introduction of both IM tools are provided in the following paragraphs.

Telegram

Telegram is a cloud-based IM service. Users can send messages and exchange photos, videos, stickers, audio, and files of any type, in which it specializes in text chat and file sending. It is completely free to use, has no ads, and no paid perks. Communication is between a user and the user's Telegram contacts only and all messages are encrypted. For extra security, one can set certain messages to self-destruct after a given time. Sent files can be of any type, and media can be stored on Telegram's cloud if needed.

VTC@HK IM

This mobile app supplements VTC's Moodle Learning Management Platform through strengthening communication among students as well as between students and teachers. It allows students and teachers under the same Moodle course to share thoughts and collaborate interactively through the use of instant messaging, without the need of disclosing sensitive personal information such as mobile phone numbers.

Research Questions

Direct focus on the educational impact of public communication tools has not been examined in previous research. This study investigates how the usefulness and differences between public and private instant messaging when these tools are used to communicate between the instructor and students. To date, this comparison has not been examined. The research in this paper focuses on the teachers' perceptions of the IM and answers the following questions:

- What are the advantages and disadvantages of both public and private IM tools in educational contexts?
- What are the key factors of consideration when introducing a public IM tool for Technology Enhanced Learning?

Results and Discussion

Difference of Public vs. Private IM Tools

Taking Telegram and VTC@HK IM as the examples of public and private IM tools respectively, it was found out that usability, innovation and security were the most three key factors of consideration. However, the key pros and cons of public and private IM tools largely depend on the technical expertise and resources available. The following table has a summary:

	Public IM Tool	Private IM Tool
Usability	Low	High
Innovation	Unrestricted flexibility / Hard to attract research and development / Fostering innovation through forums and surveys	Restricted flexibility / Easier to attract research and development due to rich resources
Security	Doubtful	More secure because it is fully tested

Usability

For education, public IM tool is generally not reviewed by usability experts and educators. User guides are not required by law and are therefore often ignored. When manuals are written, they are often not specific for educational purpose and sometime difficult to follow. For private IM tool, usability is a high selling point due to expert usability testing and users' feedback for a more targeted audience. User manuals are also provided for immediate reference and quick training along with support services.

Innovation

Telegram is an open source project and anyone can study their application programming interface (API), protocol and source code and make an informed decision. Such public IM tools could provide flexibility and freedom to change the software without restriction. However, the software providers often struggle to attract large-scale research and development which in turn limit the future support and growth of the software.

However, it has dedicated online communities that share ideas and strategies through forums and surveys, fostering innovation and allowing the product to adapt with changing needs. On the other hand, private IM tool is available for specific users only. Unlike public IM tool, it could attract research and development due to rich resources in order to regularly offer new products and upgrades.

Security

Security of public IM tool is often a concern because it is not always developed in a controlled environment. There is a lack of continuity and common direction that prevents effective communication. Once more, the public IM tool is not always peer-reviewed or validated for educational purpose.

On the other hand, private IM tool is generally seen as more secure because it is developed in a controlled environment by a concentrated team. The team is the only group that can view or edit the source code and this restriction ensures the security and reliability of the software that is fully tested and offered to all users. To use VTC@HK IM, since the mobile app uses VTC Computer and Network Accounts for secure authentication, no mobile phone number has to be disclosed. Only authorized Moodle users may use the mobile app as it is tightly integrated with the Central Moodle Platform.

Limitations

Like all research, the present research is not without some limitations. First, the research only examined students from the Hong Kong Institute of Vocational Education (Tsing Yi). Students on different campuses might generate different results about IM and its effects on the ways students achieve social and academic integration. Second, the method that was employed to compare both IM tools might skew the results as well. Selective scopes of studies might have greatly influenced the results. The directions of studies and observations of researcher could influence a lot.

Despite these limitations, previous research has not explored the impact of different types of IM tools has on college students for academic purposes. Therefore, this study provided rich information about how IM tools might be used associated with academic and social integration.

Conclusions

Students are more technology literate and Internet savvy than ever. In this connection, IM has been growing rapidly and appears to be a preferred mode of communication in higher education.

This paper presented what a teacher/an educator should think about before the use of IM technology in order to achieve improved students' learning effectiveness. It was particularly useful for those who would adopt non-academic communication IM tools such as Telegram, WhatsApp, Line, WeChat, Twitter and Skype in educational contexts. There were three key aspects of considerations, namely usability, innovation and security, be addressed for the two public (Telegram) and private (VTC@HK IM) IM tools.

Both IM tools have their own advantages and disadvantages in educational contexts. The studies were constructive and the impacts of those technologies were analysed. For example, the public IM tool has low usability in term of educational applications, however, it offers unrestricted flexibility that could foster innovation through forums and surveys. In this paper, using IM mobile applications "Telegram" and "VTC@HK IM" could no doubt enhance students and teachers' effective communication. Technology Enhanced Learning is achieved for classes using this e-pedagogies in communication to increase students' engagement and motivation.

In current technology-enhanced learning environments, benefits can be achieved through facilitating e-Learning environment, motivating students with educational technology tools and identifying the characteristics and essential elements for planning blended and flexible learning.

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METHOD OF MAKING MOVIE FOR FLIPPED CLASSROOM AND ITS EDUCATIONAL EFFECT

S. Oke*,a

[a] Department of Integrated Science and Technology, National Institute of Technology, Tsuyama College, Japan

*oke@tsuyama-ct.ac.jp

Abstract

A popular strategy of active learning is the flipped classroom method. The flipped classroom is an instructional method and a type of blended learning that reverses the conventional learning environment by providing instructional contents, often with internet. Students will not get a lecture from a teacher, because they have already viewed, at home, various lectures as movies on on-line. Students can use time for discussion, solving the exercise problems, and practice of their knowledge with their classmates in the classroom. The teacher looks around in the classroom without unilateral explanation. Amount of speaking of teacher is little in the flipped classroom. Then a teaching load of the teacher can be reduced with the flipped classroom. I have applied the flipped classroom to two classes of lecture of the electromagnetism. The learning text for my lecture include explanations, figures, example question, and some exercises. The movie learning materials include explanation of theories, laws, and how to solve exercises as well as the conventional teaching method. The length of the movies is around 5 minutes. 1 to 3 movies files are used for a lesson. The movies are uploaded onto YouTube. All of lectures and teachers are evaluated by students to research their learning effect yearly. Important items of that evaluation are volition of teacher, general evaluation of a lecture, and acidity of students. Students decided that the flipped classroom was better than the conventional teaching method for the volition of teacher. They were comprehended teacher's effort for prepare of leaning contents, such as movie. Activity of students which was evaluated by themselves obviously increased. In this year, students who study electromagnetism were answered questionnaires for an impression of the flipped classroom. Students who appreciated the lesson, had high exam results in the 3rd grade. Their relationship is a nearly linear. The 4th grade students had not such a trend. Teaching load of teacher can be reduced by the flipped classroom, since, talking in a lesson can be decreased by using the movie. The preparation of the movies is necessary only once. The movies can be used again in same lesson next year.

Keywords: *flipped classroom, movie learning material, making method, web-based learning, load saving*

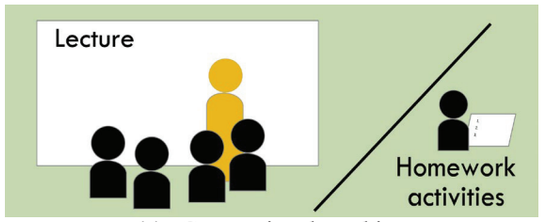
Introduction

There are many formats of active learning method, and witness from the paper shows that they can be good in improving student learning compared to conventional teaching method (e.g. Bonwell & Eison, 1991, Prince, 2004). A popular strategy of active learning is the flipped classroom method. The flipped classroom is the one of the most popular active learning format used in many schools, college, and university all over the world. The educational effect of the flipped classroom had been evaluated and described in some reports (e.g. Cheah, 2016, Kee & Wan, 2016, Ngai, 2016). Recently, an environmental for the flipped classroom has been ready, since any students have own smartphone or tablet PC. I have applied the flipped classroom on my lecture of electromagnetism since 2016. Some leaning contents for the flipped classroom could be prepared easily by myself using ICT technologies. This paper describes some techniques to prepare and to provide the leaning contents for the flipped classroom, and progress of a lecture of the flipped classroom. In addition, educational effects of the flipped classroom are evaluated based on the results of questionnaires and examinations.

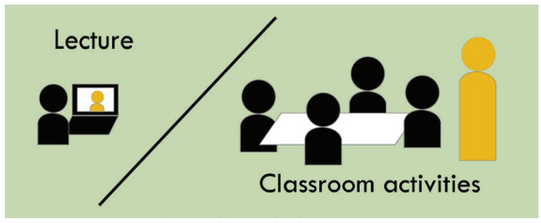
Flipped classroom

The flipped classroom is an instructional method and a type of blended learning that reverses the conventional learning environment by providing instructional contents, often with internet. Students will not get a lecture from a teacher, because they have already viewed, at home, various lectures as movies on on-line. Visual images of the conventional teaching method and the flipped classroom are shown in Fig.1.

In the conventional teaching method, the teacher is the central focus of a class and the primary provider of information during the class period. Student engagement



(a) Conventional teaching



(b) Flipped classroom

Fig. 1. Visual images of (a) the conventional teaching method and (b) the flipped classroom. (https://www.washington.edu/teaching/teaching-resources/engaging-students-in-learning/flipping-the-classroom/)

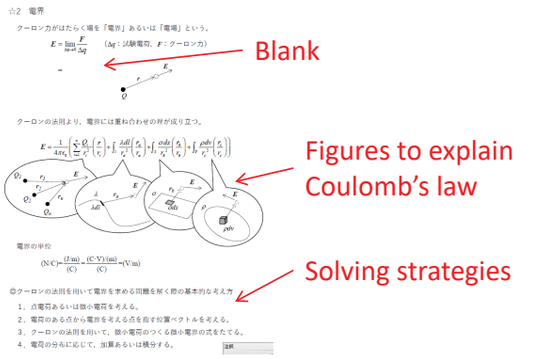
in the conventional teaching method may be limited to activities in which students work independently or in small groups on an application task designed by the teacher. Class discussions are typically centered on the teacher, who controls the flow of the conversation. (Ryback and Sanders, 1980). Typically, in the conventional teaching method, students must work their homework or review of last lesson in their house, alone. The philosophy behind the flipped classroom is that teachers can spend time working with students who need their help in the classroom and students can work together to solve problems rather than sitting home alone with work they might not understand and with nobody to ask for help (Strauss, 2012).

In the flipped classroom, students often receive learning contents with on-line in anywhere. The learning contents are often movie or pdf file prepared by the teacher or third parties. The movie can be watched repeatedly and can be stopped in anytime. Students can use time for discussion, solving the exercise problems, and practice of their knowledge with their classmates in the classroom. The students can take counsel together. Thus, the classroom is not quiet in the flipped classroom. The teacher looks around in the classroom without unilateral explanation. Students can ask teacher about what they do not understand.

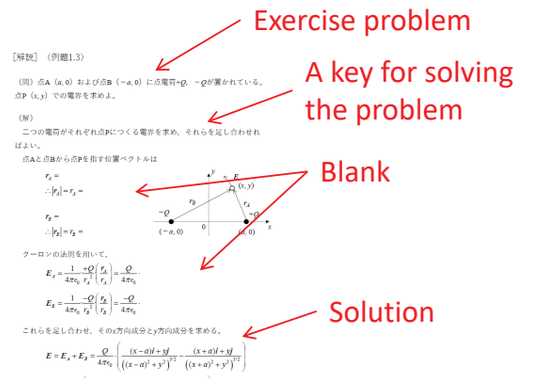
It is very hard to keep talking for 90 minutes in the conventional teaching method. However, amount of speaking of teacher is little in the flipped classroom. Then a teaching load of the teacher can be reduced with the flipped classroom.

How to make movie contents

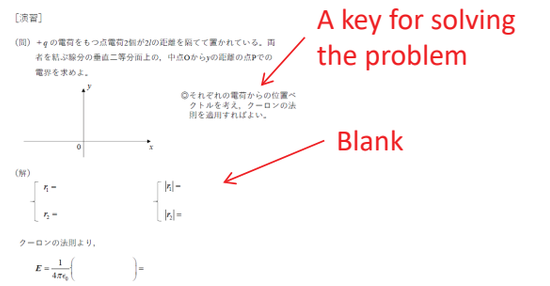
I have applied the flipped classroom to two classes of lecture of the electromagnetism. The learning text for my lecture include explanations, figures, example question,



(a) Introduction, theory, law, and important matters



(b) Example question

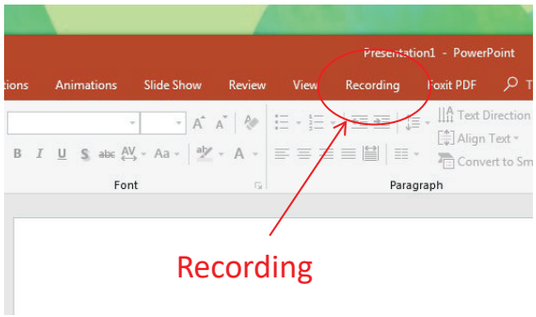


(c) Exercise

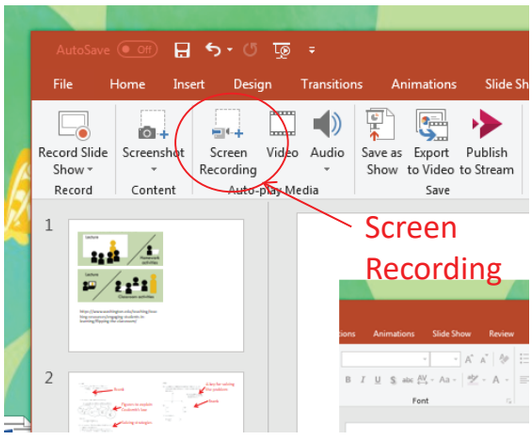
Fig.2. Construction of learning text for a lesson of electromagnetism based on the flipped classroom.

and some exercises. Length of the text for a lesson is usually 6 pages, a maximum of 8 pages. The text consists of 2~3 pages explanations and example question and 3~4 pages exercises. Fig. 2 shows that examples of my text for a lesson of electromagnetism. Introduction, theory, law, and important matters are explained with figure in page of the beginning of the text. In the example part, the problem is often provided with a key for solving the problem and a solving process with some blanks. The exercises are given with a few hints. Most difficult problem places at the final page. The problem can be solved by a few excellent students. The text is produced by using Microsoft Word and it exports to pdf file which has some blanks hide description partially.

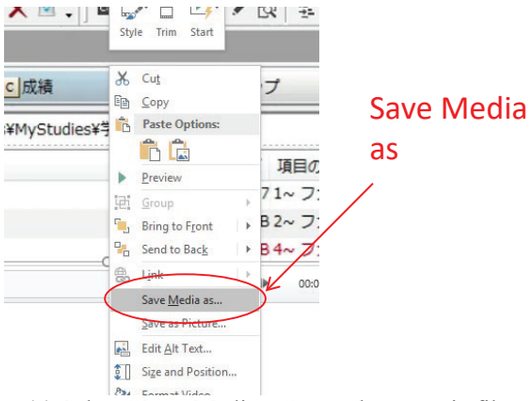
The movie learning materials can be make easily by using Microsoft PowerPoint. I recorded my explanation by "screen recording" on a function of PowerPoint. This



(a) Click “Recording”



(b) Using “Screen Recording”



(c) Select “Save Media as” to make a movie file

Fig. 3. Process to make the movie file for the flipped classroom using Microsoft PowerPoint.

function records visuals and movement on the computer display with voice and can form a movie file in brief. Process to make the movie is shown in Fig. 3. On the "Recording" tab of the ribbon, select "Screen Recording". On the Control Dock, click "Select Area". To save the recording itself as a separate file on a computer, right-click the picture on the slide that represents the recording and select "Save Media as". In the "Save Media As" dialog box, specify a file name and folder location, then click "Save" (Microsoft, 2018). The movie includes explanation of theories, laws, and how to solve exercises as well as leaning contents of the conventional teaching method. The length of the movies is usually around 5

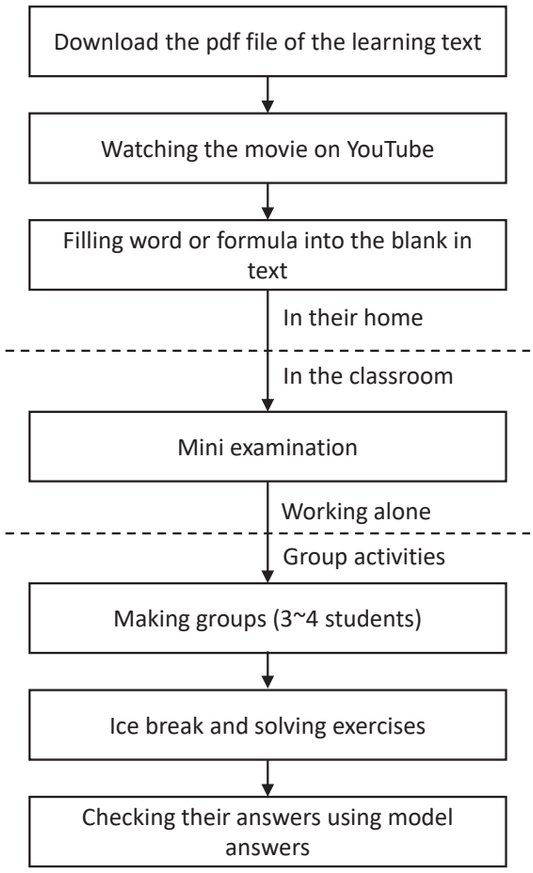
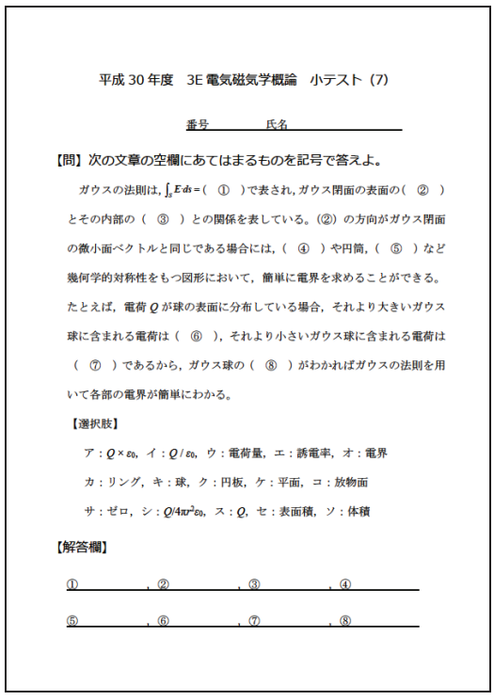


Fig. 4. Activities of students and its flow of the flipped classroom.



平成 30 年度　3E 電気磁気学概論　小テスト（7）

番号　　氏名

【問】次の文章の空欄にあてはまるものを記号で答えよ。

ガウスの法則は，$\int E\,ds =$（　①　）で表され，ガウス閉面の表面の（　②　）とその内部の（　③　）との関係を表している。(②) の方向がガウス閉面の微小面ベクトルと同じである場合には，（　④　）や円筒，（　⑤　）など幾何学的対称性をもつ図形において，簡単に電界を求めることができる。たとえば，電荷 Q が球の表面に分布している場合，それより大きいガウス球に含まれる電荷は（　⑥　），それより小さいガウス球に含まれる電荷は（　⑦　）であるから，ガウス球の（　⑧　）がわかればガウスの法則を用いて各部の電界が簡単にわかる。

【選択肢】

ア：$Q \times \varepsilon_0$，イ：Q / ε_0，ウ：電荷量，エ：誘電率，オ：電界

カ：リング，キ：球，ク：円板，ケ：平面，コ：放物面

サ：ゼロ，シ：$Q/4\pi r^2\varepsilon_0$，ス：Q，セ：表面積，ソ：体積

【解答欄】

①　　，②　　，③　　，④

⑤　　，⑥　　，⑦　　，⑧

Fig. 5. Example of questions for a mini-examination.

minutes, since a long movie is not favored by the students. 1 ~ 4 movie files are prepared for a lesson. The movies are uploaded onto YouTube. I have a "mychannel" in YouTube. Its URL is https://www.youtube.com/channel/UCo0Eo3I7Yt-1bp-0wI76z3w. The mychannel has all of upload movies and "playlist". The playlist includes some movies for every lesson. Students can access easily the movies which they need in the mychannel. The pdf file of the leaning text is uploaded onto my web site (http://www.tsuyama-ct.ac.jp/oke/contents/class.html). Students can access the movies in YouTube using links in the pdf file too.

Procedure of my lecture

The lecture applied the flipped classroom is composed of activities in home of students and that in the classroom. Activities in the classroom can be classified into working alone and group activities (Fig. 4). Students are required to download the pdf file of the learning text and to watch the movie in YouTube before a lesson. They fill some words or formulas into the blanks in their text.

At the begging of the lesson, students take a mini-examination (Fig. 5) to check their understanding themselves. Difficulty of the examination is as easy as a lot of student can solve completely. Then, small groups are formed by 3 or 4 students. They can work together to solve exercises after an ice break. Students can talk each other and ask their classmate or teacher in the lesson. In addition, they can move freely their own desk or seat. Fig. 6 shows that appearances of the classroom on a lesson. Students were sitting in their seats in the begging of the lesson, however, as time went on, they moved to talk or to ask for solving problems with their classmate.

Model answers of problems are prepared and opened to students in the classroom. Many students use the model answers to verify their answers (Fig. 7). They pointed out error in my model answer occasionally. On the other hand, a few students, who has not volition to study, copy the model answers into their notebook or smartphone.

I am always walking in the classroom with a small whiteboard to explain at the side of student's desk. Students can ask me anytime about what they do not understand. And, I talk to student who has some problems to support them. I keep on walking around the classroom during the lesson.

Educational effects

All of lectures and teachers are evaluated by students to research their learning effect yearly. Important items of that evaluation are volition of teacher, general evaluation of a lecture, and acidity of students. Fig.8 shows that results of that evaluation from 2011 to 2017. These results were provided by the 4th grade students (18~19 years old). The flipped classroom has started from after 2016. I would also like to mention that students of 2014 and 2015 had very particular characteristics. The former was very excellent and earnest class, the later students had many dissatisfactions for any lectures and



(a) Begging time of the lesson



(b) After several tens of minutes

Fig.6. Appearances of the classroom on a lesson (a) at the begging time and (b) after several tens of minutes.



Fig. 7. Checking their answers using model answers.

school. In this study, the result is discussed except the 2 years students.

Students decided that the flipped classroom was better than the conventional teaching method for the volition of teacher. They were comprehended teacher's effort for prepare of leaning contents, such as movie. Activity of students which was evaluated by themselves obviously increased after 2015. This is an effect of activities that students initiatively talk each other in my lecture. On the other hands, the general evaluation of my

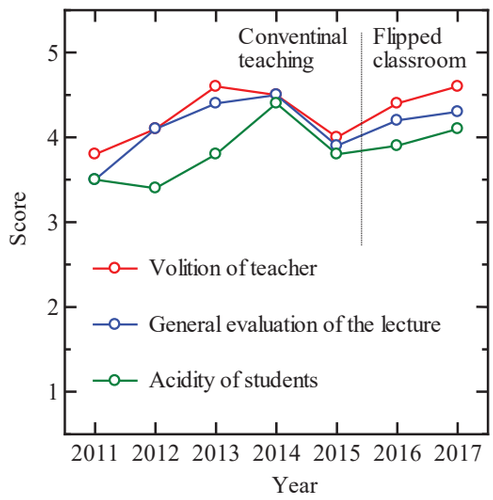


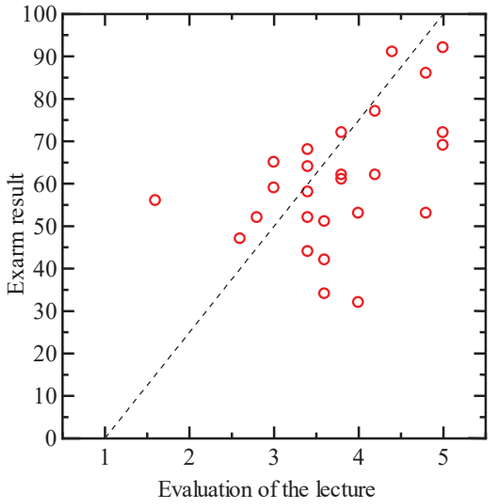
Fig.8. Evaluation of the lecture of electromagnetism by students.

lecture was not increase. I have no ways to analyses that reason.

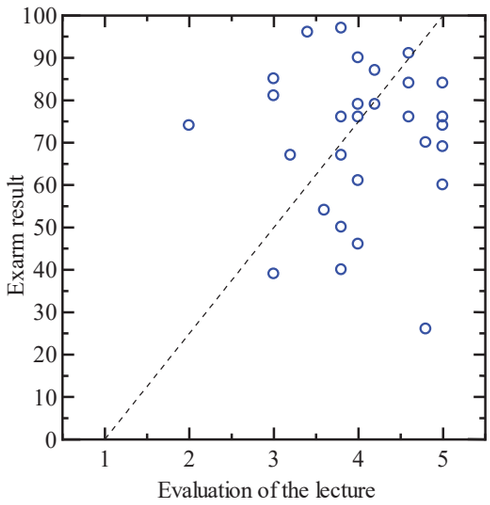
In this year, students who study electromagnetism were answered questionnaires for an impression of the flipped classroom on Forms of Office 365 every lesson. The questions were follows:

Q.1. Do you consent to contents of this lesson?
Q.2. Is this a worthwhile lesson for you?
Q.3. Do you think that the problems can be solved by yourself?
Q.4. Do you think it was good to work on the problems?
Q.5. How satisfied are this lesson?

Students answered these questions in 5 grades. Fig.9 shows that the relationship of the average score and their exam results. Fig.9 (a) and (b) are the result of 3rd grade students (17~18 years old) and result of 4th grade students (18~19 years old), respectively. Students who appreciated the lesson, had high exam results in the 3rd grade. Their relationship is a nearly linear. The 4th grade students had not such a trend. The relationships between the evaluation score and their exam results cannot be found clearly, since their evaluation score is higher than that of 3rd grade students. Teaching load of teacher can be reduced by the flipped classroom, since, talking in a lesson can be decreased by using the movie. The preparation of the movies is necessary only once. The movies can be used again in same lesson next year.



(a) 3rd grade students (17~18 years old)



(b) 4th grade students (18~19 years old)

Fig. 9. relationship of the average score and their exam results.

Conclusions

I have tried the flipped classroom for lecture of electromagnetism. Some techniques to prepare leaning contents for the flipped classroom and its educational effect based on the results of questionnaires and examinations are described in this paper. The movie learning materials for the flipped classroom can be make easily using some functions of Microsoft PowerPoint. Students can access easily the movies which they need in the mychannel of YouTube. It is found that the mini-examination to check themselves their understanding is effective in beginning time of the lesson. Students can work hard and enthusiastically in the lessons applied the flipped classroom. Students decided that the flipped classroom was better than the conventional teaching method for the volition of teacher. Activity of students which was evaluated by themselves obviously increased. Students who appreciated the lesson formed the flipped classroom, had high exam results. Their relationship is a nearly linear.

Teaching load of teacher can be reduced by the flipped classroom, since, talking in lesson can be decreased by using the movie. The preparation of the movies is necessary only once. The movies can be used again in same lesson next year.

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VIRTUAL OPTOMETRIST - ENGAGING OPTOMETRY STUDENTS THROUGH GAME BASED LEARNING

E.T. Chua*, S.M Yang* and Z.Y. Bao*

* Ngee Ann Polytechnic/School of Health Sciences, Singapore

Germaine_CHUA@np.edu.sg

Abstract

Virtual Optometrist (VO) is a web-based game designed for Optometry students in the Diploma in Optometry at Ngee Ann Polytechnic (NP). The objective was to enhance students' learning experience and learning outcomes using a virtual learning space in a game setting where students develop their critical thinking and patient management skills.

The VO consists of two game interfaces where each interface will have different stages to cater to different level of students. Content was tailored based on the learning objectives of the different modules. VO incorporates virtual case studies for self-directed learning for students with different capacities and knowledge. Students were very receptive of the VO with 90.4% of the students surveyed agreed that the VO was useful in helping them to understand the content, and motivating their interest`. 97.0% found that the cases presented were relevant, and agreed that the visuals and pictures helped them in their learning.

There was a difference in the perception that the VO experience stretched thinking abilities among different level of students. 100% of Year 1 2 students responded that it stretched their thinking as compared to 57.8% Year 3 students. This could be attributed to their different expectations The Year 3 students were exposed to internship and had completed 1.5 years of actual clinical practices prior. Therefore, they might not find the VO case studies as challenging as the Year 1 and 2 students.

In conclusion, the VO greatly enhances the students' learning, and is useful in motivating and developing critical thinking. Moving forward, more challenging and complex cases could be incorporated into VO to better meet the learning needs of Year 3 students.

Keywords: *Self-directed learning, virtual gameplay, critical thinking, virtual optometrist*

Introduction

Digital games for learning have become increasingly popular over the last two decades. Game play has been found to be associated with enhanced problem solving skills (Cooper 2014), and persistence (Shute et al. 2013). This paper discusses the effectiveness of using a web based game to encourage critical thinking among Ngee Ann Polytechnic (NP) Optometry students.

Background

The Diploma in Optometry (OPT) course is a three-year program offered by NP to train students in becoming future optometrists. Optometrists are primary eye care providers. They are required to have good clinical skills, critical thinking, and patient management skills.

The OPT course was designed to equip students with the content and practical knowledge in the first 1.5 years of their course. The content was taught through various modules across different semesters. In the second year of the course, they are required to integrate skills and knowledge learnt previously to perform full eye examinations, and to provide appropriate management of public patients. Students found these requirements challenging, as they have to remember, integrate and apply what they have learnt from various modules here. As a result, many faced difficulties in integrating the practical skills and the content knowledge to the real world scenarios. To address this issue, case studies were introduced to provide some authenticity during the learning process. However, it was still not authentic due to the absence of a clinical setting. Students often gave feedback on the lack of participation and involvement, especially in the decision making process. This led to the development of the Virtual Optometrist (VO), which provided a platform to enable students to integrate their skills and knowledge in a virtual environment, which is a mimic of the real-world environment.

VO rationale and game design

Researchers (Gee 2004; Shaffer 2006) have indicated that successful computer games are supposed to provide structured and immersive problem-solving experiences to enable the development of knowledge and 'ways of knowing'. This can then be transferred to the situations outside of the original context of gaming or learning. The VO game was designed with the above pointers.

VO consisted of two interfaces 1) Optical Practice Counter and 2) Optometric Consultation Room, which

cover the two major roles of practicing optometrists. The optical practice counter requires students to recommend and provide appropriate frame and lens selection for the patient. The optometric consultation room allows students to diagnose and manage patients with common eye conditions. Both interfaces consist of realistic cases and optometric test results to simulate actual clinical cases. Students need to assimilate the knowledge obtained from all relevant modules to effectively apply them in the realistic clinical situations.



Figure 1. Stage 2 Consultation Room Interface of VO Game (Selecting of appropriate test)

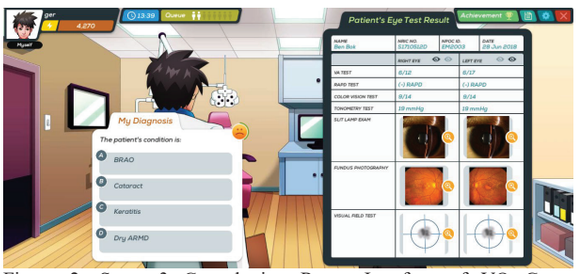

Figure 2. Stage 3 Consultation Room Interface of VO Game (Diagnosing the condition based on the clinical findings)

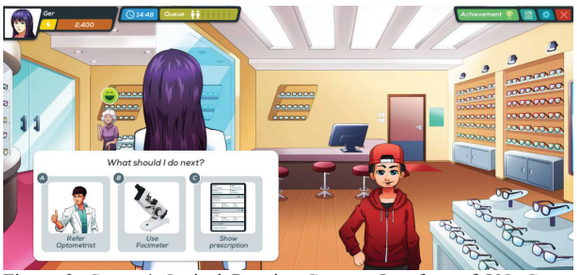

Figure 3. Stage 4 Optical Practice Counter Interface of VO Game (Selecting appropriate procedure to perform based on clinical case)

VO was designed with increasing complexity to ensure that the cases presented were appropriate for the student's cognitive level (Table 1); these differences are deliberately designed to prevent gameplay fatigue and to match their level of study. The gameplay also includes achievement and scoreboard to trigger the intrinsic motivation in students to perform. Scores are based on both speed and accuracy. This urged the students to not only play it fast but also ensure that learning takes place. For instance, if a wrong selection is chosen, the "happy index" of the customer/patient will drop resulting in lower scores. Students will need to perform the task accurately and at the same time efficiently. This simulates a real retail setting where there could be multiple customers coming to a practice and optometrists are required to perform eye examination efficiently and accurately.

Game Interface	Stages	Requirements
Optical Practice Counter	1	Select & Manage Single Vision
	2	Select & Mange Progressive and Bifocal
	3	Manage both Single Vision & Progressive based on the customers' needs and requirement
Consultation Room	1	Identify and diagnose anterior eye conditions
	2	Identify and diagnose posterior eye conditions
	3	Select appropriate test to be perform and diagnose & manage conditions based on clinical findings
	4	Diagnose, manage and provide advice to patient based on their clinical findings
	5	Diagnose, manage two complex conditions and provide appropriate advice to patients

Table 1. Summary of VO game stages and requirements

Another important aspect of learning is the importance of providing feedback. Gibbs and Simpson (2004) identified feedback as the single most powerful influence on student achievement. It is most effective when it contains advice originating from the student's own recent work. Immediate feedback with explanation are given throughout the gameplay to allow students to know if their selection is appropriate and provides channel for repeated selection. Both the interfaces consist of different levels with increasing difficulty thus allowing them to develop higher order learning.

The "backend office" of the VO is another highlight of the game. It is fully customisable to allow module leaders to add, edit, and delete cases, dialogue and case results. The versatility in the presented scenarios allows development of learning outcomes aligned with the student's need. For instance, if there are certain areas that students are generally weaker in; module leaders can include more relevant cases for them to practice. The backend office allows for real clinical photos to be added for simulating real clinical results.

Implementation & Benefits of VO

The VO was incorporated in eight different modules across five different semesters. The objective was to allow students to participate in an immersive environment for development of critical thinking and problem solving skills, as well as a sense of responsibility.

All these soft skills are integral to the role of an optometrist. The VO was used by module leaders differently. They may incorporate it in a flipped classroom pedagogy, or as a form of e-learning. Module leaders are able to generate the results at the backend office to monitor the progress of the students.

As mentioned earlier, there were some learning gaps in the optometry program and VO was implemented to address these issues. VO enhances students learning in the four following ways:

(1) Enables the application of their clinical knowledge throughout their course of study

Previously, students learn about the different skills and knowledge in the first semester but were unable to practice what they have learnt, as they were not scheduled for clinical duties at the Ngee Ann Polytechnic Optomtery Centre (NPOC) until the fourth semester. Many students feedback that they have forgotten the skills when they start their clinical practice and have difficulty in adapting to the clinical environment. VO provides a virtual platform for students to apply their clinical knowledge throughout their course of study. Students are not only constantly exposed to the use of virtual clinical test to enhance their knowledge, they are also able to revisit the previous levels to relearn, recap and revise without constraints in time and space.

(2) Allows for equal learning opportunities

Students are scheduled at different days for clinical practice in NPOC. It is a fully equipped optometric clinic that allows the public to get a detailed eye examination at a nominal fee and at the same time provide a work-based learning environment for our students. Students are able to apply what they have learnt and integrate the knowledge and skills to perform a full eye examination on the general public. The patient profile in the clinic is wide-ranging - from children as young as 3-4 years old, to elderly in their 90s. Some could be having simple prescription issues while others could be suffering from complex ocular or systemic health problems. Due to the diversity in the patient profiles, it is difficult to ensure that all students are given a mixture of all possible scenarios. This leads to students having different learning experiences as some students may get to examine challenging patients, while others can only contend with simple cases. With the VO, students are able to experience all types of critical clinical scenarios that may not necessarily be seen by every student during their clinical training. This ensures that students will have equal learning opportunities and experience.

(3) Allows for immersive learning opportunities

As mentioned earlier, case studies might not be as effective to engage students in their learning even as these were used to provide students with real-world examples. VO not only provides students with practice in handling different types of clinical scenarios, where they are required to integrate their practical and theory knowledge, but also requires them to think critically about the next course of action. Through the gameplay, they are able to understand the consequences and see the value in their learning. This promotes and triggers their problem solving and critical thinking skills.

Students have also shown a preference for learning in an immersive environment where they could make decisions and take charge of their learning and get immediate feedback on their task.

(4) Allows for training of communication skills

While students are able to prepare themselves to respond to different clinical situations by ensuring that they understand and are able to apply content knowledge, many students are weaker in their communication skills. However, the role of an optometrist requires good communication skills, as they need to interact with their patients effectively to gain understanding of their condition and to be able to explain the results of the diagnoses to them. The VO provides students with the opportunity to interact and communicate with the virtual patients as VO is designed with speech interaction between player and patient/customer. If an appropriate response is selected, the "happy index" of the patient/customer will improve, and the reverse happens if an inappropriate response is chosen. It allows students to understand that the role of an optometrist requires not merely good optometric skills, but also good communication skills.

Student's Perception of VO

Survey Question	% of Strongly Agree/Agree			
	Year 1	Year 2	Year 3	Average
VO helped me understand the topic (management of the patient with the diseases).	100	100	89.4	**96.5**
VO stretched my thinking.	100	100	57.9	**86.0**
VO motivated my interest in the module.	100	100	52.7	**84.2**
The activity/activities (e.g. case scenarios and learning activities in each game) is/are appropriate and relevant.	100	87.5	94.7	**94.1**

Table 2: Breakdown of students' feedback on VO by OPT students

Feedback from students were generally positive especially among the Year 1 & 2. It is encouraging to know that students find the gameplay useful and the activities appropriate (Table 2). Previously, students had shared that they could see the relevance of some subjects only after they start their clinical practice in Year 2. VO is useful to motivate them in their Year 1 and 2 because they can appreciate how their learning will eventually be useful in their clinical practice. Based on the comments from students (Table 3), it seems that learning objectives were met and students can appreciate the use of this gameplay to enhance their critical thinking & communication skills, particularly among the Year 1 and 2. This might be due to lack of any actual clinical practice. Therefore, the students find the integration of VO interesting, as they are able to be relate the theory to practice.

Student Level	Positive Comments
Year 1	I like how it penalize for bad language, as the way we speak to patient is very important to professionalism.
	I like the animation, it showcase proper real life scenarios.
	The whole process not only teach us ocular diseases but also how to react to different situations.
Year 2	I like how this online activity provides comprehensive description on the various case scenarios.
	This helps me mentally prepare myself for my upcoming internship where I will physically experience handling real patients.
	When errors are made, there are additional text boxes with detailed descriptions to clarify my doubts about the case.
Year 3	The game is fun and interactive but it does not feel like how it will be like in the actual clinical setting.
	It enables me to think of the differential diagnosis and what causes the conditions from the following signs and symptoms.
	I like the animation and the improvement could be on the instructions.

Table 3: Students comments on the VO by student's level

However, there was varied perspectives regarding the motivation and the critical thinking skills development between the Year 1 & 2 (100%) and Year 3 students (57.9%). Year 3 students felt that the cases presented were straightforward and the answers were obvious, and thus is not as helpful in stimulating their critical thinking skills. This difference was as expected because Year 3 students had undergone internship, participated in various eye screenings, and had 1.5 years of clinical practice, which exposed them to clinical cases of various complexity. Hence, the VO game currently might not be adequate to trigger their critical thinking and motivation.

Learning points

(1) Appropriate level and pacing for learning

The design of a digital game for learning requires careful planning to ensure that the learning objectives are met and yet engaging for the students. Gameplay should be paced appropriately to students' learning.

" *Speed is too fast, I feel I need to clear as many patients as possible rather than really diagnosing what they have" – Year 2*
"Too rushed, the patient get angry too easily, it would be good if patient can calm down while waiting for their turn" – Year 2

The gameplay tried to mimic a real optometry setting whereby there could be multiple customers coming through a store at once and optometrists are required to perform eye examination efficiently and accurately. However, it seems to be a distractor for students as they see it as a hurdle rather than a challenge. It highlights a key learning on the importance of balancing the challenge to trigger motivation. Challenges should motivate students to do well, but if the challenge is too unachievable, it might demotivate the students. Hence, changes were made to the speed of the game at the backend office to enable a better learning experience.

(2) More complex clinical cases

Some Year 2 and Year 3 students have requested for VO to include more challenging cases so that they are able to have a better variety of learning experiences.

"More variety in the type of cases, some conditions got too repetitive" – Year 2
"Please provide lesser repetition of the cases for the optometrist clinic" – Year 3

Based on the above suggestion, the team had made changes to VO e.g. more cases and clinical images were added to provide greater variety of clinical cases. For the Year 3s, other than increasing the variety of the cases, more complex cases were added to provoke their critical thinking and ensure that they benefit equally from VO.

Conclusion

The VO has been useful in supporting optometry students to enhance their learning experience by providing an avenue to integrate the knowledge from different modules, develop critical thinking, and communication skills. VO also provided the students with equal learning opportunities through the set of clinical scenario. Although students were generally receptive of the VO game, a greater variety of challenging cases should be included to "stretch" students' ability.

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DEVELOPMENT AND PRACTICE OF AN EXPERIMENTAL KIT FOR THE "IN-SITU EXPERIMEMT" IN ELECTRONIC CIRCUIT RELATED CLASSES

N. Tokui*, S. Seto, T. Kanmachi and Y. Morita

Department of Electrical Engineering, National Institute of Technology, Ishikawa College, Tsubata Ishikawa, Japan

*tokui@ishikawa-nct.ac.jp

Abstract

In our Electrical Engineering department, we have been introducing a new engineering education method called "in-situ experiment" into the specialized subjects since 2009. It is an education method based on simple experiments performed in classroom for our students to check and confirm basically physical laws and rules just after learning them. In the electrical engineering, the electrical and electronic circuits are fundamental subjects to learn the wide range of specialized subjects when students advance to the next year. In our department, 1st and 2nd year students learn the electrical circuits including digital circuits in the classes named "Fundamentals to Digital Circuits" for 1st year students and "Basic Electric Circuits" for 2nd year students. In these classes, the students make typical logic circuits by themselves during class to confirm each function and movement of digital devices. In the class of "Basic Electric Circuits" for 2nd year students, they learn for the first time Kirchhoff's law, a principle of superposition in linear electrical circuits and Thevenin's theorem through the in-situ experiment. Among them, Thevenin's theorem is a key theorem to analyze electric circuits but difficult for students to understand. In order to make these theorems easily understandable, we fabricated a small size of variable DC voltage source and a quasi-sine wave generator by using a dry battery. We confirmed the effectiveness of the in-situ experiments through the improvement of the average scores of the examination. We also conducted questionnaire survey about the "in-situ experiment". As a result, we got many positive opinions on the in-situ experiment from the students. As a further positive aspect, the number of students who repeat the same classes decreased by about half before the introduction of the in-situ experiment for 1st, 2nd and 3rd year students in our department.

Keywords: *in-situ experiment, first-year education, digital circuit, electric circuit, Kirchhoff's law, Thevenin's theorem*

Introduction

One of main features of KOSEN (National College of Technology in Japan) education is a specially designed curriculum having specialized subjects which are introduced in an early stage of college year. However, there are some students who cannot follow the classes of the specialized subjects. Such students tend to lose their interests in their specialized subjects and find it difficult to continue to study those specialized subjects. Unfortunately, a few students resulted in leaving the college, which we think is related to some abstract contents of the specialized subjects such as electric circuits.

We propose here a new education method to resolve the above-mentioned problem in the early stage of college year. It is a positive introduction of simple experiment in a classroom for students to check and ensure physical laws and rules just after learning them. We called it "in-situ experiment" and have introduced actively this "in-situ experiment" into the early-stage of our engineering education since 2009. After that time, we have developed two kinds of "experiment kit" to execute the "in-situ experiment "in a classroom. We expect that this kind of the "in-situ experiment" makes it easier for them to understand abstract physical laws or rules.

In this paper, we report introduction of newly developed "in-situ experiments" into introductory classes related to electrical and electronic circuits for 1st year and 2nd year students of the department of electrical engineering and verify their educational effects.

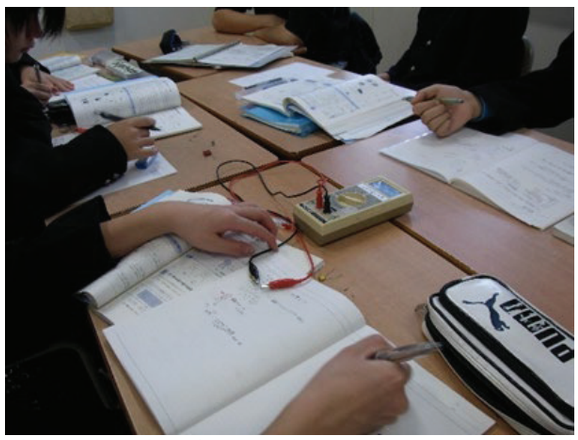
The "in-situ experiment" in the specialized subjects for 1st year students

We introduced "in-situ experiment" into two specialized subject classes for 1st year students. One is a class named "Fundamentals to Electrical Engineering". Students learn basic contents of electric circuit and electric magnetics in this class. Figure 1 shows a photograph of students who are performing the "in-situ experiment" we introduced. They are measuring physical values of electronic elements in circuit.

In addition, "Fundamentals to Digital Circuits" are also taught in this class to learn logical algebra as well as logic circuits. Figure 2 is another photograph in the same classroom, in which students are assembling a logic

circuit using an IC trainer kit and confirm how to work them. The IC trainer kit has a bread board, switch and LED and it can work with two dry batteries. This kind of “in-situ experiment” is practiced in the class every week during one semester.

Figure 1. Photograph of the class of "Fundamentals to



Electrical Engineering". Students are measuring physical values of the electronic elements by a circuit tester.



Figure 2. Photograph of the class of "Fundamentals to Digital Circuits". Students are designing a logic circuit and connecting wires on bread board.

These new in-situ experiments we introduced are effective for 1st year students as introductory specialized classes. We confirmed their effectiveness from the average score. Table 1 shows the average scores of "Fundamentals to Digital Circuits" from 2007 to 2010. The average score gradually increases year after year by the introduction of the in-situ experiment into the class.

Table 1. Final average scores of "Fundamentals to Digital Circuits". We have introduced the “in-situ experiment” from 2008.

Years	Average	Variance
2007	77.3	11.7
2008	79.2	12.9
2009	80.8	11.5
2010	81.3	13.6

Introduction method for the subject of 2nd year students

In the class of “Basic Electric Circuits”, students learn about Kirchhoff's law, a principle of superposition in linear electrical circuits and Thevenin's theorem as fundamental laws in electrical and electrical circuits for the first time. In order to performing the “in-situ experiment” about these law and rules, we developed a small sized variable DC voltage source and a quasi-sine wave generator by using a dry battery, which are suitable for the “in-situ experiments”.

In the first semester of the class named "Circuit Foundation", they learn about fundamental laws of DC circuit. Just after learning some fundamental laws, they confirm them through the “in-situ experiment”. For example, students performed practices “Thevenin’s theorem” using the real circuit shown in Figure 3. Through this kind of the “in-situ experiment”, students understand that a circuit including a voltage source surrounded by the dashed line in the left figure is equivalent to a simple voltage source model which include only one voltage source and one internal resistance.

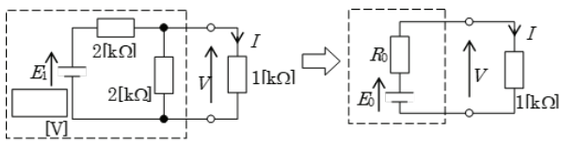


Figure 3. Thevenin's theorem of the direct-current circuit I.

Figure 4 shows the expanded circuit diagram surrounded by the dashed line in Figure 3, and how to measure open-circuit voltage (left circuit) and internal resistance (right circuit) for Thevenin's theorem. For these experiments, we used the new DC voltage source fitting to the “in-situ experiment”. It is a variable DC voltage source with a small size working composing of one small battery. The new variable DC voltage source was operated by an OP Amp to get stable output voltage. The DC voltage more than 3 V is necessary to do the “in-situ experiment”. Therefore, we also used DC-DC converter to increase the voltage from 1.3 to 3.3 V. Figure 5 is a circuit diagram of the simple variable DC voltage source we designed. Chip components were used for the simple variable DC voltage source to arrange them in a small area of the board. One equipment cost is only approximately 1,100 yen.

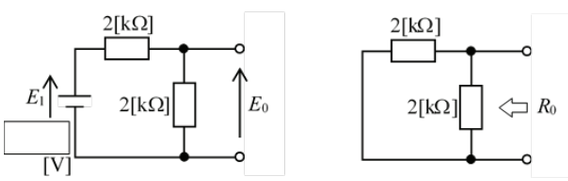


Figure 4. Thevenin's theorem of the direct-current circuit II.

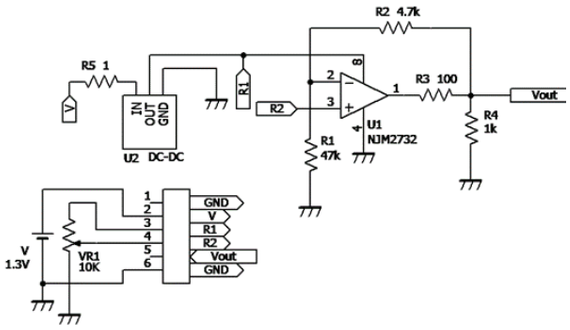


Figure 5. Circuit diagram of the simple variable power supply.

In "Basic Electric Circuits" of the second semester, the students learn about the basics of alternating current (AC) circuits and fundamental concepts and laws for AC circuits such as impedance and Ohm's law. We also developed a new “in-situ experiment” for measurement of AC impedance. In this “in-situ experiment”, students build up a circuit which is composed of coil, capacitor and oscillator. For the experiment, we have designed a simple oscillator which works with one battery. Although the designed simple oscillator cannot produce exact sine-wave signal, the simple oscillator is enough to measure AC impedances with an appropriate accuracy for the “in-situ experiment”. The circuit diagram of the simple oscillator is shown in Figure 6. This equipment is composed of only chip devices to be downsized. We fabricated this equipment with approximately 350 yen. Therefore, we could distribute it to each student in the class.

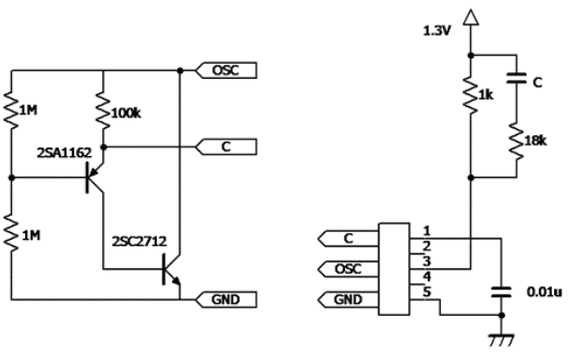


Figure 6. Circuit diagram of the simple oscillator.

Figure 7 shows the completed circuit boards of the simple variable power supply (red board) and the oscillator (green board). This simple variable power supply can produce voltage range of 0-2.4V by a variable resistance. The simple oscillator produced quasi-sine wave by connecting capacitor and resistor to a battery. An upper limit of the oscillatory frequency is approximately 1.5 kHz. Students measure voltages across each element as well as across two elements in a series circuit comprised of a resistor and a capacitor when applied an appropriate AC voltage. In DC circuit, the whole voltage is simply the sum of voltages across each element, resistor and capacitor. In AC circuit, on the other hand, the whole voltage is not the sum of voltage of each element. Through the “in-situ experiment”, the students can understand difference between DC and AC circuit. Furthermore, the students learn about the phasor representation which explains visually AC circuits with sine wave signal in complex plane. In addition, they also realize that an impedance of the capacitor decreases increasing frequency.

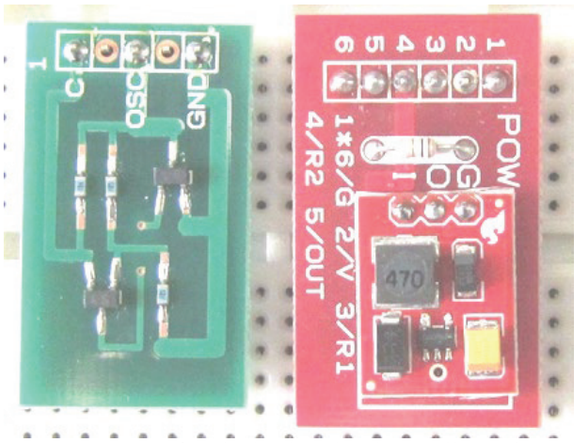


Figure 7. Left-side is the simple oscillator (green board) and right-side is the simple variable power supply (red board).

Figure 8 is a photograph of the class of "Basic Electric Circuits” for second year students. In this class, each student is fabricating an AC circuit using a variable power supply shown in Figure 7. Each student is discussing and helping each other to fabricate the circuit and how to measure AC impedance. The students study actively basic laws of electric circuits through the “in-situ experiment”.



Figure 8. Photograph of the class of " Basic Electric Circuits”. Students are measuring value of the element using simple variable voltage power supply.

In order to ensure the effectiveness of the “in-situ experiments” for students, we conducted questionnaire at the end of the semester. The results are shown in Figure 9-12. As can be seen in Figure 9, the positive resposes from students on the question of "Interests for the electrical engineering" are more than 90%. In Figure 10, the positive resposes on the question of "Understanding

of the specialized subjects" are more than 80%. Furthermore, as can be seen in Figure 11, it was found that the students who feel to be able to understand the theorem or rules increases year by year. In Figure 12, approximately more than 70% students answered that they want to do the same number of the "in-situ experiment" at least. From these results, it is shown that the "in-situ experiments" lead to enhancemant of their interests and motivations in the field of electrical engineering. However, we think that the contents of the "in-situ experiments" need to be improved continuously.

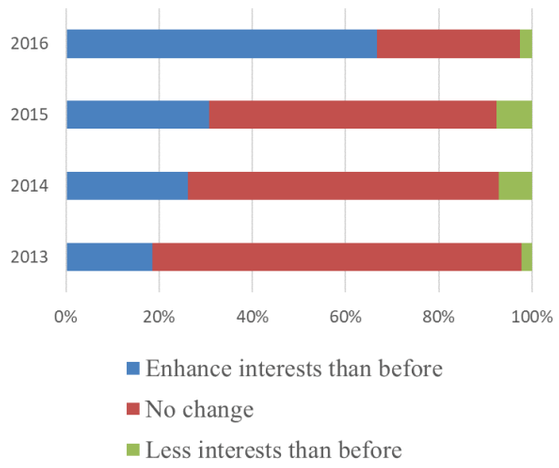


Figure 9. The result of question "Interests for the electrical engineering".

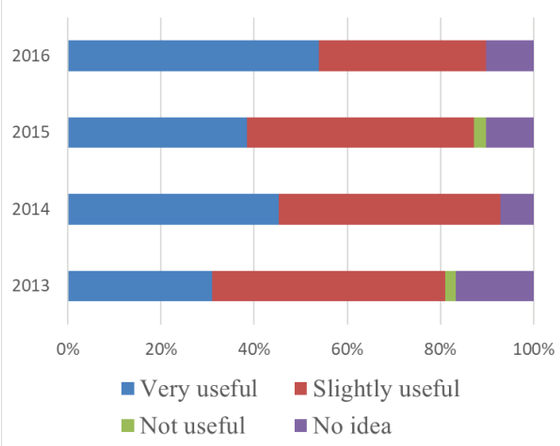


Figure 10. The result of question "Understanding of the specialized subject".

Results and Discussion

In our department, the so-called "in-situ experiments" were introduced from 2009. Table 2 shows an average number of students in a class who repeat the same academic year or leave college for 1st, 2nd and 3rd year students in the department of Electrical Engineering. For comparison, the similar average numbers for other departments in our college, Mechanical Engineering, Electronics & Information Engineering, Civil engineering, and Architecture, are also shown in the table.

After the introduction of the "in-situ experiments", the number of students in the department of Electrical Engineering decreases. On the other hand, such kind of decrease is not distinctly seen in other departments in our college. From this result, we can say that the "in-situ experiment" is effective education method for students in the early-stage of engineering education of KOSEN, especially in the department of Electrical Engineering.

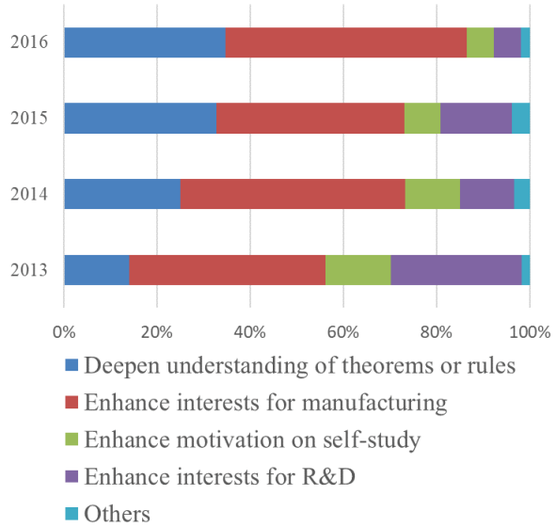


Figure 11. The result of question "Which aspect did you change your mind after doing the in-situ experiments".

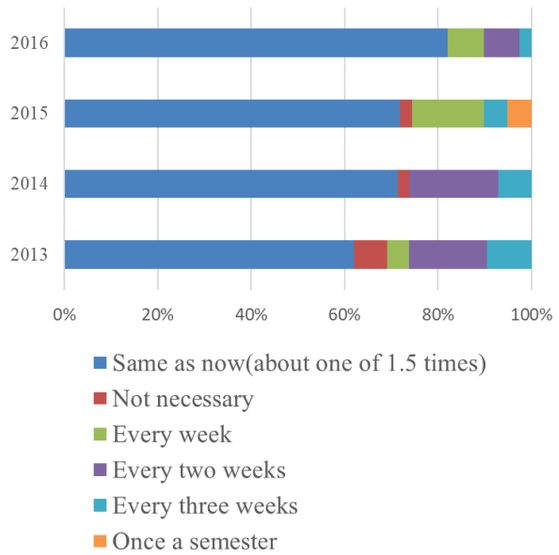


Figure 12. The result of question "How many times do you want to do the in-situ experiment in a class".

Table 2. Average number of student who repeat the same academic grade or leave college.

	Academic year	Before introduction	Introduced
Electrical engineering department	1st	0.0	0.4
	2nd	1.0	0.5
	3rd	2.0	0.7
Other departments	1st	0.2	0.2
	2nd	0.9	0.8
	3rd	1.1	1.9
Grouping of the year	1st	2007-2008	2010-2014
	2nd	2007-2009	2011-2014
	3rd	2007-2010	2012-2014

Conclusions

The “in-situ experiment” as a new active learning method has been introduced into the department of electrical engineering in our college (NIT, Ishikawa college) since 2009. In addition, we have been improving the education method of the “in-situ experiment” and developed new in-situ experiments in the classes of electrical circuit. For the new in-situ experiments, we developed small sized power supply and oscillator. It was shown that these “in-situ experiment” help students to understand abstract laws or rules in electrical circuits and keep their interests to electrical engineering. As a result, an average number of students who repeat the same academic year or leave college decreased after the introduction of the in-situ experiment. Furthermore, we need to develop this kind of “in-situ experiment” and to share the other college of KOSEN as a new engineering education.

Acknowledgements

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LEARNING STUTTERING WITH NO BORDER: SHARING EXPERIENCE TOGETHER

Shin Ying Chu*[a], Grace McConnell[b] and Man-Ching Yuen [c]

[a] Universiti Kebangsaan Malaysia, Faculty of Health Sciences, Centre of Rehabilitation and Special Needs, Kuala Lumpur, Malaysia

[b] Rockhurst University, College of Health and Human Services, Kansas, United States of America

[c] Hong Kong Institute of Vocational Education (Tsing Yi), Department of Information Technology, Hong Kong, China
Senior Member, IEEE

*chushinying@ukm.edu.my

Abstract

With advances in technology, collaborative learning is an e-learning approach trend where students are able to socially interact with other students and instructors. Currently, instructors are able to distribute teaching materials, collect students' assignments, and communicate with students via e-learning platforms. However, this trend does not always fully utilize the functions of e-learning platforms. To explore some broader capabilities, we created an e-learning experience using a free open learning platform (MOOC) for students from two institutes (National University of Malaysia and Rockhurst University) who enrolled in their respective stuttering courses. Students were asked to share their experiences in their assignments to act in public as a person who stutters (pseudostutterring) to better understand their patients' perspectives. An online discussion was created using MOOC for students to write their experiences as a 'stutterer' and to comment on their peers' experiences. Feedback from students indicated that they felt this activity was useful to understand the emotional impact and pressure felt by the patient as a person who stutters, which would impact their perceptions and clinical management for these patients. This e-learning experience from two different cultures raises the likelihood of knowledge absorption, knowledge sharing, increased engagement, social learning interactivity, and cross-cultural understanding of communication impairments.

Keywords: stuttering, health care, public awareness, communication disorders, speech-language-therapist

Introduction

Massive open online courses (MOOCs) is rapidly growing worldwide. It is "massive" because one course enables the serving of thousands of students. It is "open" because it is free. It is "online" because the course is delivered through the Internet. It is a "course" because each sequence is structured with specific learning objectives and curriculum (UK Department for Business Innovation and Skills, 2013). Often, these online courses are delivered in various formats, including watching and listening to online lectures, completing tasks, reading articles, and having group discussions. This online forum provides students opportunities to engage with their peers and teachers around the world. The MOOC is becoming increasingly popular because it is free to access 24/7 from all countries on the same level of education, especially to learners from developing countries (Anderson, 2013).

For many years, behaviorism, cognitivism, and constructivism have been the three main learning theories that are most utilized in instructional environment (Kop & Hill, 2008). Behaviorism states that learning is through observable behavior and this is more important than understanding internal activities (Gredler, 2001). Cognitivism views learning as a process of inputs, which are managed in short-term memory and coded for long-term recall. Constructivism states that the learner creates knowledge as they attempt to understand their experiences (Driscoll, 2000, p.376). These theories, however, were developed before learning was impacted through technology and fail to describe how learning happens outside of people (i.e., learning that is manipulated by technology). In today's environment, we can easily obtain new knowledge by drawing information through the internet. Hence, Siemens (2004) proposed the "connectivism" theory, whereby knowledge is distributed across an information network and can be stored in a variety of digital formats. Siemens (2004) states, "A community is the clustering of similar areas of interest that allows for interaction, sharing, dialoguing, and thinking together." Connectivism provides a framework for understanding learning processes in a digital era that captures the MOOCs unicity - the sense of community

and the opportunity for participants to engage online in order to learn from each other.

With e-teaching becoming more and more popular, advances in educational technology have enabled educators to incorporate technologies in the teaching-learning process (Peng, 2017). While MOOCs are increasingly popular, it is not known whether this method of self-learning at the student's own pace is better than conventional lectures. At present, students have reported both positive and negative experiences using MOOCs (Zutshi, O'Hare, & Rodafinos, 2013). From the academics' and teachers' perspectives, most agree the MOOCs could never replace a knowledgeable and engaging teacher in front of a class (Cassidy, Breakwell, & Bailey, 2013). However, MOOCs could provide students with a different type of learning experience from their peers. Currently, instructors distribute teaching materials, collect students' assignments, and communicate with students via Forum on the e-learning platforms. However, it does not fully utilize the functions of e-learning platforms. On top of conventional lectures, we added an online discussion on a MOOC platform to provide opportunities for students in two countries to discuss and share their experiences on a task. This paper summarizes the task that the instructors designed and reports students' views on participating in MOOC for a course.

Materials and Methods or pedagogy

An e-learning experience using a free open learning platform (MOOC) was developed by the research team for students from two institutes (National University of Malaysia and Rockhurst University) who enrolled in the institutions' respective stuttering courses. Students were taught about the clinical characteristics of speech production in individuals who stutter in class before participating in the pseudostuttering tasks. Students were asked to share their experiences as a person who stutters (pseudostuterring) to better understand their patients' perspectives and emotional reactions. Students were asked to produce at least three episodes of pseudo-stuttering in different speaking environments with strangers over the course of a week. Students were to speak using the speech patterns of stuttering, including primary characteristics of stuttering, such as repetition of sounds and words, prologations of sounds, and inaudible blocks, interjections, and revisions, as well as secondary characteristics, such as eye blinks and head nods. This task created the opportunity for students to feel their client's emotional reactions to stuttering, thus developing empathy. Students were able to observe the various reactions of the general public to people who stutter, from kind and supportive to derisive and dismissive. This psudostuttering task was also implemented to help desensitize students so that they will not act negatively when they begin working with their clients. An online discussion platform was created using MOOC for students to write about their experiences, observations, and reflections as a 'stutterer' in terms of modifications of their speech and their emotions during these interactions. Students were encouraged to read about their peers' experiences and make comments on these. Finally, students filled out a survey that expressed their opinions on this task and the MOOC experience.

Results and Discussion

A total of 49 students (16 Malaysia, Mean age 23.6 years old [SD=1.4]; 34 American, Mean age 24.3 years old [SD=1.3]) participated in this study. The students in Malaysia were enrolled in the undergraduate stuttering course during participation. The US students were enrolled in the graduate stuttering course. (In Malaysia, the undergraduate degree is the terminal degree for becoming a clinician, whereas in the US, the graduate degree is the terminal degree for the profession. This explains why students take their stuttering course at different levels.

Two parts of results are reported in this paper. The first section focuses on the emotional impact and knowledge that students have learned from this task and their reflection about this activity. The second part report the survey results, whereby descriptive data on the survey are summarized in Table 1, and two major themes were found from students' responses and summarized here.

Theme 1: Understanding the emotional reactions and social challenges faced by people who stutter.

This experience taught us not only to see the challenges people who stutter(PWS) face but also challenge our own perspectives towards PWS.

Stuttering can be really exhausting! PWS should be praised for their attempts to communicate with other people because not only they have to gather courage to speak up in public but they also need to bear with all the exhaustion that comes after it.

Based on my observation, most of them made attempt to hear and understand on what I want to say. They give their full attention especially the waiter and cashier in order to get a correct order and to avoid any mistakes. Some of them also did ask for clarification when ordering the food (e.g: cashier at KFC asked, "what drinks?) in expecting me to repeat my order.

In conclusion, this assignment experienced me the difficulties for PWS to carry out a conversation and to fulfill their social demands. Normal people seem enjoy to have a conversation, but for PWS it can be very stressful for them. Here come to SLP's roles in providing intervention by teaching some techniques and have an empathy towards them on how does stuttering affects their daily life.

This activity helps me to understand that stuttering is not only about the fluency problem. It affects individual as a whole. Their social network will become very limited. It takes a lot of courage for them to start a conversation. It influences their life so badly, even when I tried to speak few sentences with stutter

I already felt tired. As a speech-language pathologist, this activity helps me to see how emotionally influencing stuttering is and we should always concern about emotion aspect of each client.

This pseudostuttering assignment is actually very worthy as I did manage to feel how a stutter feels so tired when every time he/she to maintain conversation and also manage to felt how people looked at me weirdly.

Theme 2: Interaction with peer through online-learning

I can relate to how you felt on your first trial! When I prepared for my first trial, I practiced and show how still had the same anxious feelings. I agree with you that this activity was eye opening and gave me a better understanding of how people who stutter feel in social situations.

I had the exact same thoughts as you did while going through this experience. When I stuttered at my waitressing job, I was extremely embarrassed and felt like I couldn't do my job to the best of my ability. I'm sorry to hear that someone chuckled at you and that someone eventually started to ignore you. That just reinforces how hard it must be for those who stutter on a regular basis.

I like how you mention we need to work on our reactions to people who stutter. They are already struggling to fluently communicate and may become embarrassed so it would be nice if the person they are communicating with is understanding and patient with them to make them feel more comfortable.

I can understand your anxiety and nerves. I was also nervous when I was at the pharmacy. People were staring at me and the lady behind me was very rude. I also agree that this experience is very eye-opening to understand what the clients we will work with are going through.

I can relate to your experiences. I anticipated that it would feel awkward to stutter in public, but this experience enlightened me to how strong the feelings of anxiety and anxiousness can become when others are overtly commenting on your speech. The blank stares and confused expressions also negatively reinforced my feelings of anxiousness. This assignment helped me to become a better listener for PWS and to be more aware as a future clinician.

Table 1. Students' response about the task (percentage, US/Malaysia).

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Production of pseudo-stuttering in speaking environments with strangers is necessary for me to better understand what my clients experience daily	0 (0/0)	4 (5.9/0)	16 (20.6/6.3)	54 (52.9/56.3)	26 (20.6/37.5)
2. Production of pseudo-stuttering in speaking environments with strangers helps to understand the struggle of a person who stutter	0 (0/0)	0 (0/0)	8 (11.8/0)	58 (61.8/50)	34 (26.5/50)
3. Observing peer's pseudo-stuttering situation helps to understand the impact of stuttering on one's social life	0 (0/0)	2 (2.9/0)	20 (26.5/6.3)	58 (55.9/62.5)	20 (14.7/31.3)
4. The peer's comments posted on the assignment page are very relevant to my clinical practice	0 (0/0)	2 (3/0)	30.6 (33.3/25)	53.1 (54.5/50)	14.3 (9.1/25)
5. The interactive forum on MOOC provides me a platform to share my pseudo-stuttering experience with my peers	0 (0/0)	2 (2.9/0)	12 (14.7/6.3)	60 (28.8/62.5)	26 (23.5/31.3)
6. I feel that reading my peers' experiences (from Malaysia or US) is interesting and help me to understand their perspectives toward people who stutter	0 (0/0)	0 (0/0)	18 (20.6/12.5)	58 (64.7/43.8)	24 (14.7/43.8)
7. I like the type of online discussion assignment compared with traditional presentation or paper pencil assignment	0 (0/0)	4 (5.9/0)	16 (14.7/18.8)	50 (52.9/43.8)	30 (26.5/37.5)
8. I feel like I understand more on what my clients experience daily	0 (0/0)	2 (2.9/0)	10 (11.8/6.3)	54 (52.9/56.3)	34 (32.4/37.5)
9. I feel like I have learned other useful skills from my peers after this assignment (e.g. observing the reactions of the people nearby when my peer is producing pseudo-stuttering)	0 (0/0)	0 (0/0)	20 (26.5/6.3)	52 (50/56.3)	28 (23.5/37.5)
10. I feel like this assignment helps me as a speech-language pathologist	0 (0/0)	0 (0/0)	18 (23.5/6.3)	52 (52.9/50)	30 (23.5/43.8)
11. I enjoy this assignment	0 (0/0)	6 (8.8/12.5)	28 (35.3/12.5)	40 (38.2/43.8)	26 (17.6/43.8)

Online teaching through MOOC is one of the emerging technologies in the field of education (Viswanathan, 2012). It enables participants to connect outside the traditional learning environment, thereby offering autonomy, openness and emergent knowledge. The growing trend of encouraging connected learning among students reflects the need for teachers to participate in an online course.

Using the MOOC, we provided a platform for students from two countries for learning and sharing their experience using a simple pseudostuttering task. One of the important aspects of the MOOC was the opportunity it provided for students to engage with other students. The course coordinators posted the task where students can express and comments freely among themselves and with the coordinators. In this case, the course coordinator/teacher acts at the connected educator, as suggested by Dabbs (2012). None of the students reported that they felt reluctant to fully engage in this discussion activity due to English concerns. Indeed, some of the students stated that they enjoyed this aspect of the course and the opportunity to communicate with students from different countries.

One of our goals was to increase general understanding of clinical symptoms and emotional reactions in individuals who stutter among speech-language pathology students. From the task that we have designed and the reflections from students, we found that students were able to grasps the emotional reactions and clinical symptoms of a persons who stutter. Implementing MOOC in addition to traditional in-class lecture encourages the students to share their views with others and this trains students to take up responsibility for the learning (Mary, 2012). Students from both countries were able to share their experiences and comment on each other's experiences online without face-to-face discussions. This fits the theory of Connectivism for having the ability to seek out information and including the social context in the learning process (Kop & Hill, 2008). This activity shows that acquisition of knowledge happens not just by listening to lectures, but through interactions with other participants. The MOOC provides an online community that students could participate in consistently and collaborate with others. Future work could

further explore the needs of student when using MOOC, especially students from developing countries to better understand the culture differences and impact of such learning experience (Liu et al., 2016).

Conclusions

This e-learning experience from two different cultures raises the likelihood of knowledge acquisition, knowledge sharing, increased engagement, and social learning interactivity. Students from a developing country can now learn the same knowledge and interact with other students from an advanced country with no cost.

Acknowledgements

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BASIC INFORMATION SECURITY EDUCATION BY FLIP TEACHING

H. Hamada[*,a], R. Ohura [a] and R. Maeda [a]

[a] National Institute of Technology, Sasebo College, Sasebo, Japan

*h-hamada@sasebo.ac.jp

Abstract

At National Institute of Technology, Sasebo College, a new subject was established in 2017. It is called Basic Information Security. The targets of this subject are the first grade of all students at Sasebo College and the subject holds the first semester. It is expected that all our students study basic information security skills in the early stage of their life. In this paper, we report education method and effect of Basic Information Security. We made a survey for all students of the first grade at Sasebo College in 2018. We teach our students using informational literacy materials created in Human Resource Education Project on Information Security (KOSEN Security Educational Community, K-SEC), one of projects of National Institute of Technology. The materials include e-learning contents, presentation slides, quizzes and so on about not only information security but also information literacy. In Basic Information Security, we use their materials by flip teaching, one of active learning methods. Before the lesson starts, students watch movies related to course contents of the lesson using e-learning on Blackboard, a learning management system (LMS), as homework. In the beginning of each lesson, carrying out quizzes on Blackboard, students and teachers confirm the level of understanding of e-learning contents. In the main part of each lesson, students do works related to e-learning contents such as group works and exercises using personal computers. These works contribute to enrich their understanding of contents of learning. In the survey, we examined from three points of view, flip teaching, education using Blackboard and goals of Basic Information Security. There are a lot of positive answers of flip teaching and technology enhanced learning, and the effect of information security also shows. More than 85% of all students are satisfied with flip teaching and more than 90% of all students achieve goals of Basic Information Security.

Keywords: *information security, flip teaching, survey, e-learning, learning management system*

Introduction

As information technology such as the Internet has made progress over recent years, security threats have increased and their damages have been more serious problems. At National Institute of Technology, we provides an environment for our students that are from 15 to 20 years old to be able to use much hardware and software. Our education in the early stage of their life can contribute to society in the field of information security. National Institute of Technology established Human Resource Education Project on Information Security (KOSEN Security Educational Community, K-SEC). We support to be not only information security specialists but also students learned fundamental information security skills. To achieve this goal, at National Institute of Technology, Sasebo College, we established a new subject, Basic Information Security, in 2017. The targets of this subject are the first grade of all students at Sasebo College and the subject holds the first semester. We expect that all our students study basic information security skills in the early stage of their life.

In the new subject, Basic Information Security, we practice flip teaching using e-learning contents, presentation slides and quizzes created by K-SEC. Flip teaching (or flipped classroom) is one of active learning methods proposed Baker (2000). They can study basic skills before lessons and experience proactive learning. By flip teaching, it is assumed that students aspiringly study, learn problem-solving ability and increase learning efficiency.

We use e-learning contents, presentation slides and quizzes on Blackboard, a learning management system (LMS). Blackboard can be used at all colleges of National Institute of Technology. It is easy for teachers of National Institute of Technology to use Blackboard. For example, we can use Blackboard by distributing course materials, submitting homework, taking tests and so on. Students maybe consider that Blackboard have a number of advantage.

In this paper, we report education method and effect of flip teaching and technology enhanced learning using Blackboard in Basic Information Security. We examined from three points of view, flip teaching, education using Blackboard and goals of Basic Information Security. We made a survey for all students of the first grade at Sasebo College in 2018.

Materials and Methods or pedagogy

We explain method of lessons of Basic Information Security. We teach our students by flip teaching using information literacy materials created by K-SEC including e-learning contents, presentation slides, quizzes and so on. The contents of these materials are utilized for not only informational security but also informational literacy. The materials can be run on Blackboard. Before each lesson of Basic Information Security, students watch movies on Blackboard related to the course content of lessons using smartphones or personal computers and so on as homework. It takes students about thirty minutes to watch movies in each lesson. Figure 1 is a screen capture of a movie used in Basic Information Security.

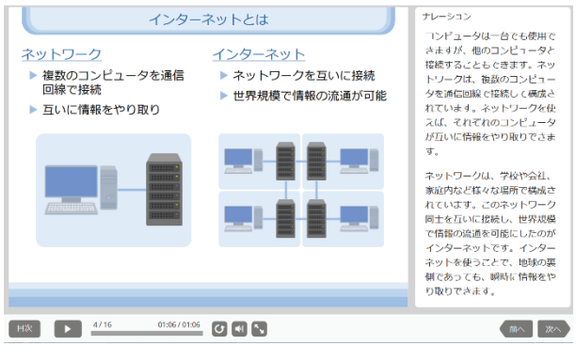


Figure 1. Movie for prior learning of flip teaching

In each 90-minute lesson, first, the students take quizzes which are ten four-choice questions in most cases on Blackboard. The students and teachers can confirm the level of understanding of e-learning content. Then, they review the part they do not understand and retry quizzes. Figure 2 shows quizzes on Blackboard to check understanding of prior learning.



Figure 2. Quizzes carried out at the Beginning of each lesson

The main part of each lesson is works relate to e-learning contents, for example, work for discussing information moral (Figure 3) and work for suggesting new information system to improve daily life (Figure 4). These works contribute to enrich their understanding of contents of learning.



Figure 3. Work for discussing informational moral using KJ method



Figure 4. Presentation of suggesting new informational system to improve daily life

Results and Discussion

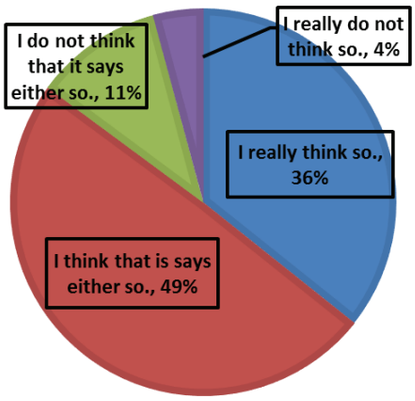
We made a survey for all students of the first grade at Sasebo College in 2018 to measure effectiveness of Basic Information security. The circle graphs in Figures 5-7 show the results of the survey. We examined the survey from three points of view.

The first is that we evaluate teaching methods themselves, flip teaching (Figure 5). (a) denotes that 85% of the students think that I think so, whereas the remaining 15% do not think so. (b) shows that more than 90% of the students think that I think so. In (c), almost all students feel satisfied with works in lessons. A lot of students are satisfied with flip teaching, whereas it is seen that small number of students want to participate in traditional concurrent lessons such as teachers explain students from the beginning to end of lessons.

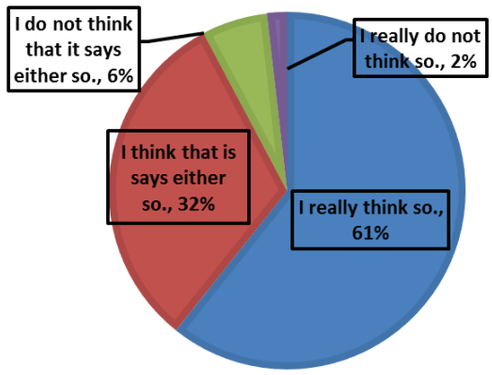
The second is an education using Blackboard (Figure 6). (d), (e) and (f) denote that about two third or more than two third of students think that I really think so. It seems that it is useful to utilize Blackboard.

The third is whether students achieve three goals of Basic Information Security (Figure 7). (g), (h) and (i) show that more than 90% of students feel to achieve three goals. Moreover the number of students I really think so is roughly equal to that of students I think that is says either so.

(a) It is easier to understand by taking lessons using flip teaching than concurrent ones.



(b) You can confirm how much you understand e-learning contents by carrying out quizzes at the beginning of lessons.



(c) When you study a lot of works in lessons, you can acquire the knowledge you studied e-learning before lessons start.

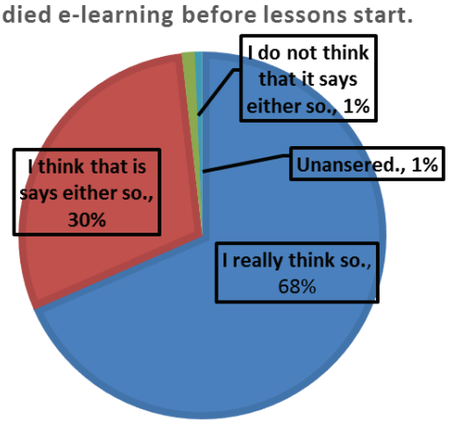
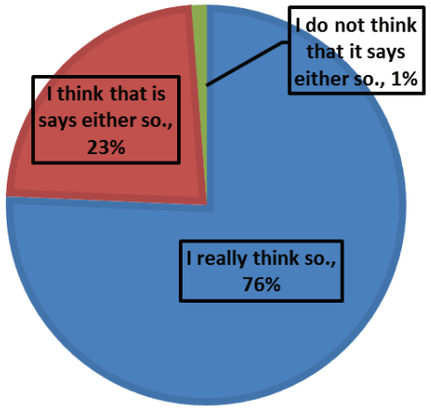
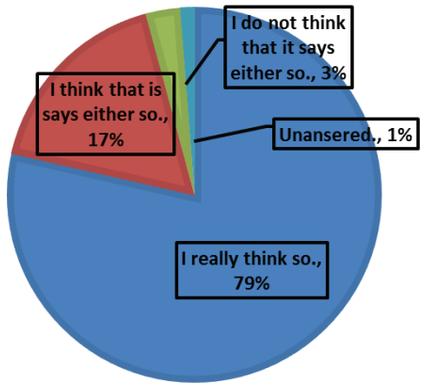


Figure 5. Results of the survey from the view point of flip teaching

(d) It is easy to take lessons to cheak cource contents on Blackboard at any time.



(e) It is easy to check results of quizzes and homework on Blackboard at any time.



(f) It is easy to study for regular examinations to utilize Blackboard.

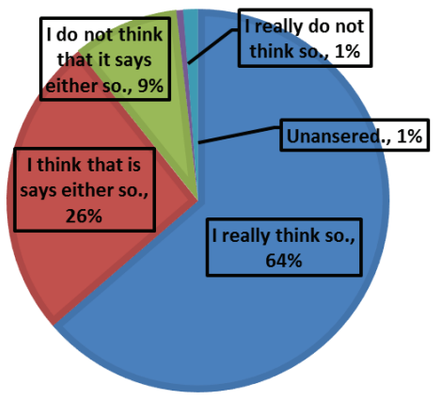


Figure 6. Results of the survey from the view point of using Blackboard

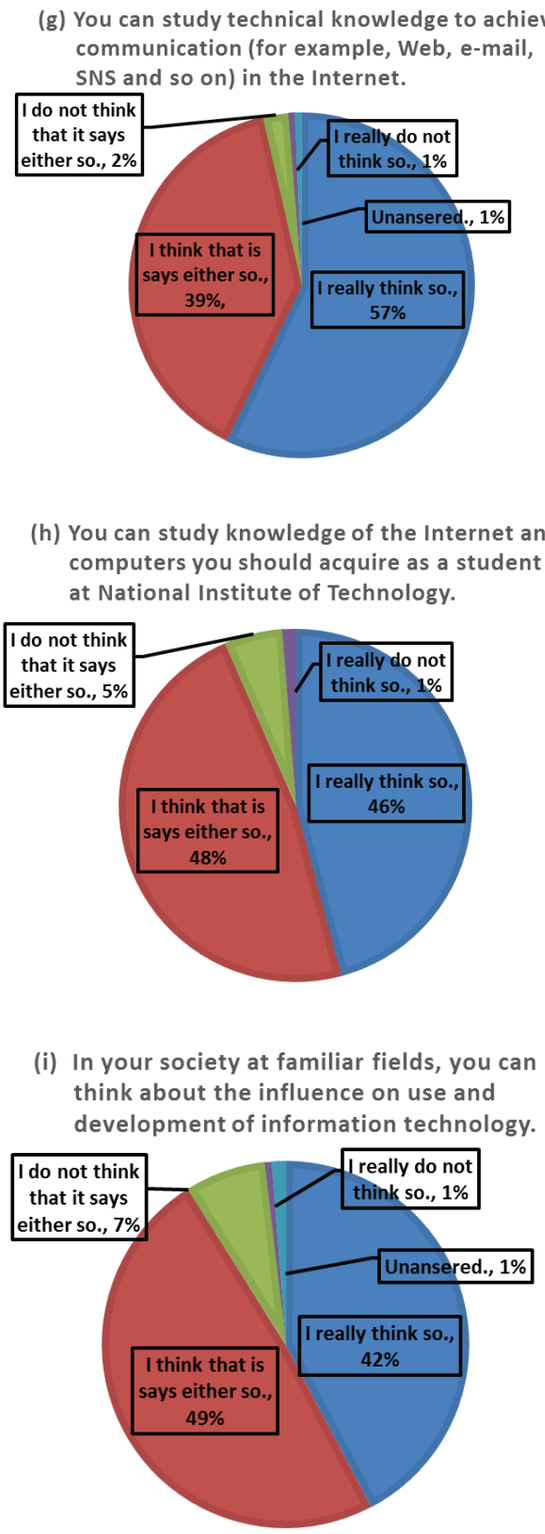


Figure 7. Results of the survey from the view point of goals of Basic Information Security

Conclusions

At National Institute of Technology, Sasebo College, a new subject was established in 2017. It is called Basic Information Security. In this subject, flip teaching is used on Blackboard. More than 85% of all students are satisfied with flip teaching and acheive goals of Basic Information Security. There are a lot of positive answers of flip teaching, technology enhanced learning, and the effect of information security shows.

On the other hand, it is seen that small number of students want to participate in traditional concurrent lessons such as teachers explain students from the beginning of lessons. It is assumed that flip teachong is not completely perfect. There are needs to help students which are not adapted to flip teaching individualy.

Moreover in the future we are going to expand the method of Basic Information Security to other colleges at National Institute of Technology. There seems to be classes to teach information literacy for first grade in every colleges at National Institute of Technology. We have advertised the method of Basic Information Security to introduce in various regions.

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PRACTICING EFFECTIVE CLASSROOM MANAGEMENT USING YAMMER IN OFFICE 365®

Eikoh Chida*

* Division of Informatics and Computer Engineering,
Department of Engineering for Future Innovation,
National Institute of Technology, Ichinoseki College, Japan

*Email chida+isate2018@g.ichinoseki.ac.jp

Abstract

Office 365®, which is the brand name for a software-as-a-service-type cloud service provided by Microsoft®, offers service subscriptions for productivity software and related services. Since 2015, service subscriptions under the ‘‘Microsoft Education Alliance Agreement’’ have allowed all users in KOSEN to use Microsoft Office apps on various operating systems, and have also provided email, storage, and social networking services (SNSs).

I decided to utilize the SNS ‘‘Yammer’’ with the aim of managing my classroom effectively. Access to a Yammer network is determined by a user's Internet domain; therefore, it is easy to construct a private communication environment. In addition, it can be used not only through a web browser on a PC but also on mobile terminal-dedicated applications on smartphones and tablets. I regard Yammer as a very easy and convenient service for students who are familiar with mobile communication devices.

This report covers the practice of effective classroom management using Yammer. The practice had the following features. First, using the document posting function, I issued an announcement about assignments for daily duty, cleaning duty, and so on. Then, the students posted comments, instead of keeping a class diary. Second, using the file attachment function, I distributed electronic documents such as application forms and class schedules. Further, the students posted pictures of school events. Finally, using the private message function, I could make contact with students, for example, to call them to my office for an interview. In addition, using Microsoft Forms, I made a questionnaire survey regarding the laboratory students wished to enter, their desired career after graduation, and so on. Once signed in to the class's Yammer, the student would immediately see the feed, which notified them of any activity and of important posts by those in the class.

I believe that it will be relatively easy for various types of schools to adopt Yammer for managing classrooms effectively. In this paper, I detail my activities and present matters for the consideration of schools wishing to use this cloud service in the future.

Keywords: *classroom management, information and communications technology (ICT), social networking service (SNS), Office365, Yammer, questionnaire survey*

1. Introduction

Our college aims to cultivate global, sensitivity-rich, creative, and practical engineers working in the global society. In 2017, to respond to recent changes in society and the industrial arena, we reorganized four former departments into one department consisting of four major divisions with seven courses. We put our ardor for developing human resources to lead the future of mid-northeast Japan into the name of our new department, ‘‘Department of Engineering for Future Innovation.’’ In this new program, 2nd-grade students will select one of four major divisions, “Mechanical and Intelligent Systems Engineering,” “Electrical and Electronic Engineering,” “Computer Engineering and Informatics,” or “Chemical Engineering and Biotechnology” that is a good fit for themselves after receiving first-year common education.

Prior to the reorganization, in 2007, we had revised a curriculum and established a technical subject, namely Information and Computer Literacy (ICL) [2], in which all first-year students take lectures using the same syllabus in mixed classes composed of students from all technical backgrounds. By innovating the ICL course, we tried to enrich the quality of computer and information education and expected that various educational benefits would develop. Through the ICL class, all first-year students learn ICT skills. As stated above, we are engaged in our ICT education, including making good use of smartphones.

In 2015, service subscriptions under the ‘‘Microsoft Education Alliance Agreement’’ allowed all users in KOSEN to use Microsoft Office apps on various operating systems and also provided email, storage, social networking services (SNSs), and so on. Specifically, Office 365 A1 Plus Licensing has been

provided since 2015, and then Office 365 A3 Enterprise Mobility + Security E3 was provided since 2017. This means that many apps in Office 365 and services are available for all of the faculty and students in our college free of charge.

In this context, I took the opportunity to be in charge of a 5th-grade class in 2017 and decided to utilize Office 365, specifically the SNS ‘‘Yammer’’ and ‘‘Microsoft Forms’’ in Office 365®, with the aim of managing my classroom effectively.

In this paper, I describe contents of our activities and their background in Section 2. Then, we also describe the effects and features in Section 3. Finally, in Section 4, I conclude my paper with a focus on the possibility of various types of schools adopting Yammer for managing classrooms in the future.

2. Materials and Methods or Pedagogy

In this section, I provide a report of the background of adoption and examples of utilization of the SNS ‘‘Yammer,’’ with the aim of managing my classroom effectively.

2.1 Yammer

Yammer is provided as a service in Office 365 and is characterized by a timeline, file sharing, and private messages, similar to Facebook or Twitter, while it also allows for social interaction in a limited environment such as a school class. In addition, it can be used not only through a web browser on a PC but also on mobile terminal-dedicated applications on smartphones and tablets.

I regard Yammer as suitable for keeping up with changes in groups that require interaction by my students who are familiar with mobile communication devices. This report covers the practice of effective classroom management using Yammer. The practice had the following features.

A) Document posting function (Timeline)
I issued announcements on the timeline as follows.

- [Update/Announcement]
  - ➢ Announcements from a class teacher (including announcements from the Office of Academic Affairs)
  - ➢ Assignments for daily duty
  - ➢ Assignments for cleaning duty
  - ➢ Group photos posts of on-campus events,
  - ➢ and so on



Fig. 1. Posted Comment (Class Diary)



Fig. 2. Posted Completion Reports of Cleaning



Fig. 3. Posted Group Photos (Celebration Party)

Note that a student whose turn it was on day duty had to post comments, instead of keeping a class diary, and a student whose turn it was on cleaning duty had to post that the task was completed (see Figs. 1&2). Further, the students posted pictures of school events (see Fig. 3).

- [Poll]
  - ➢ I conducted a simple questionnaire about changing the seating arrangement several times a year (see Fig. 4).



Fig. 4. Results of Questionnaire about Changing the Seating Arrangement

- [Praise]
  - ➢ I posted praise to students who won prizes in various contests(see Fig. 5).

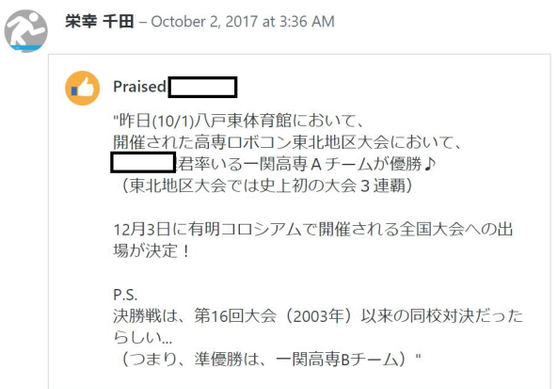

Fig. 5. Posted Message Praising Student (Regional tournament of KOSEN Robot Contest)

B) File attachment function (File Sharing)
I distributed electronic documents, along with various announcements, such as on-campus documents, application forms, class schedules, and photos (see Figs. 6&7).



Fig. 6. Posted Document on Graduation Ceremony Timetable



Fig. 7. Uploaded File List

C) Private message function (Private Messages)
I could make contact with students, for example, to call them to my office for an interview.

Thus, once signed in to the class's Yammer, students would immediately see the feed, which notified them of any activity and of important posts by those in the class.

2.2 Microsoft Forms

Microsoft Forms allows for the creation of customized documents that can be assigned to a student and results that can be collected and analyzed. Once I create the form, I can share the form or assign it only to my class's students.

I made various questionnaire surveys for my students as follows.

- Laboratories students wish to enter(see Fig. 8)
- Desired careers after graduation
- Their desired schedule for teacher and parents meeting
- Attendance checking at on-campus events

- Their strengths, interests, certified qualifications, future dreams, and so on, for my writing a cumulative guidance record
- Opinion on adopting Yammer as a classroom management tool



Fig. 8. Questionnaire Survey about the Laboratories Students Wish to Enter

3. Results and Discussion

In this section, we review the effects and features concerning the adoption of Yammer in Office 365 as a classroom management tool. My activities are described in the previous section, while the class that I am in charge of was organized by 5th-grade students, final-year students in the department of electrical and computer engineering. A final-year student class has the following feature. The number of courses they take in their classrooms decreases; on the other hand, the amount of graduation research they conduct in their laboratories increases. Therefore, it tends to be difficult to contact my students directly in their classroom. For this reason, I decided to make use of Yammer with the aim of managing my classroom effectively.

First of all, providing a "Portal Site" using Yammer can reduce my operation cost as a homeroom teacher; namely, Yammer is an effective service for various announcements and communications. I believe this is both a feature and a merit.

Another reason why I adopted Yammer is because I am often out of my office on meetings or business trips, and it is hard to ensure sufficient time to contact my students.

Each effect and point of attention is described below in detail.

3.1 Yammer

A) Document posting function (Timeline)

I can contact my students from both on-campus and off-campus at any time efficiently and effectively. On the other hand, my students can receive my notification as needed.

B) File attachment function (File Sharing)

There is no need to print for me, so I can save printing paper, time, and trouble printing documents. From the students' point of view, they can take a look at documents uploaded to Yammer at any time without losing them. If they need to print something out, they can do it by themselves.

C) Private message function (Private Messages)

For my part, I do not have to go to their classroom or their laboratory to directly contact or call them. In addition, I can keep the record of that. Then my students can notice my message immediately.

3.2 Microsoft Forms

Taking and tallying a questionnaire survey electronically is very convenient, compared to those in the print medium. Besides, I can share the form only to my class's students with the user authentication function for Office 365. Once my students complete the form, I can come back into forms and see the responses immediately.

There are several topics of discussion, as follows.

It is generally effective as a method of announcement and contacting my students. I believe this is because Yammer is also provided as an application on smartphones, and it is easy for students to notice a notification on their smartphone's screen. It is noted that all the students in my class are in a Yammer group and have their smartphones, but it could not be confirmed that all the students made use of the Yammer application on their smartphones. This means that a few students might not check the timeline.

However, I am not sure whether interactive communication through Yammer can be achieved sufficiently or not. Though I instructed students whose turn it was on day duty or cleaning duty to post comments, instead of keeping a class diary, or to post that the task was completed, students did not post much more than those posts (see Fig. 9). To activate a class, it is desirable to have more interactive communication, not only as teacher-to-student but also as student-to-student. In fact, it seemed that private groups on LINE were utilized only among classmates.

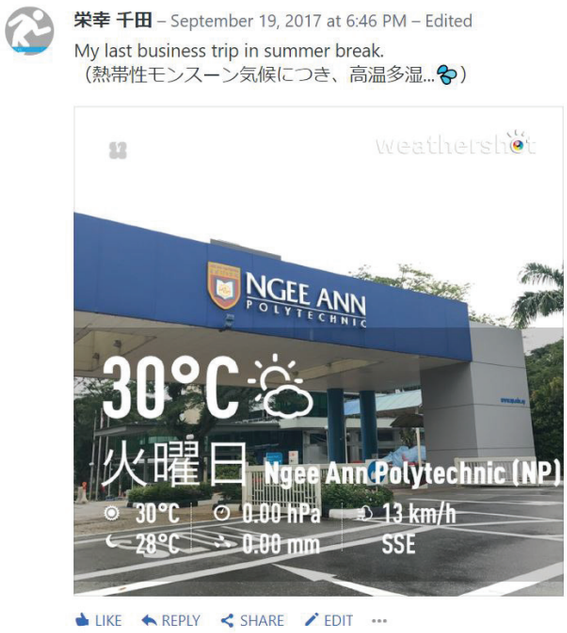

Fig. 9.
My Post as for ISATE 2017
(No one responded to my post…)

Next, the point to be discussed is the case in which we want to share information with faculty, as well as my class students. For example, an announcement of a presentation of graduation research should be common knowledge among my class students and teachers in our department. In such cases, I had to use two other ICT tools, Moodle and Gmail. Fortunately, in our college, Moodle has been put into service a decade ago with the aim of supporting classes [3]; all students and teachers use the system in their daily school lives. Moreover, Gmail is adopted as an emergency contact method for our students [4]. By creating a unique mailing list for each class in each grade, we can contact not only individual students but also an entire class by email. In daily school life, it is mainly used for announcements from a class teacher, teachers in charge of class subjects, and so on. Thus, I utilized ICT tools as complements to Yammer.

Finally, I review students' opinions on adopting Yammer as a classroom management tool. There are many affirmative responses, such as convenience for making contacts, easy to take information, appreciation of class teachers trying hard to keep everyone informed and on task, and so on. Here, I must mention the opinion of the minority. In contrast, a few students said that Yammer is a bother to check, so Gmail is better, and that they wanted to keep a class diary in a paper medium

4. Conclusions

As shown by the above, Yammer in Office 365 can be comparatively easily adopted and utilized for various kinds of schools other than KOSEN, and also adopted for any educational activities other than class management. However, I am of the view that the several issues mentioned in the previous section should be taken into consideration when adopting these services.

I continually improve the method of managing these services, including other SNS-like services such as Microsoft Teams by utilizing PDCA cycles. For instance, I now utilize Yammer for managing my laboratory (see Fig.10).



Fig. 10. Yammer Group of My Laboratory

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E-ASSESSMENT OF COMPUTER PROGRAMMING

Rh. Gwynllyw*,[a] and J. Smith[b]

[a] Dept. of Engineering and Mathematics, University of the West of England, Bristol, UK.
[b] Dept. of Computer Science, University of the West of England, Bristol, UK.

*rhys.gwynllyw@uwe.ac.uk

Abstract

This paper demonstrates how we have used Dewis, an algorithmic open source e-assessment system, to automatically assess programming skills, in particular, in the C programming language. Teaching and assessing programming skills is challenging; prior to the implementation of this automatic assessment system, computing assessments were marked manually and this proved unpopular with students and academics due to the delay in marking and providing feedback. This new approach enables students to submit their computer code online through a link on their Virtual Learning Environment. From a student's perspective the marking process takes a matter of seconds before the student is provided with a mark and feedback. A number of pre-submission and post-submission checks are performed on the student's supplied code. These are essential to ensure that the student's code satisfies certain operational and security requirements before running on the system. Typically, the e-assessment system executes the student's supplied code a number of times with different input sets and the student's code is evaluated based on their code's resulting output. Prior to execution, the student's code may be augmented by Dewis-specific code to facilitate deeper analysis of the student's code. The analysis of the code's output enables the system to respond to the student's submission with 'intelligent feedback'. This feedback explains to the student, where appropriate, reasons for their submission not scoring full marks. There are also in-built detectors for 'common student errors' which, when triggered, further enhances the intelligent feedback. In their first few weeks at UWE Bristol, students are presented with a number of mini-tasks involving assessing C competencies with Dewis. These tasks are purely formative, support is given to students in computer lab sessions and students may submit as many times as they wish. Later on in their first year, students are given more significant programming projects (e.g. the n-Queens problem, path-finding problem), the assessing of which is summative. Results show that this innovative work is making a positive impact on students.

Keywords: *C programming, e-Assessment, intelligent feedback*

Introduction

The use of e-assessments in the Department of Computer Science at the University of the West of England (UWE) is well established both for formative assessments and for examinations. These assessments have been designed to primarily assess the students' knowledge of computer science principles as opposed to computing in practice. Further, with most of these assessments being of the form of multiple-choice questions, there is limited scope for 'intelligent feedback' in response to the students' input. We do make extensive use of Blackboard 'tests', which provide a range of different question styles, and considerable scope for bespoke feedback attached to different correct/incorrect responses. These have proven highly successful for summative and formative assessments, and provided useful cohort-level analysis of different questions. Some of this work was supported by external funding (e.g. UK Higher Education Authority grants) and these resources have been made available for sharing by the community. However, assessing more than simply 'recall' requires considerable expertise in question design to test higher level skills in problem analysis and reflection. The success of these e-assessments led to the consideration of whether e-assessments could be applied to test students' ability in the practice of computer programming. At the start of this project we undertook a review of available systems for providing automated teaching and assessment of coding. While there is a body of materials available for interpreted languages such as Python (such as the courses in Codeacademy.com) there was nothing available for languages which require code to be compiled and run (e.g. C, Java/C++) because of the security implications and difficulties in providing bespoke feedback related to specific learning activities.

In previous years, the summative assessment of computer programming in the module Artificial Intelligence on the Computer Science award at UWE, took the form of students submitting computer program solutions to set assessments via a VLE with the academic marking each submission by running the code and assessing the output. The main disadvantage of this process was, with a large number of student

submissions, the turnaround time it took for the academic to mark the submissions and provide feedback. To some extent this can be ameliorated by arranging for students to provide in-class 'walkthroughs' of their code, which provides great scope for immediate feedback and discussion, but this creates significant timetabling issues on large modules and it can be hard to automatically capture face-to-face feedback for students to reflect on later.

With UWE having their own algorithmic e-assessment system (Dewis) running on a Linux web-server, it was decided to develop that system to e-assess these computer code submissions.

Dewis is an e-assessment system created in 2006 at the UWE's Mathematics department (Gwynllyw and Henderson, 2009; Dewis Development Team, 2012). The primary purpose of the system was to provide algorithmic and intelligent e-assessments in numerate based subjects. In addition, the system was designed to be data-lossless so that all data for all assessment attempts is kept on the system's server. The question-editing mechanism on Dewis allows significant flexibility in the design of the question and includes coding the assessment on the server side (primarily using Perl) and on the client side (using html, css and javascript). The Dewis system is used extensively at UWE Bristol, and its satellite colleges, across several subject areas including Mathematics and Statistics, Engineering, Computing, Accounting, Science, Nursing and Business Studies. It is also used at other UK HEIs. The system is designed to support both formative and summative assessments and also has an 'examination setting' designed specifically for e-assessments in controlled conditions. The success of the system, its flexibility in the question authoring and its data-lossless storage made Dewis a natural consideration for hosting the e-assessment of computer programming at UWE. In addition Dewis had already been used to communicate with other programming environments. For example, Dewis has used system calls to Python/Sympy to implement a computer algebra system and it has also been used to interact with R to produce statistics e-assessments (Gwynllyw, Weir, and Henderson, 2015; Weir, Gwynllyw and Henderson, 2015).

The Dewis system was modified to allow for students to submit computer code, concentrating initially on submissions of the C-programming language. Two projects were started in 2015 which we will refer to as project-F (formative) and project-S (summative) for the purposes of this paper.

Project F (Formative e-Assessment)

Being able to program in C is not an entry requirement of the Computer Science award at UWE but it is highly desirable that students learn the basic C programming syntax at an early stage. Depending on the award taken, students at UWE may learn C (BSc Robotics), Java (BSc Computer Science) or C++ (BSc Games Technology), but in the early stages C is a good choice as it avoids the issues of object orientation and the syntax is common to these (and other) languages.

Retention on Computer Science and related awards is a national problem and, although UWE does well in this regard compared to other UK HEIs, it is still highly desirable to increase the retention rate. One contributory factor to low retention is that some students have particular problems with programming and it was recognised that such issues need to be identified and addressed as early as possible. Further it was recognised that a large number of computing students are activist learners and thus it is desirable to support their learning by supplying formative computing tasks to aid their learning. Providing such computing tasks with manual marking and fast feedback is infeasible due to the large number of students and the lack of staff time on the award. In a previous year, first year students were invited to email their tutor with their solutions to a small programming task. Take-up on this invitation was high which lead to excessive delays in feedback and a negative student experience.

Following a 'works in principle' period with the e-assessment of C computer code, it was recognised that automated assessment could support a 3-week introductory course in programming starting in induction week. This course was aimed to remove some of students' fears about programming by enabling a sense of recognised achievement. It was also aimed at facilitating a rapid understanding of basic C programming syntax, especially in the use of conditional statements and loops. The course provided computer laboratory sessions but students were told they also had to commit a significant amount of self-study hours (the pace of delivery was aimed to require approximately 4 hours per week) and to become used to the habit of using other resources such as the Faculty's drop-in *'espressoProgramming*' sessions. The use of e-assessments accommodated for the different work patterns that students employed and provided instant feedback on the students' submitted work, thus enhancing the student's experience of the course.

An important part of this project was the monitoring of student engagement. Students' engagement with these e-assessments was monitored through the e-assessment system's performance reporter; this monitoring was in addition to the traditional engagement measure of attendance recording. Non- or low-engagement students were emailed directly by the module team in addition to passing engagement information on to a dedicated retention monitoring team.

With regards the e-assessment's specific contribution to this short course, eleven formative tasks were identified by academics to teach basic computer programming constructs. These C-programming tasks were as follows:

Task 1: Print out a specified string and then wait between 5 and 10 seconds, and then terminate. This assesses the ability to combine and modify simple code snippets.

Task 2: Print out a specified string and then wait for an input character from the user. Echo that character back

and terminate. This assesses simple i/o and the use of 'print and pause' constructs useful in debugging.

Task 3: Perform the addition of two floating point numbers that are read interactively during run time from the keyboard (via scanf). Output the resulting addition if both the two inputs are numbers, otherwise output 'invalid input'. This assesses simple interactive conditional flow.

Task 4: Same as Task 3 except that the inputs for the program are taken at the start of the run process - provided via the command line (via arg).

Task 5: Similar to Task 4 except the requirement is for the calculation of the quotient of two floating point numbers. If the second number is a zero then output 'invalid input – division by zero not allowed'. This assesses simple conditional flow.

Task 6: Read an operation from the command line of the form $x \circ y$ where x and y are expected to be numbers and $\circ$ is expected to be one of '+', '−','×' or '÷'. If the input is not as expected, then output 'invalid input'. If the calculated output is not a number then output 'invalid output'. Otherwise, output the numerical value. This assesses more complex conditional flow (e.g. embedded *if* or *switch* constructs).

Task 7: Modify Task 6 to include the option of a 'running total' whereby the code accepts, as input, a file containing a sequence of operations of the form $x \circ y$. In addition, if the character p appears in the place of an expected number, then the p assumes the number in the immediately preceding calculation. This assesses the use of mechanisms for storing state/history.

Task 8: Similar to Task 7 but the reading of the input and its validity testing is done using a call to a function called 'read_and_validate_input'. Further, the implementation of the numerical operations should be done using calls to functions 'addition()', 'subtraction()', etc., implemented using signatures supplied to the student. This assesses the use of modularisation and code re-use.

Task 9&10: Print out an 8×8 checkerboard containing o's and x's generated using two nested 'for' (**Task 9)** or 'while (**Task 10**) loops with each execution of the inner loop producing exactly one character. These two tasks assess the use of iteration.

Task 11: Read a string via the command line and output eight strings on different lines, with each output containing the input string but with the final character replaced by the loop count (1..8). This assesses the use of more complex data types such as arrays.

It was an essential requirement of the construction of these 11 e-assessments that the student experience was a positive one. This included consideration to the ease of the student submitting their solutions and the efficacy of the feedback in the case of a student's submission being rejected (e.g. their code containing illegal content or not compiling) or their submission being incorrect in that their code does not satisfy the assessment criteria.

The process of submission of C-code involves the student accessing the relevant module's web page on the university's VLE and, from there, accessing the assessment task's specific Dewis page via an LTI link (such a link allows for Dewis to pass back the student's attainment mark back to the VLE's Grade Centre). The Dewis system then prompts the student to submit their C-code. Such a prompt, for Task 1, is shown in Figure 1.

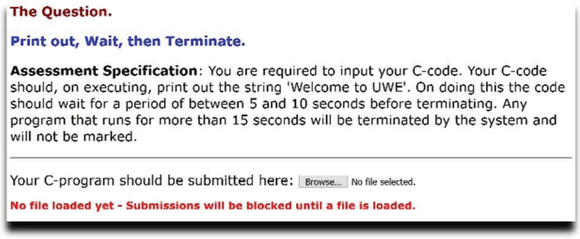

Figure 1: Dewis prompt for the student to submit their code for Task 1.

The submission process involves Dewis eventually running the student's C-code on the Dewis server. This action has significant security implications and hence there are a number of checks the Dewis system makes to ensure that the student's code cannot be malicious. A result of this is that there are a number of commands that Dewis prohibits from being submitted in the student code. These commands include, for example, potentially malicious system calls and the inclusion of undesirable header files. As part of ensuring a positive student experience of the process, these security checks are made on the student code when they link their C-code to their web browser. That is, these checks are made prior to the student submitting their code to the Dewis system. On detecting prohibited content, the student is informed immediately that their submission cannot proceed together with the reason for the barrier. Text on the VLE page for each task provides more help in these cases.

Having submitted the code, the next stage is for Dewis to compile the code. If the student's code fails to compile, the system will echo back to the student the compilation error. In the case of a common compilation error being triggered, the system will aim to supply suggestions to the students to address the error. A compilation error can be construed as detrimental to the student experience and, in the case of a student preparing their code on a different operating system to that of the Dewis system (Linux), a compilation error may not have been anticipatable by the novice programmer. Because of this, most Dewis assessments of this form have an associated 'compiler check' assessment whereby students can check their programs for compilation on the Dewis server without foregoing an assessment attempt.

For some of the assessment tasks, prior to executing the student's submitted code, the Dewis system will

augment this code with additional code to facilitate the marking process. For example, for Task 9, augmented code is used in order to ensure that the correct number of nested for-loops are used in the construction of the required output.

An example of the Dewis system detecting a code submission on this assessment task not satisfying the criteria is given in Figure 2. The feedback informs the student as to the reason why their submission was deemed incorrect. In this example, the student used only one for-loop (1..8) with each execution producing complete lines in the grid ('oxoxoxox' or 'xoxoxoxo').

Following the feedback in Figure 2, this student subsequently submitted an entry which was unaltered except that it contained a 'null' inner for-loop (1..8) which produced no output. Again, the Dewis system informed the student that their submission did not satisfy the criteria. This later student submission was presumably an attempt to trick the Dewis system. It was encouraging to note that the student did eventually submit code that satisfied the task's requirement.

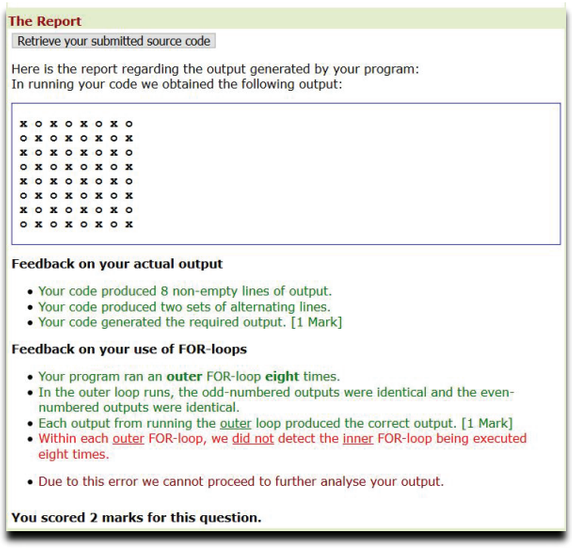

Figure 2: Example feedback for Task 9 where the student's submission did not use nested for-loops to generate the required 8 × 8 grid.

In Figure 2, we also show that, in supplying the student feedback, the system also provides a link to the student's original submitted code. This feedback is available to students at any future time via the VLE/Dewis link to the assessment so that students may revisit their past submissions.

On executing the student's code, certain system limiters are applied to ensure that the student's code does not consume an excessive amount of the system's resources. For example, the student's code is terminated if it consumes excessive CPU or memory, or simply does not terminate within a reasonable period of time. In such cases the student is informed of the reason for their submission not being suitable for marking together, where possible, with suggestions as to how to address this issue.

Impact

Student uptake on these tasks has been encouraging. For example, Table 1 shows the uptake results for the 2017/2018 academic year.

Task #	# students	# attempts	# correct
1	189	535	171
2	187	613	163
3	168	836	152
4	151	796	127
5	140	577	111
6	122	783	84
7	64	290	37
8	35	148	17
9	71	180	59
10	88	454	70
11	32	135	17

Table 1: Engagement statistics for the eleven summative tasks. For each task, the 2nd column lists the number of students that submitted their C code, the 3rd column lists the total number of submitted attempts, the 4th column lists the number of students who fully achieved the tasks' criteria.

Since these tasks were formative, there was no limit as to the number of attempts for a student to attempt these tasks. In most cases the students had several attempts at each task, seeking targeted help in response to the system's feedback and worked through their code to eventually produce code that met the assessments' criteria. For example, from Table 1, we see that 171 out of the 189 students that attempted Task 1, succeeded in submitting C-code that satisfied the task's requirement.

This level of engagement is mirrored by the volume of emails, and hence staff-student interactions generated. Notably, as we have refined the system over 2-3 years, the volume of emails, particularly regarding later tasks, has been reduced without the patterns of engagement changing. The process of identifying recurring issues in emails and error logs, and then amending the system to recognise and respond to those cases, has been successful in moving from manual to automated feedback. The system is transparent enough for students to 'learn how to learn' – taking more time to use the automated feedback.

The drop-off in the number of submissions reflects to some extent the different rates of progress that students were making on their 'standard' programming modules. Anecdotal evidence via students emails and anonymous end-of-module feedback also suggests that some students engaged less if they felt that the system was 'overly restrictive or strict' in terms of the constructs allowed and the way that exact output formats are required (e.g. use of capitalisation, spaces etc.). Capturing this feedback has been invaluable for staff, and we now pay considerably more attention in-class to pointing out that the days of the '*lone developer*' are largely over, and that all code should be designed for a specific purpose and tested to meet specific

requirements and interfaces. Being able to pull specific (anonymised) examples of code that *'looks right but does not meet the specifications'* is invaluable in providing concrete examples of more abstract ideas.

These formative tasks are now being used on several different modules across various awards and being used in level two to help students refresh their C-skills as a form of pre-requisite test.

Anecdotal evidence of the success of this was an improved performance in the summative assessments discussed in the next section. Since the introduction of this system, tutors in-class have noted a significant increase in the proportion of students discussing algorithmic issues in more advanced problems as opposed to programming syntax issues. E.g. students were more comfortable with writing out algorithms in pseudo-code to discuss functionality as opposed to syntax.

A highly positive outcome has been that by the fourth week of term we are able to get students collaborating in-class to work on pseudocode designs and mechanisms for simple algorithms – valuable learning activities that had been not previously been possible. Familiarity with basic programming constructs means that, from far earlier in the module run, lectures can include pseudo code and code snippets to demonstrate search and machine learning algorithms. For many of our students this helps demystify the abstract definitions.

Other staff who used some of the first activities during induction week have also commented that these provided a useful 'icebreaker' mechanism to get students collaborating and problem-solving.

Project S (Summative e-Assessment)

Dewis was also used for the e-assessment of C-programs in a summative environment in the module 'Introduction to Artificial Intelligence', part of the Computer Science award. There are two such assessments on this module and initially they were quite low stakes (each accounting for 12.5% of the total marks for the module). Although the two assessments seem quite different, they are closely related in that they both require the student to produce C-code that solve problems involving search algorithms. The two problems are:

- the 8-Queens problem, solved using Depth-First Search;
- the shortest path problem (SPP) using Dijkstra's algorithm on a map modelled by a square grid.

These two problems are both 'search' problems, and use a common code framework (written by the academic) provided to the students and used for earlier tutorial work. One of the intended learning outcomes is to see how a framework can be used to (i) implement different algorithms and (ii) tackle very different problems, with only very minor changes (typically a few lines).

In previous years, students were given a tool written in Netlogo that involved PacMan searching a maze (Smith, 2009). Switches allowed students to choose policies to apply whenever a junction was made, and these effectively implemented different algorithms. The students were then asked to write down their results and to submit their solutions via the VLE for manual marking. However, while providing a nice visual interpretation of the effects on a toy problem, the module leader wanted the students to implement the algorithms in actual code with the aim of ensuring a better understanding of the functionality of the algorithm.

For the assessment of these search algorithms, the Dewis marking process will be two-fold, namely:

- the solution is checked for correctness;
- the number of candidate solutions considered is consistent with the method of search.

The latter criterion was included to ensure that the student's code implemented the correct method of search. Full marks are awarded to the student's submission if, and only if, both these criteria are met.

For both types of problems, the student's code was executed a number of times for different inputs. The inputs for the two problems are as follows:

- 8-Queens: the position of the Queen in the first row of the chessboard;
- SPP: the start and end point of the path on a square grid, together with the location of the obstacles on the grid.

In the case of the 'number of candidate solutions' considered being incorrect, the marking algorithm would attempt to identify a pattern in the number reported by the student's code. For example, some students' code consistently produced a numerical value one higher than the correct solution. In such a case, the student would be informed of this, together with stating common reasons that code consider one more candidate solution than is required.

The two current metrics effectively perform black box testing of the supplied code, therefore test problems have been designed to ensure that different algorithms give different results. For the next academic year, the code has been further refined to perform 'white-box testing', via checking of values that student's code passes as parameters to supplied functions.

For these summative e-assessments, the student was only required to provide the 'main' function call for solving the problem. As part of the student's development of their code, their code would be built with pre-supplied code (written by the academic), and they are told what a subset of the intended results should be (i.e. for one starting queen position or map).

The student would submit, to the Dewis system, only the 'main' part of the code. That is, the pre-

supplied code that is part of the build, already resides on the Dewis system. The version that resides on the Dewis system keeps track of the number of candidate solutions considered in the search process as well as the final solution obtained in the search process. As such, the Dewis system does not depend on the student's code telling it the solution nor the number of candidate solutions. This ensures that the correct solutions are not obtained artificially (e.g. hard coded in the student code).

Results

Quantitatively, any difference in the coursework pass rates is smaller than the annual fluctuations seen on any course. Qualitatively, feedback from students has been that they appreciated the opportunity to submit in their own time – giving them the chance to manage different demands on their time safe in the knowledge of the marks they would get.

Following the success of the phase one project, the assessment regime of the module has been changed to incorporate a further two exercises (again each worth 12.5%). In the third task, students submit a text file containing the knowledge base for a chatbot in AIML. The Dewis system marks and provides feedback by running a java programme that exploits the file handling and output-interpreting mechanism developed. Students are told the 'questions' in advance, and marks are awarded according to how well their knowledge base exploits different language features.

The final task requires students to submit a C code implementation of the machine learning algorithm of their choice, which is assessed via its predictive accuracy on a number of datasets designed to test aspects such as handling duplicates, class imbalance etc.

The impact of these two more 'open-ended' pieces of coursework, where competition has been encouraged, has been incredibly positive. In both the last two years an 'arms-race' has developed with students contributing specific ideas to discussions of how the tests could be made harder/ more discriminating – via different chatbot questions, or datasets with different characteristics. In the machine learning task some students implement simple algorithms such as K-nearest neighbours, but we have seen example of Bayesian networks, Rule Induction algorithms, and Multi-layer Perceptrons being submitted.

As we have said previously, many of our students self-identify as being predominantly activist or pragmatist learners and many are more likely to submit credit-bearing work. Dewis' '*instant marking and feedback'* means that the depth of insights displayed during in-class discussions about the merits of different approaches has been raised to new levels by the provision of learning activities more suited to our students' styles of learning.

Discussion

The success of the approach described in this paper, which allow students to "self-learn" programming skills, has led us to develop the system further. Competence in programming is desirable in many academic disciplines, not just for Computing students. Indeed Bond (2018) recommends that computer programming becomes a core part of mathematics degrees. In the forthcoming 2018/19 academic year, the e-assessment of computer programming will be extended to Level 3 Mathematics students using Python on the Numerical Analysis module at UWE Bristol. Students will be required to write numerical methods in the Python programming language and this will be assessed automatically using Dewis.

Previously, a manual marking process was employed for the Numerical Analysis module but the workload involved in processing these student submissions resulted in difficulties in producing appropriate and timely feedback. The cases whereby the feedback was delayed resulted in negative student feedback about the process. The previous deployment of Dewis to e-assess computer code in C means that the development time required for Dewis to e-assess Python was significantly reduced.

The success of this extension to the project will be evaluated using student feedback via the module evaluation process and a comparison of student performance in their programming competencies.

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IN-CLASS E-TESTING OF STATISTICS IN A LARGE COHORT OF DIVERSE ABILITY

I.S. Weir*, D.Rh. Gwynllyw and K.L. Henderson

Department of Engineering Design and Mathematics
University of the West of England, Bristol, UK

* iain.weir@uwe.ac.uk

Abstract

We report on our experience of running in-class e-Tests for a new Level 1 Business Decision Making module taken by 800 Business School students at the University of the West of England (UWE Bristol). The module comprises a one semester course covering statistical methodology in far greater depth than had been taught previously and modernised to include analyses using the statistical software SPSS rather than by hand calculations. The syllabus constituted a challenging amount of material to cover, especially since the student cohort was a large, diverse group of non-mathematicians.

The controlled conditions element of the module's assessment comprises the average mark of the best two from three in-class e-Tests. In each e-Test a student receives their own unique data set to work on and performs a complete statistical analysis of it, using SPSS. We describe how we securely assessed the large number of students over fifteen 50 minute PC classes.

The main learning tools were key skills e-Assessments that provided the student with a random data set to import into SPSS to then appropriately analyse and report on. Repeated use of these would ensure that a student would thoroughly learn a key skill and cover various analysis outcome scenarios, for instance significant or not significant test outcomes. Each key skill e-Assessment has multiple embedded links to comprehensive Help pages that provide SPSS 'how-to' information or output interpretation. This form of support is more targeted and immediate than a student having to refer back to the notes. It also encourages the student to self-learn rather than automatically seek staff help. This allowed the staff to concentrate on giving statistical understanding and interpretation advice as opposed to say wasting time on the mechanics of producing SPSS output.

The e-Assessment system used was Dewis which is a fully algorithmic open-source e-Assessment system which was designed and developed at UWE. It is a completely stand-alone web based system used for both summative and formative assessments. Dewis' ability to communicate with the R programming language greatly facilitates the task of generating bespoke student data and providing answers that match SPSS screen output.

Keywords: e-Test, e-Assessment, Statistics, Dewis, R, SPSS

Introduction

We report on our experience of running in-class e-Tests for a new Level 1 Business Decision Making module taken by 800 Business School students at the University of the West of England (UWE Bristol) and partner institutions (Villa College, Maldives, British College Kathmandu, Nepal and Northshore College, Sri Lanka). The module comprises a one semester course covering statistical methodology in far greater depth than had been taught previously and modernised to include analyses using the statistical software SPSS rather than by hand calculations.

The module covers the following statistics topics, which were taught in the order listed:

- Exploratory data analysis including normality testing;
- One sample t-test & nonparametric equivalents;
- Probability & Decision trees;
- Two sample t-test & nonparametric equivalents;
- Critical Path Analysis & Gantt charts;
- Correlation and simple linear regression;
- Chi-squared tests;
- Time series.

The controlled conditions element of the module's assessment comprises the average mark of the best two from three in-class e-Tests. In each e-Test a student receives their own unique data set to work on and performs a complete statistical analysis of it, using SPSS. The e-Assessment system used was Dewis which is a fully algorithmic open-source e-Assessment system which was designed and developed at UWE. It is a completely stand-alone web based system used for both summative and formative assessments (Gwynllyw and Henderson, 2009; Dewis Development Team, 2012). Dewis' ability to communicate with the R programming language greatly facilitates the task of generating bespoke student data and providing answers that match SPSS screen output (Gwynllyw, Weir, and Henderson, 2015; Weir, Gwynllyw and Henderson, 2015).

The in-class e-Tests are equally spaced throughout the teaching delivery period and prepare the students for the subsequent uncontrolled element of assessment which is a 1200 word report that comprises the statistical analysis using SPSS of a supplied dataset in response to a business question.

Description of the problem or issue

The syllabus presented above constituted a challenging amount of material to cover, especially since the student cohort was a large, diverse group of non-mathematicians. In addition, students were expected to learn how to use SPSS and to gain sufficient competency/understanding of the techniques so that they would be able to perform data analysis when collecting their own primary data in their level 2 research project the following year. Some of the challenges to overcome in designing the way the statistics material was to be taught and assessed were identified as follows:

1. How to teach the students so that they were able to self-learn SPSS;
2. How to securely assess the large number of students over fifteen 50 minute PC classes.

Teaching strategy

The Statistics staff deliver to the students a one hour lecture and a one hour computer practical each week. Business School staff supply relevant context to each of the statistical topics taught through a one hour tutorial per week. The Business School staff were also responsible for the uncontrolled element of the assessment.

The Statistics staff provided notes that covered statistics and use of SPSS and this material was delivered in the lecture. The initial computer practical session concerned the basics of SPSS (e.g. data entry, variable labels, file opening and saving) and the creation of summary statistics, graphics and tables. For this purpose, several bespoke self-learn videos were created so that the students could pause at will and thus work at their own pace. This was deemed necessary due to the wide range of computer abilities amongst the cohort.

From the second computer session onwards, the main learning tools were Dewis key skills e-Assessments. Each use of these provided the student with a random data set to import into SPSS, appropriately analyse and report on. Repeated use of these would ensure that a student would thoroughly learn a key skill and cover various analysis outcome scenarios, for instance significant or not significant test outcomes. Each key skill e-Assessment has multiple embedded links to comprehensive Help pages that provide SPSS 'how-to' information or output interpretation. This form of support is more targeted and immediate than a student having to refer back to the notes. It also encourages the student to self-learn rather than automatically seek staff help. This allowed the staff to concentrate on giving statistical understanding and interpretation advice as opposed to say wasting time on the mechanics of producing SPSS output.

On submission, students are supplied with the correct answer as well as colour-coded feedback on each of their answers. Green indicates that they are correct and red indicates that the answer was incorrect. Access to full and bespoke feedback is important because it has been found that students learn from e-Assessment feedback, using it to perfect their technical knowledge (Greenhow and Gill, 2008).

To supplement the key skills e-Assessments, students are also given pre-prepared word templates which are designed to represent a complete statistical analysis on a specific supplied data set. The templates have the SPSS output removed, numerical values blanked out and inserted multiple choice interpretation decisions to make. Setting it up in this way for students to complete enables them to concentrate on the mechanics of the creation of SPSS output and interpretation of results.

Dewis key skill e-Assessment example

The data scenario for this particular key skill e-Assessment concerns using a 95% confidence interval (CI) for the mean to infer whether the mean IQ of people on a particular medication appears to differ to the general population IQ value of 100. Fig. 1 shows a screenshot of the question that is presented to the student.

The data is supplied to the student via a CSV file as a downloadable link. The successful transfer of the data into SPSS is checked by the student comparing the stated standard error of the mean to that which they obtain in SPSS. Having confirmed agreement, the student is told to input all numerical answers to the same number of decimal places that SPSS reports to.

After the appropriate analysis in SPSS, the student is then required to input the numerical values for the sample size, sample mean and the 95% confidence interval limits before choosing from a dropdown menu the correct inference concerning the problem posed. In Fig. 1 for illustration purposes, the student's attempt has a mixture of correct, incorrect and blank answers.

Fig. 2 demonstrates the initial report which summarises the students attempt and provides an e-Assessment percentage score. Fig. 3 displays 'The Solution' and 'The Report' sections from the feedback of the student's attempt at this e-Assessment. The 'Solution' section supplies the correct answers that the student needed to complete. A pictorial representation of the confidence interval is included along with accompanying text in blue that is extra feedback information that aims to aid the students understanding of the correct inference to the question posed. The 'Report' section indicates, with colour coded marking, what the student has answered correctly (green) or incorrectly (red). It can be seen that the student has one wrong answer and a not answered (NotAns) input.

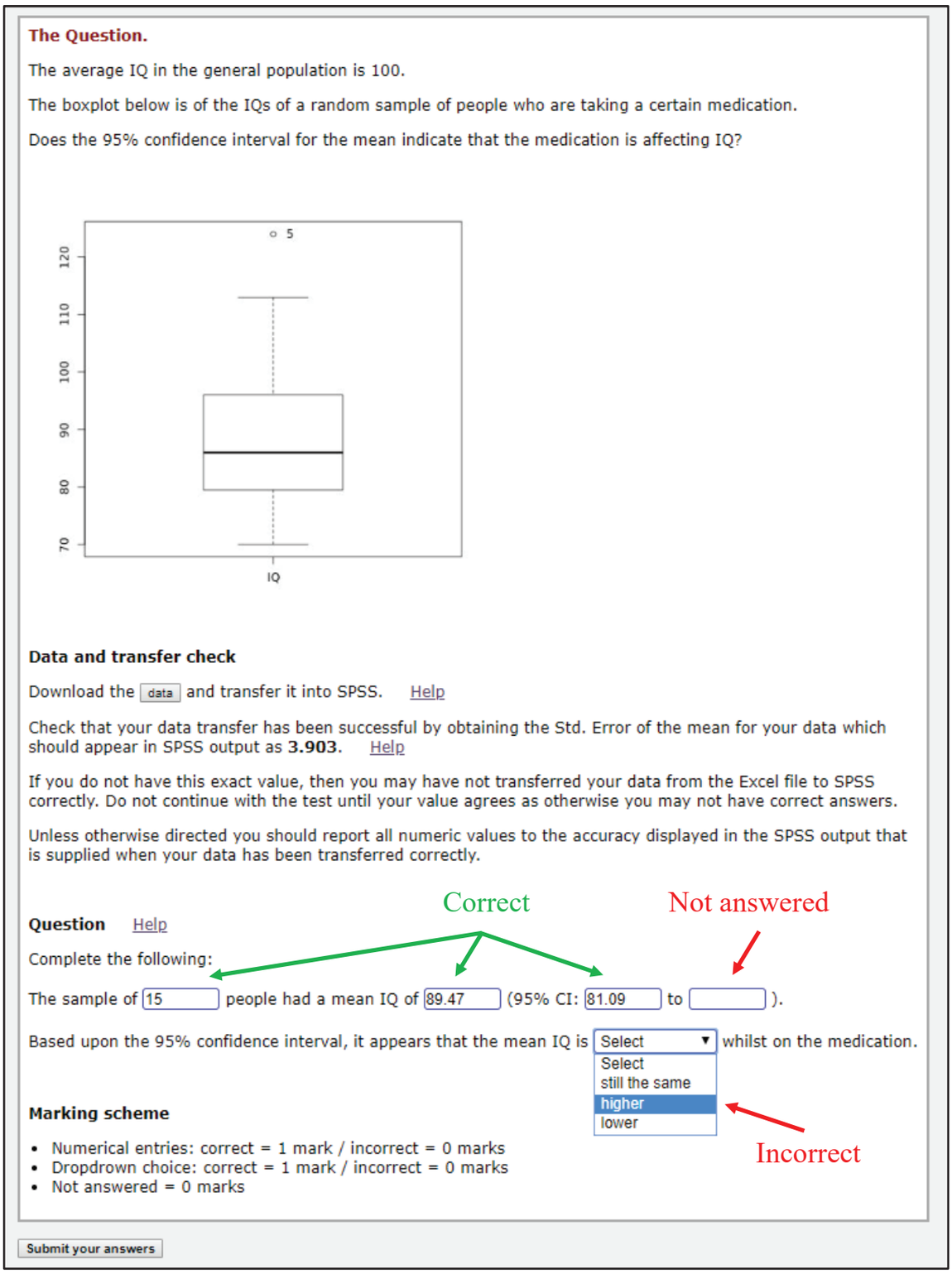

Figure 1. Screenshot of key skill e-Assessment example. The student has entered correct answers bar not supplying the 95% CI upper limit and has an incorrect inference concerning the mean IQ.

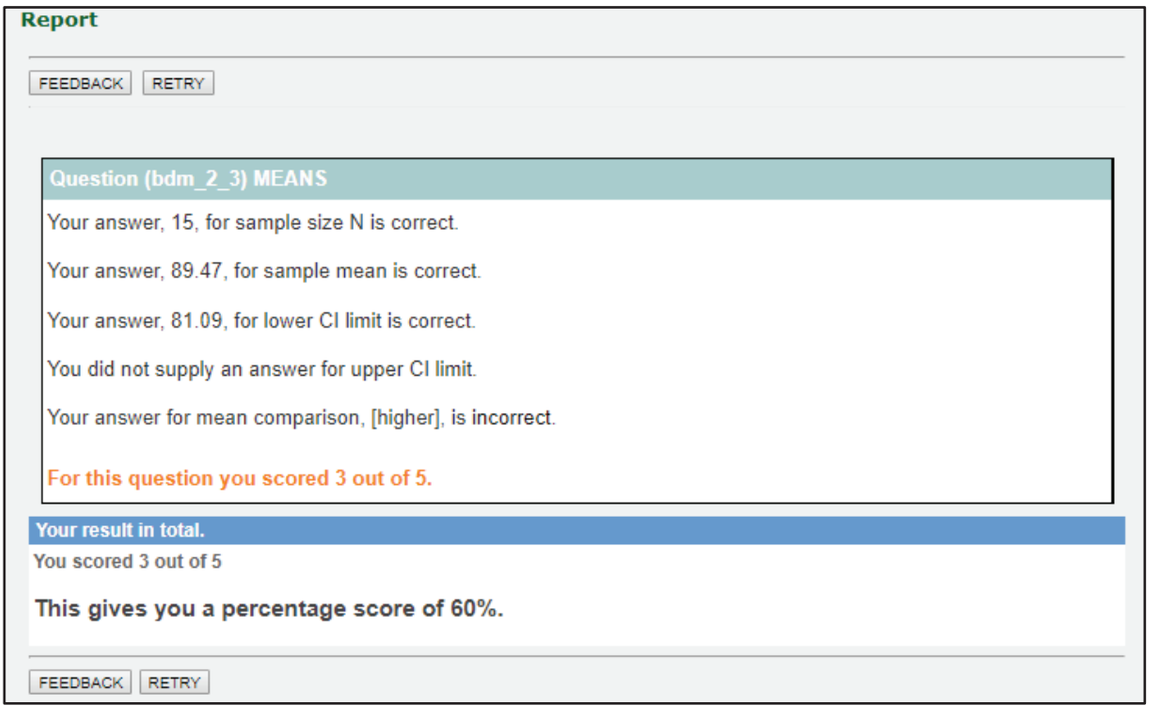

Figure 2. Screenshot of key skill e-Assessment example initial report.

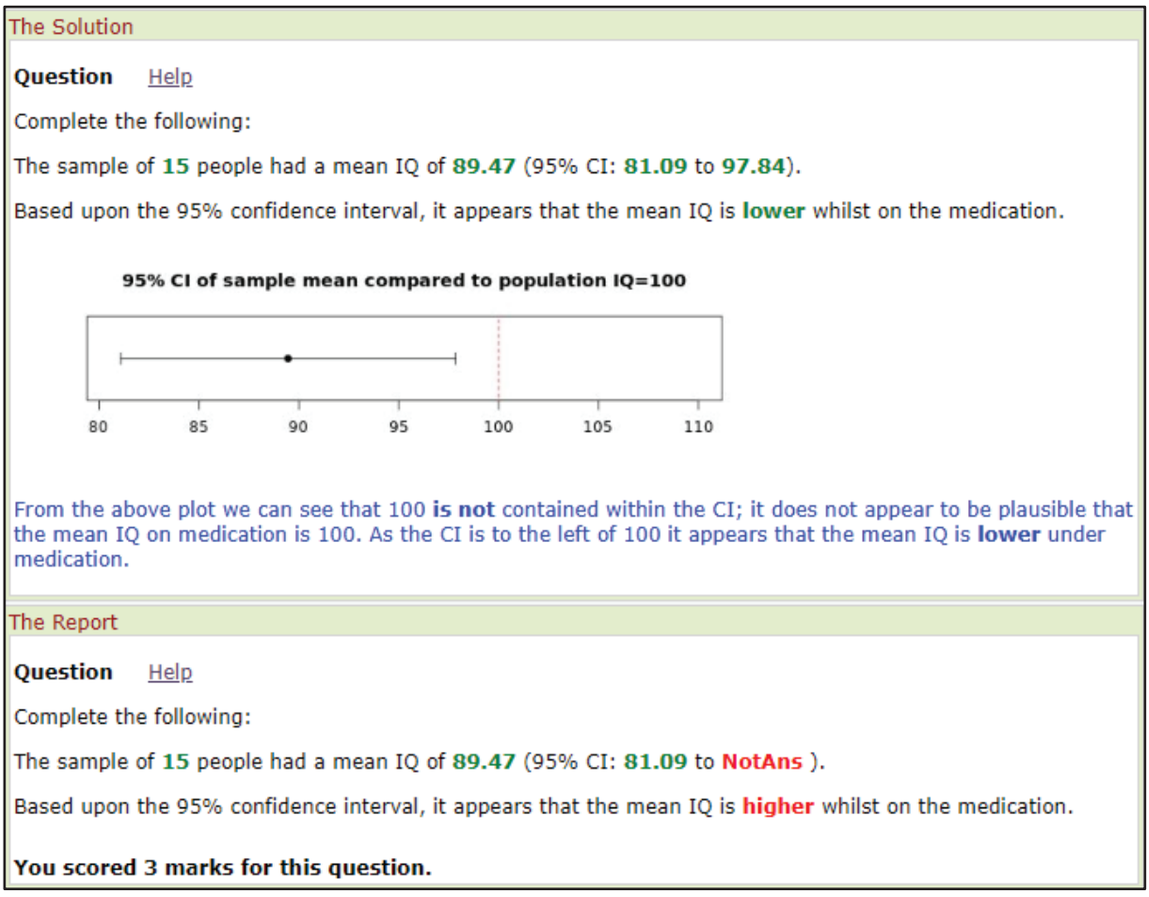

Figure 3. Screenshot of key skill e-Assessment example solution and report sections of the feedback.

The in-class e-Tests

The first in-class e-Test concerns the data dependent choice of the application of either the one-sample t-test or Wilcoxon signed rank test to evaluate a supplier's claimed average sodium content of mineral bottle water. Each run of the test would result in data of random sample size and with a supplier's claimed average that was also random. Furthermore, the data was randomly generated so that with equal chance students would experience both tests and significant or nonsignificant results. The basic statistical analysis tasks tested were the ability to transfer data from CSV format to SPSS, perform an exploratory data analysis for summary statistics, graphics and assumption testing; identification of appropriate statistical test (parametric or nonparametric equivalent), interpretation and reporting of test output. In total there are 22 numerical/dropdown entries that are each assigned 1 mark if correctly answered. There are a further 3 marks available for the correct choice of test to report; this weighting acknowledges the complexity of a decision based upon taught guidelines that consider sample size, skewness and normality.

The second in-class e-Test concerns the data dependent choice of the independent samples t-test, Welch's t-test or Mann-Whitney U test to evaluate the average amount of time visitors spent on two website designs. Each run of the test would result in data of random sample sizes with equal chance that students would experience any of the three tests with significant or nonsignificant results. The statistical tasks required built upon those of the first test and included as extras the interpretation of overlapping confidence intervals and the evaluation of equality of variances. The extra complexity of the guidelines for choosing between three tests was weighted to be worth 4 marks, there were 21 numerical/dropdown entries that are each assigned 1 mark if correctly answered.

The third in-class e-Test concerns the prediction of the sales value of a particular product from the market potential. Each run of the test generates data from a random number of sales territories with varying strengths of positive correlation between the two variables. Students are required to perform and report both a correlation analysis and a regression analysis. It is required that they report on the strength of the correlation, assess the fit of the regression model, report on outliers, interpret the gradient coefficient and produce predictions together with associated 95% confidence intervals. Unlike the analysis in the other two e-Tests, this analysis does not require the student to make any data dependent decisions on techniques to apply. In total there are 25 numerical/dropdown entries that are each assigned 1 mark if correctly answered.

In-class e-Testing procedure

The in-class tests that were run at UWE Bristol were scheduled to run in the same session/room as students' timetabled PC session. This was the only practical way of running the e-tests given the large number of students involved and the fact that the biggest PC lab on campus holds at most 50 students. Each session was scheduled for 50 minutes and the time limit for the in-class e-Test was 30 minutes. Each student was allocated to a group on the University's Virtual Learning Environment (VLE) which corresponded to their PC session. Using adaptive release, access to a practice test for each group was enabled immediately after the corresponding PC class a week before the in-class test. The practice test was exactly the same as the in-class e-Test and remained available to that group until midnight the day before their in-class test was scheduled. During its availability period, students were allowed unlimited attempts at the practice test getting different data (and hence analysis outcomes) each time they attempted it together with full feedback. The Dewis system enforced a strict time limit of 30 minutes to get students used to working under exam conditions.

Using adaptive release the link for the in-class test was only available for a particular PC group during their scheduled computer lab. At the start of the in-class test students were instructed to log into the VLE to access this link and to open the SPSS software. The in-class test link was protected by an examination key and this was different for each PC group. Once all the students were ready to start this examination key was issued and students were directed to enter it and "Start the online exam". This ensured that only students within the room were able to access the in-class test. During the in-class e-Test students were only allowed to access Dewis and the SPSS statistical package. Dewis displayed a persistent grey bottom horizontal bar containing details of the student's identity. This display was intended to facilitate the invigilation process and has been successfully used previously for e-exams run using the Dewis system (Henderson, Gwynllyw and Hooper, 2016). On submission of the assessment, the colour of the horizontal bar changed to pink. Students were allowed to submit their answers ahead of the 30 minute limit and, in such cases, they were instructed to ask an invigilator to view the pink bar before leaving the room. This bar provided the invigilators with an easy visual check of the student engaging with the Dewis system and also of the status of their assessment attempt. The first two in-class tests were invigilated by academic staff involved with the module; however the final in-class test was supervised by staff from the university's exam invigilator team.

Each student's attempt was marked instantly on submission. However disclosure of the mark to the students was delayed until the end of the week. This allowed us time to review and analyse the complete spread of marks once all the students had taken the in-class test. Once we had completed the review process, students were able to log back into the in-class test link and view their submission to get full bespoke feedback for their attempt as well as their mark.

The number of students taking the module at partner institutions was considerably smaller than for those taking it at UWE Bristol. This meant that they were able to give access to the whole cohort in one sitting.

Results

Results have been excellent (e-Test 1: one-sample t-test $N = 643$, $M = 75.2$, $SD = 20.0$; e-Test 2: two-sample t-test $N = 640$, $M = 75.8$, $SD = 24.0$; e-Test 3: correlation and regression $N = 380$, $M = 67.5$, $SD = 24.7$). The decline in the number of students attempting the third e-test is due to the final mark being the best from two; many students with high marks from the first two tests elected not to take the final test. Based upon the best two from the three e-Tests, 83% of students passed this element of the module. This is an excellent pass rate, especially as 9% of students did not sit any of the e-Tests.

Of those students that sat each e-Test, the majority had previously tried the practice tests (e-Test 1: 59%; e-Test 2: 64%; e-Test 3: 54%). Many students made multiple attempts at the practice attempts (e-Test 1: $Mdn = 5$, $IQR = 2 – 9$; e-Test 2: $Mdn = 6$, $IQR = 3 – 11$; e-Test 3: $Mdn = 4$, $IQR = 2 – 7$). Those that did practice experienced a significant uplift in average marks compared to those that did not practice (e-Test 1: 20.8 (95% CI 18.1 – 23.5); e-Test 2: 24.3 (95% CI 20.9 – 27.7); e-Test 3: 20.7 (95% CI 16.2 – 25.3).

There was a high number of students who have viewed their feedback (e-Test 1: 72%; e-Test 2: 70%; e-Test 3: 56%). This is much higher than the 10% that is typical for paper-based work. Research (Race, 2014) shows that feedback has to be quick to be effective, while students still remember clearly the work they were engaged in and online exams are one way of achieving this.

Discussion

Feedback from students to the module has been mixed, in part due to the fact that some students did not feel that there was enough linking between the Statistics and Business elements of the module. Given that 2017/18 was the first year that the module ran in this form this is not totally surprising and greater liaising is planned for future years. However in general the students liked the in-class tests, recognising that "it is fair for all students" because it is not possible to "cheat" as is the case for uncontrolled coursework.

Using e-Assessment for coursework has become standard practice in many institutions (Sangwin, 2013) and it seems likely that online examinations will become standard practice in the near future (Kuikka et al, 2014). However progress has been slower than predicted by Collins, Ripley and Roads (2003). Gray, Sheppard and Ferrell (2016) found that there is considerable interest in online exams yet few reliable sources of good practice. Roads (2016) reports that most organisations expect to increase their use of e-Assessment over the next five years and identified that lack of space for invigilated testing as one potential barrier. In this paper we provide a model for how robust online testing of statistics can be achieved.

The Statistics element of this module is designed to provide a solid foundation for Business School students in using SPSS to perform standard statistical tests. They will experience further material in their second year and will then be required to use the techniques that they have learnt to analyse real data in a substantial research project. It is hoped that the testing regime and the fact that students will have access to the comprehensive materials produced throughout their studies will facilitate their transition to becoming independent researchers.

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OVERVIEW OF START-UP ACTIVITIES WITHIN THE ONLINE-BASED EDUCATIONAL FRAMEWORK OF KOSEN SPACE ACADEMIA

T. Takada*[a], J. Nakaya[b], Y. Kajimura[c], M. Tokumitsu[d] and K. Kitamura[e]

[a] National Institute of Technology (NIT), Kochi College,
Department of Social Design Engineering, Nankoku, Japan
[b] National Institute of Technology (NIT), Gifu College,
Department of Mechanical Engineering, Motosu, Japan
[c] National Institute of Technology (NIT), Akashi College,
Department of Electrical and Computer Engineering, Akashi, Japan
[d] National Institute of Technology (NIT), Yonago College,
Department of Electrical Control Engineering, Yonago, Japan
[e] National Institute of Technology (NIT), Tokuyama College,
Department of Mechanical and Electrical Engineering, Shunan, Japan

*takada@ee.kochi-ct.ac.jp

Abstract

This paper describes the activities of the KOSEN Space Collaboration, organized by teachers from the National College of Technology (KOSEN) who specialize in space science and engineering. KOSEN does not have a dedicated department for space science and engineering, so there are limited opportunities for interested students to develop skills and expertise in these fields, even though space agencies and manufacturers of space equipment in Japan are greatly inclined hiring KOSEN students. Grassroots KOSEN Space Collaboration members have gathered together to organize the KOSEN Space Camp every summer since 2015. At this camp, KOSEN students attend lectures delivered by first-line researchers and compete in creating a model rocket and a pico-satellite CanSat model. KOSEN teachers use the opportunity to exchange information about study materials on space science and engineering. Since 2017, we have employed a new educational framework under a three-year grant-in-aid from the Ministry of Education, Culture, Sports, Science and Technology (MEXT)—'KOSEN Space Academia,' started in 2018—using online-based conference systems. The Academia's students currently attend lectures and practical trainings on space science and technology. KOSEN Space Collaboration has developed new teaching materials, such as a CanSat kit for beginners, a CubeSat model with functions comparable to those of real satellites, and a simple receiver with a software-defined radio (SDR) for satellite transmission. Using these equipments, our students can experience a complete series of events from the development of a satellite to a rocket launch and to subsequent data reception from the satellite. In this paper, we describe the initial activities of the KOSEN Space Academia and discuss our plans for the future.

Keywords: *space technology, space science, CanSat, model rocket, CubeSat model, SDR*

Introduction

Our modern life is supported by many satellites, including meteorological, communication, and GPS satellites. Since small satellite development is being conducted by universities and companies, there are challenging opportunities for engineering students. In universities, students can be involved in developing small satellites, especially in departments of space science and engineering. In fact, various educational approaches have been carried out (e.g. Nakasuka et al., 2010; Miyazaki & Yamazaki, 2013). For educational purposes, some university students even tried to create a CubeSat model (Yamazaki, 2016). In Japan, there are several contests for CanSats (satellites that fit in a soda can) and/or model rockets open to university and high school students.

In support of this growing field, the KOSEN Space Collaboration was organized by teachers specializing in space science and engineering from the National College of Technology (KOSEN) to help students develop such skills and expertise. KOSEN students, including the same age as both university and high school students, gain training in technical fields such as space development. Some KOSEN graduates are active in domestic space agencies and space related manufacturers; several space agencies and manufacturers of space equipment in Japan are greatly inclined hiring KOSEN students. However, because

KOSEN does not have a dedicated department for space science and engineering, there are limited opportunities for students aspiring for relevant institutions and companies to develop their skills and expertise in these fields. Although the space engineering is a complex system, general engineering skills are often included such as mechanical engineering, electrical and electronic engineering, information technology, and civil engineering etc.

The KOSEN Space Collaboration, whose members have gathered together at the grassroots level, have organized the "KOSEN Space Camp" every summer since 2015 (Wakabayashi et al., 2018; Kitamura et al., 2018). In these camps, KOSEN students attend a special lecture delivered by first-line researchers and create a model rocket and CanSat for beginners. The main event is the competitions for group CanSat production. In the competition, students must design an original mission and develop a unique CanSat in just three days and work with other KOSEN students (Tsubouchi et al., 2018). Space Camp combines mission design in the space development field with exposure to manufacturing that KOSEN students are generally good at. Space Camp has provided valuable hands-on training and teamwork opportunities for KOSEN students.

At beginning in 2017, we instituted a new educational framework under a three-year grant-in-aid from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), as a way of reaching out to and educating interested students and qualified teachers and lecturers across Japan. We call this new framework KOSEN Space Academia. Created in 2018 using an online conference system, KOSEN Space Academia enables students to attend lectures and practical trainings based on space science and technology. In this paper, we describe the initial activities of the KOSEN Space Academia and discuss our plans for the future.



Figure 1. Space Camp 2017 in Niihama, Japan.

Overview of KOSEN Space Academia

KOSEN Space Academia is a framework for conducting lectures and practical trainings related to developments in space and engineering, in regular class periods held via online conference systems. Expanding on the know-how and educational materials developed for the Space Camps, we designed lectures and practical trainings for distance learners, since the relatively small number of students interested in space development and teachers and experts in space science and engineering are scattered across KOSEN campuses nationwide. By linking KOSEN students and teachers, we can provide lectures and practical trainings without having to create a centralized department on a single campus. Figure 2 shows an overview of KOSEN Space Academia.

There are 51 National College of Technology (55 campuses) in Japan, and there are multiple communication means for each college. Teachers can use the video conference system with Polycom terminals (the 'Blue Jeans Network'), Skype for Business (part of Microsoft Office 365), or other video conferencing applications: for delivering lectures to a large audience scattered around the country, we use Blue Jeans Network; for practical training, Skype for Business allows us to choose our own connection location(s). For individual students connecting without teachers, Skype is another useful application.

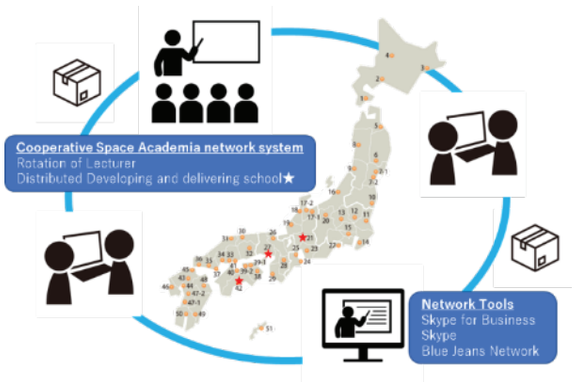

Figure 2. Online-based educational framework of KOSEN Space Academia.

Academia's lecturers are teachers from each of the Space Collaboration member KOSENs. Three KOSENs (Kochi, Gifu, and Aakashi) form three node schools in the network of KOSEN Space Academia and oversee the development and preparation of teaching materials. All KOSEN space collaboration members cooperate with each other to develop and prepare various educational materials. We distribute physical educational materials (e.g. printed materials, CanSat kits, etc.) from the node schools to participating KOSENs nearby, keeping delivery costs low. Participating students choose a KOSEN teacher as their contact person for receiving deliveries, preparing online conferences, and so on.

Start-up Activities of KOSEN Space Academia

In academic year 2017, we held a kick-off meeting at the Tokuyama KOSEN in January, followed by follow-up lectures at an online conference. In academic year 2018, we have recruited new Space Academia students and, as of April, have been holding lectures, practical trainings, online conferences, etc., once a month. Figure 3 shows leaflets from the January 2018 kick-off meeting for the first half of 2018. The kick-off

meeting featured a special lecture delivered by Dr Tomohiro Ishikawa of the Tokyo Metropolitan College of Industrial Technology, who spoke on 'Satellite Development by the College of Technology'. A 'Workshop on satellite communication by a simple receiver was instructed by one of our members, involving production practice. Eleven faculty members and 15 students participated. For the 2018 KOSEN Space Academia, there are 66 students (from 13 KOSENs, with 15 teachers) currently taking classes. The main educational topics and content for the first half of 2018 are model rocket production, CanSat production, and lectures on model rockets and CanSat.



Figure 3. Leaflets for the KOSEN Space Academia 2017 kick-off meeting (left) and 2018 online lecture series (right), written in Japanese but including information of theme, titles, schedules, programs and so on.



Figure 4. Sample educational materials: simple receiver and antenna (left and upper left), model rockets (upper right), CanSat (lower left), and CubeSat model (lower right).

Figure 4 shows some of the teaching materials actually produced (or to be produced) by the KOSEN Space Academia's start-up activities: a simple receiver and an antenna for satellite radio waves, a model rocket for beginners (ready-made), a CanSat for beginners, and a CubeSat model. These teaching materials simulate the real rockets, satellites, and ground receiving stations involved in actual satellite development and deployment. Educational tools can be easily accessed by students for use in experiments. Important elements that explain the functions of actual satellites are included. These are useful teaching materials for space and human resources education. Most of the tools, such as a simple receiver, a CanSat kit, and a CubeSat model, were developed by the KOSEN Space Collaboration group.

A simple receiver for real satellite radio waves is a device that combines a small computer board with an antenna and uses a software-defined radio (SDR) (Tokumitsu et al., 2017). At the workshop, we demonstrated assembling simple receivers, executing instructions with them, and receiving test waves. In addition, all participants brought their receivers to their KOSEN and conducted actual satellite radio receiving experiments. For the results, at an online conference, the students reported to each other. Figure 5 shows students involved in production practice of the simple receiver and antenna.



Figure 5. Production practice with the simple receiver and antenna at the laboratory in Tokuyama KOSEN.



Figure 6. The online-based model rocket production course in progress.

At the KOSEN Space Academia that began in academic year 2018, 66 students submitted applications for the year. The first lecture was a model rocket course that included 50 minutes of theoretical lecture and one hour of kit production. Although it involved off-site work demonstrated via an online conference system, there were no big problems, and many students completed the model rocket. By launching their model

rockets at the camp to be held in the summer (Kajimura et al., 2017), participants will be qualified for a fourth-grade license from the Japanese model rocket association. Figure 6 shows the online-based model rocket production course in progress. Communicating via Skype, students worked in each workspace while receiving explanations by slide and instructions from the lecturer.

The second and third courses of KOSEN Space Academia covered CanSat production for beginners. This provides a hands-on introduction to real satellite development, mainly for college students (Colin, 2017). For our course, we used a CanSat kit with a small can size of 160 ml (Issiki et al., 2017). Producing a CanSat involves a lot of manual work such as circuit connection by bread board, soldering, cutting and drilling empty cans, and parachute making using plastic bags. Figure 7 shows a CanSat kit for beginners and it was prepared and distributed by three academic base KOSENs.



Figure 7. CanSat kit for beginners.



Figure 8. The online-based CanSat course in progress.

Figure 8 shows the CanSat production course in progress via the online conference, where one CanSat kit was assembled by one or two students. Since this was the first time for us to conduct practical training using an online conference system, we had the same lesson for two days. As the results, the group of participants was divided almost in two. This helped us learn a lot about remote practical trainings—for example, that the number of connection sites should ideally be fewer than ten. The produced CanSats will be launched by model rocket during the summer Space Camp.

Results of Questionnaire on KOSEN Space Academia's Activities

Regarding the activities of KOSEN Space Academia, participating students and faculty members were asked to respond to a questionnaire. Table 1 shows some of the results of the questionnaire for the model rocket course. Out of 65 participants, 49 students completed the questionnaire. Most of the students showed great interest in the course itself and were mostly satisfied with the contents. However, there were some problems with the smoothness of the Skype communication since there were too many connection points. Based on this result, we changed to using Skype for Business for the next lecture instead of plain Skype. Further analysis of the questionnaire results, including the CanSat course, will be done after Academia's complete lecture series on the practical training via an online conference.

Table 1. *Results of Questionnaire Covering the Model Rocket Course*

(49 answers)	Good	…	Normal	…	Bad
Was the content interesting?	57%	31%	10%	2%	0%
Was the Skype picture easy to see?	20%	31%	31%	18%	0%
Was the Skyped voice easy to hear?	24%	31%	20%	24%	0%

Future Plans and CubeSat Model Competition

Although the activities of the KOSEN Space Academia have just begun, Table 2 lists the activities up to the present and the schedule until the first half of academic 2018. The courses have held at a pace of one a month. The series of activities is connected to the activities at the Space Camp held during summer vacation. The schedule of the second half of the year will be adjusted in the future, but it is intended to incorporate lectures on real rockets and satellites and to incorporate applied practical training using the teaching materials produced so far. For the next academic year, we are considering how to continue courses for beginners and for participating students who wish to continue to attend.

The KOSEN Space Camp, which has been held every summer since 2015, lasts three nights and four days. KOSEN students who are interested in space can experience a special lecture by a first-line researcher, a build and launch a model rocket, produce a CanSat, and the group competition for CanSat experiments. It is confirmed that they gained valuable experience that is not generally provided through daily classroom activities. In this academic year, we were able to teach beginners to produce model rockets and CanSats in KOSEN Space Academia. Thus, we decided to

challenge the students with the creation of a somewhat advanced CubeSat model at the camp. In addition, we are trying new ventures such as holding a CanSat contest for high school students in Shikoku in parallel and implementing an Ideathon related to satellite development. Table 3 shows the schedule and program of Space Camp 2018.

Table 2. *Schedule of KOSEN Space Academia for 2017 and 2018*

FY	Date	Type	#	Contents
2017	1/7–8	Meeting (Shunan) +Skype	15 (11)	Special lecture Simple receiver production
	2/28	Download doc.	-	Simple receiver follow-up
	3/28	Skype	5 (3)	Telemetry receiving experiment
2018	5/24 (2 hr)	Skype	65 (14)	Model rocket
	6/19 or 20 (2 hr)	Skype-B	47 + 16 (8 + 6)	CanSat production 1
	6/27 (2 hr)	Skype-B	4 (4)	[free connect.] CanSat production
	7/18 or 19 (2 hr)	Skype-B (Video)*	27+26 (6+6)	CanSat production 2
	8/16–22* (2 hr)	Skype-B	-	Rocket and CanSat application
	8/30–9/2*	Camp (Niihama)	-	Special lecture CubeSat production Ideathon

*plan (): number of teachers

Table 3. *Program Plan of KOSEN Space Camp 2018*

Date	AM1	AM2	PM1	PM2	night
8/30 Thu.			CubeSatM group production		Special lecture
8/31 Fri.	CubeSatM group production		Rocket launch CubeSatM competition-1		Welcome party
9/1 Sat.	CanSat contest for high school students				Exchange meeting
	Ideathon	Radio Receiving	CubeSatM competition-2, 3		
	Radio Receiving	Ideathon			
9/2 Sun.	Presentation	Prize-awarding			

Table 4. *CubeSat Model Competitions for Space Camp*

Functions of CubeSat Model	Contents of Competitions
Power supply system	• To monitor solar panel and battery • To compete the status of long-time data acquisition
Attitude system	• To determine the attitude with several sensors • To complete accurate positioning in the field of view (FOV) of the camera
Communication system	• To complete successful communication conditions during a 10-min flight in the sky (using captive balloon)

The CubeSat model is a kit for building a box-shaped nanosatellite called CubeSat and is designed to operate on the ground (Yamazaki, 2016; Tanaka and Kitamura, 2017). It is made mainly for educational purposes and has functions similar to those of CubeSats released into space. In the camp, we plan to produce this CubeSat model focusing on the assembly, and we plan to have groups take part in experimental competitions. This will be the first time we will hold the CubeSat model competition, which will give students a structured setting to try the challenges for each of the main functions of CubeSat model, such as the power, attitude, and communication systems. Then we will comprehensively evaluate the data and present an analysis of the results, highlighting the uniqueness of their ideas and problem-solving achievements. Table 4 shows specific plans for each function. We hope that our educational materials and the design of the competitions will fuel the students' aspirations.

Summary

To nurture space personnel capable of contributing to real satellite development, we have started designing, practicing, and refining an educational system: KOSEN Space Academia. In KOSEN Space Academia, we use online video conferencing to reach and to connect interested students and teachers spread among multiple different KOSENs. This paper described the main start-up activities: working with a simple receiver with a software-defined radio, making a model rocket, and building a CanSat for beginners. In addition, we presented our plans for the group production of and competition with CubeSat models at the KOSEN Space Camp in August in 2018. KOSEN Space Academia's educational focus is currently on manufacturing and hands-on training for KOSEN students. This is implemented through long-distance lectures, practical training sessions, and discussions via online video conferencing. We confirmed that our online-based system functioned well, with only minor difficulties relating to bandwidth with Skype. Regarding the development and distribution of teaching materials, it is confirmed that three KOSENs distribution bases for delivering materials and coordinating with neighbouring participating colleges works effectively. In the future, we hope to enhance our expertise in delivering practical lectures and hands-on training using an online conferencing system and to build an increasingly fulfilling curriculum.

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We acknowledge all the members of the KOSEN Space Collaboration group and all the participants in KOSEN Space Academia 2018. We are very grateful to the students of National Institute of Technology at Yonago College, Kochi College, Gifu College, and Akashi College for the help we received in preparing the simple receiver and CanSat kits. The KOSEN Space Technology Education Project was supported by the Human Resource Development program of MEXT, Japan, in 2017. This work was supported by JSPS KAKENHI Grant Number JP17K01169.

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INSPIRING YOUNG PEOPLE TO LEARN ABOUT THE LATEST HEALTHCARE TECHNOLOGIES AND PRACTICE THROUGH HEALTHTECH CENTRE

KONG, J.C.F.* and CHEUNG, K.C.

Department of Applied Science, Hong Kong Institute of Vocational Education (Kwai Chung), Hong Kong Special Administrative Region, China

E-Mail Address of the corresponding author: joseph.kong@vtc.edu.hk

Abstract

As the manpower demand of healthcare practitioners arising from ageing population and healthcare concerns is reiterated almost every year in the Chief Executive of Hong Kong Special Administrative Region Government's policy addresses, education and professional trainings in these two areas are crucial and essential in Hong Kong.

Apart from traditional classroom-based lectures and workshops learning and teaching activities, equip learners with practical skills in healthcare areas through workplace attachment is necessary. Therefore, training opportunity in an emulating industrial working environment that can enhance customer service and interpersonal skills of students; facilitate interaction with the healthcare industry and community is important. In view of this, the HealthTech Centre ("The Centre") was established with the mission of promoting awareness of community health and offering Vocational and Professional Education and Training (VPET) in this field.

The HealthTech Centre, located in the Hong Kong Institute of Vocational Education (Kwai Chung), a member institution of the Vocational Training Council ("VTC"), was officially opened on 16 March 2017. The Centre aims at providing advanced and professional facilities for training manpower needed in the healthcare services sectors.

The HealthTech Centre is equipped with advanced and professional technology-centric facilities, providing real-world training for students pursuing health studies, applied nutritional studies, vision health care, community health care for senior citizens and medical centre operations. The centre is collaborating with local community organisations and elderly centres. Elderly residents are invited to join the health activities provided by the Centre like cognitive training and exercising games with the aid of Virtual Reality technologies. The Centre also provides general health services, foot health, geriatric services, vision health and nutrition counselling services. The elderly participants can gain more health knowledge and interact with young people. At the same time, students can put into practice what they have learnt through conducting basic health screening services for the elderly in areas like vision health, nutrition and cognitive abilities.

Keywords: *Active learning, practice-based learning, workplace learning, healthcare skill learning*

Introduction

The HealthTech Centre ("the Centre") was established in Hong Kong Institute of Vocational Education (Kwai Chung) on 16 March 2017, with an aim to provide advanced and professional facilities for training healthcare professionals. Elderly was recruited, through the elderly centre networks, to participate in different kinds of health activities in the Centre. Under the guidance of the teachers, students from different higher diploma programmes in Applied Science Discipline were providing health services to the elderly.

As illustrated in the floor plan in Figure 1, the Centre was divided into two different zones, namely Delighted Zone and Service Zone. The Delighted Zone is a multi-purpose area that is equipped with a 100" multimedia wall and innovative health technology applications. Some innovative applications were designed by colleagues and students of Applied Science Discipline to facilitate the provisioning of health services. For example, a motion-sensing cognitive training application named "Wet Market" was installed in the Delighted Zone. Making use of multimedia wall and Kinect technology, participants were required to pick a variety of food ingredients in a simulated wet market environment. Students and elderly could experience the latest cognitive training and exercising technology. It also created a training opportunity for students to interact with the elderly.

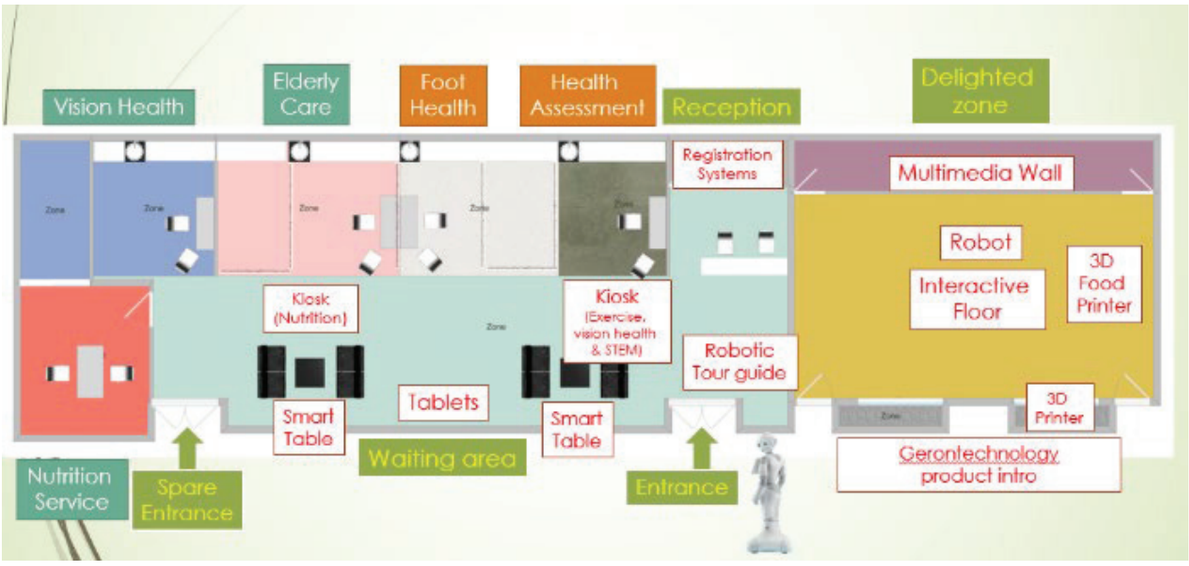

Figure 1. HealthTech Centre Floor Plan



Figure 2. A student is assisting the elderly to play the motion-sensing cognitive training game - Wet Market in the Delighted Zone

The Service Zone is further divided into General Health, Foot Health, Elderly Care, Vision Health and Nutrition Service areas. Sophisticated equipment are installed in respective areas to enable the students to apply what they have learnt to handle the real cases. For example, by using equipment like non-contact tonometer and digital retina camera, Higher Diploma in Vision Health Care students can provide simple vision screening service including visual acuity, Amlser Grid, rough refractive error, eye pressure assessment and retina health screening to the elderly participants. On the other hand, other higher diploma students can use bladder Scanner, In-body analyser and podoscope to provide a wide range of health services in the Centre.

The Learning Process

Dammers (2007) mentioned that the use of real patients complemented a problem-based learning approach by creating a strong motivational context and fostering a sense of responsibility. Real patients brought complexity and encouraged "elaborated" learning when new information is incorporated into what learner already knows and restructured into more complex networks. The learning experiences in the Centre could bring an empathic dimension, which is unlikely to be replicated in a lecture setting.



Figure 3. Students are providing health service to the elderly

Dornan (2006) found that today's students learned practically relevant theory in seminar rooms using well theorised methods. They could integrate their knowledge and skills in workplaces through a process for which there are no better descriptors than 'clinical teaching' or 'primary care placement'. The simulated workplace like HealthTech centre could be where competence has eventually to be applied.

Since the service pilot run in September 2016, over 300 students participated in 170 sessions of health services. A total of 4,000 training hours were provided, benefiting 2,500 elderly participants and clients. In each service session, 10 to 15 clients were recruited to join the health service. Teachers tried to arrange the same number of students to provide a one-to-one service for the visitors.

The details of training process can be illustrated through an example of a typical service session: at 9:30

on one Monday morning, a group of Higher Diploma in Medical Centre Operations students were scheduled to provide health services to 12 elderly residents recruited by an elderly centre. Students were required to carry out the registration process, conduct particular health screening activities and take care of the elderly. The training session lasted for about 1.5 hours. Teachers would provide support and guidance in the whole process.

Before sending invitation to elderly centres, several briefing sessions were conducted to help students to get familiar with the equipment and the procedure of the service session. With a small group of students, each student would have more chances to practise different kinds of health screening equipment such as In-body analyser and Bone densitometer. Under the guidance of teachers and technicians, students could have a deeper understanding of using the equipment, ranging from equipment calibration to the techniques of handling different situations. Those activities are usually difficult to arrange for a larger class size. Knowing that they need to handle real cases in subsequent sessions, students would have a higher motivation to learn how to use the equipment and the skills needed to provide a good service to the clients. After each service session, debriefing would be conducted to review the performance of each student. Teachers would explain some improvement actions to the students if necessary.

Evaluation method

An evaluation questionnaire was designed to investigate whether the health services in the HealthTech Centre could facilitate the learning of skills and knowledge of their respective programmes. A total of 50 year 2 students (17 male and 33 female) studying different health programmes in Hong Kong Institute of Vocational Education (Kwai Chung) took part in the survey. They have participated in an average of 14.3 hours of learning activities in the Centre. Students' comments on the learning activities were collected in the evaluation questionnaire. Participants' selection was based on willingness to take part in the study.

A 5-point Likert scale was adopted in the questionnaire. Students were asked to evaluate the setting and experiences of the HealthTech Centre. Observations of the group process and feedback from the students were kept by the teachers. On the other hand, discussions with the participating teachers were held to collect the feedback from the teachers' perspectives.

Results and Discussion

All 50 students completed the questionnaire covering the evaluation on the environment, the facilities and the design of learning activities. Students were asked to describe their learning experiences in the survey. All responded the question "Training activities in the HealthTech Centre enhance his/her communication skills with patients/clients". All of them expressed positive value in the question "Health technology application and equipment can improve his/her motivation in learning."

Table 1. Extracts of results of the questionnaire survey

Questions	Mean	N	SD
Activities in the Centre enriched my nursing skills and experiences	3.78	50	0.78
Activities in the Centre improves my communication skills with patients	4.02	50	0.71
Through the activities in the Centre, I can gain confidence in working in the healthcare industry	3.88	50	0.68
Activities in the Centre helps me to have a better understanding of what is learnt in lectures	3.8	50	0.72

Findings show that the Centre can provide a different environment for the students to learn the skills proactively.

Teachers reflected that students could learn to deal with different situations through real cases. For example, they could learn to communicate with the elderly who could only speak certain dialects. In another occasion, they could learn how to handle an elderly who were reluctant to try out some activities. The Centre could provide a semi-structured environment and tailor-made training opportunity for the students, which might not be easily replicated in a normal classroom setting.

In addition to the knowledge and skills of medical practice, students need to acquire confidence and a sense of professional identity and sustain their motivation. Attaining those various learning outcomes reinforces the learning process, and failing to acquire them weakens it. The educational climate and behaviour of individual practitioners – nurses as well as doctors – has great power to enable or disable workplace participation that brings students closer to their ultimate goal of helping patients. (Dornan et al, 2007) During the discussions, teachers acknowledged that HealthTech Centre could provide such an environment to facilitate the learning of nursing skills for the students.

The survey showed that the practice in the Centre could help prepare the students psychologically and equip them with the necessary soft skills to cope with the challenges in the workplace. Under teachers' guidance, students could gain more confidence to apply their skills on providing services to the people in need.

Conclusions

Opportunities to engage in work, the kinds of tasks in which individuals are permitted to participate, and the guidance provided, become key bases to understand and evaluate how and what individuals learn through their works. (Billett, 2002) The Centre was believed to provide the environment and opportunities to inspire the young people to sharpen both their soft and hard skills, contributing to the development of talents to work in the healthcare industry.

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BUILDING YOUR OWN RAPID eLEARNING AUTHORING TOOL

TSE KWOK KEUNG*

Nanyang Polytechnic/Foundation and General Studies, Singapore

*tse_kwok_keung@nyp.edu.sg

Abstract

This paper will discuss the benefits of building one's own rapid eLearning authoring tool vis-a-vis using commercial software packages. These benefits range from cost savings in the long run, customised features and capabilities to a consistent user experience standard.

Keywords: *eLearning, content, authoring, HTML5, web, application*

Introduction

Rapid eLearning authoring tools are widely used by subject matter experts or teachers to develop eLearning content in a very short time frame, usually in terms of weeks. These tools allow content authors to assemble text and media objects into files that run on HTML5-compliant browsers. As HTML5 is supported by various devices, learners can use computers, tablets or smartphones to consume the eLearning content. This paper argues that while most commercially available tools are powerful and user-friendly, choosing which tool to use may not be that easy as the decision involves many factors. At the end, it may be easier if one builds one's own tool.

Why use rapid eLearning authoring tools?

In recent years, there is an increasing demand for teachers to design and develop their own eLearning materials. After all, teachers, especially the experienced ones are in the best position to understand their learners' needs. If it is not unusual for teachers to prepare their own course materials for conventional class delivery, they can also learn new ways to publish their course materials on an electronic platform.

Teachers who are involved in blended learning[1] feel all the more necessary to develop and manage their own eLearning materials. If they want to ensure a seamless integration between the online learning content and their classroom teaching, they will need to edit and fine-tune the eLearning materials as often as possible.

Modern rapid eLearning authoring tools are designed for users who have little or no programming background. Most of these tools come with a graphical user interface that allows users to assemble text and media objects on the computer screen a la PowerPoint.

Choosing the tool

Rapid eLearning authoring tools come in two categories in terms of costing: commercial packages and freeware tools. It is fair to say that most content developers will not be bothered too much about the cost of acquiring such tool so long as it is useful. In fact, many popular commercial packages (such as Adobe Captivate and Articulate Storyline) are cost effective. As for freeware tools, some (such as Adapt) come with a comprehensive set of features and functionalities comparable to those of the commercial packages.

If you are an independent developer, you can choose your tool according to your needs and liking: you may need certain features and functionalities and prefer certain design and architecture. There are many product guides[2] available on the internet to help you identify the tool that suits you most.

If you work in an organization, your choice may be constrained by your organization's software policy, IT infrastructure, eLearning strategy, etc. For example, your organization may have a learning management system (LMS) in place. In this case, the tool you are going to choose must work well with the LMS. In the best scenario, they can complement each other in terms of features and functionalities.

At the Foreign Language Centre (FLC), Nanyang Polytechnic, Singapore, our choice of eLearning authoring tool is governed by three major considerations:

1. Course delivery – Our foreign language courses are delivered in blended learning mode whereby students learn in part through conventional class teaching and in part through online learning. At Nanyang

[1] In this paper, we adopt the definition of "blended learning" as stipulated in Christensen, Horn and Staker (2013).

[2] For a comprehensive product guide, see "The Ultimate List of HTML5 eLearning Authoring Tools" by Christopher Pappas (2017).

Polytechnic, we use a learning management system (LMS) called Blackboard to administer students' online learning. The LMS provides us with tools to monitor the students' learning progress and to create assessments with marking schemes (which consist mainly of multiple choice questions), but we have to develop our own learning content using third party tools.

2. Instructional design – We design our learning content with the textbook metaphor in mind: learning content is organized in lessons according to communication themes. A typical lesson consists of situational dialogues, explanatory notes, vocabulary lists and reinforcement exercises (such as grammar drills, fill in the blanks and cloze passages).
3. Media objects – Our learning content contains lots of voice recordings of our own production. Audio is played at various levels: word, phrase and passage. We use images to illustrate various language situations. Many of the images are acquired through licensing. As video production is resource-taxing and beyond our budget, we make use of public domain video wherever appropriate.

While most of the rapid eLearning authoring tools available in the market allow content authors to build engaging learning content, they are not well-suited for creating materials specific to our language courses. For example, with the popular authoring tools we have tested, it is very difficult to include inline audio (i.e. words or phrases with clickable sounds) and to make cloze passages with draggable word items.

On the other hand, as these tools are meant for general purpose use, they contain many features and functionalities which our teachers would never use. In fact, instead of helping us to build our learning content, they could stand in our way and contribute to the steep learning curve.

Building your own rapid eLearning authoring tool

If you cannot find a suitable authoring tool in the market, then how about building your own tool? It is not as intimidating as it may sound. As mentioned earlier, what the tool does is to help you assemble text and media objects into HTML5-compliant files that run on web browsers. In other words, the output is a set of web pages, albeit web pages with a higher complexity.

Therefore, for those who are familiar with building web pages (which is considered to be an IT skill quite common in the age of the internet), they may very well consider developing their eLearning content from the ground up by leveraging on the versatility of HTML5. Indeed, many web-savvy teachers have been using commercial HTML editors (such as FrontPage and Dreamweaver) for years to build eLearning content.

A simple framework for a rapid eLearning authoring tool

At FLC, Nanyang Polytechnic, we have created our own rapid eLearning authoring tool using the framework as follows:



Figure 1: The FLC rapid eLearning authoring framework

For the content authors, the tool is basically a web-based text editor which they run from the web browser on their PC. As it is web-based, the editor supports practically all natural language scripts, including those of Japanese and Korean which are among the foreign language courses that we offer.

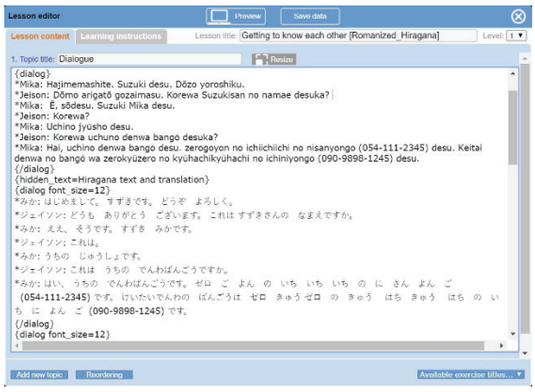

Figure 2: The FLC web-based text editor running from a browser

Our language teachers use a pre-defined set of mark-up tags to assemble text and media objects in the text editor. For example, the {dialog} tag is used for formatting a dialogue passage, the {audio} tag for inserting a clickable inline audio recording, and the {embedExo} tag for embedding a reinforcement exercise in the lesson.

A teacher with no programming background may need to spend 3 to 4 hours to learn how to use the most common mark-up tags before he/she can start building a typical lesson. Indeed, most of our language teachers managed to pick up the editing skill within hours, and some of them became masters within weeks.

The text editor will format the lesson content in XML data and save it in our web server. Together with the relevant media object files, the XML file will be uploaded to the LMS where a pre-built lesson

file in HTML5 format will interpret the XML data accordingly and display the learning content on the learner's browser screen:

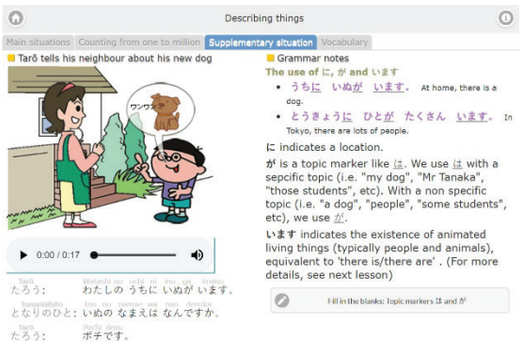

Figure 3: A Japanese lesson delivered from the LMS to the learner's browser on a computer screen

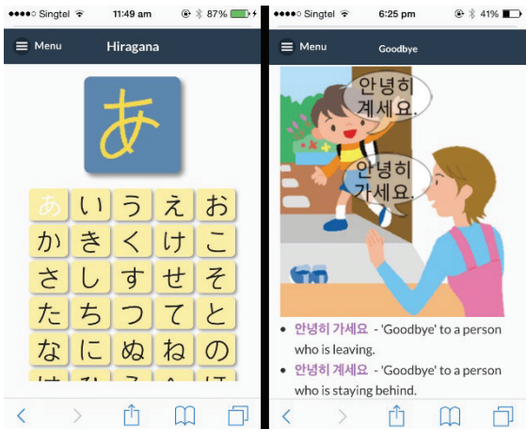

Figure 4: A Japanese lesson and a Korean lesson created by the same editor for smartphone screen

If the content of a lesson needs to be amended for one reason or another, the author can retrieve the XML file from the web server into the text editor for editing. After the amendment, he/she just needs to upload the updated XML file (and eventually new versions of media object files) again to the LMS.

Who needs an in-house eLearning authoring tool?

Admittedly, building an eLearning authoring tool even as basic as the one mentioned above will require some coding techniques. Based on our experience, an authoring tool with basic features and functionalities will require a skillful programmer to work over a period of three months. The cost is justifiable if the development involves a large group of content authors who share among them the same instructional design, similar sets of media objects and computer-mediated activities.

For instance, at FLC, our in-house authoring tool is used by some 10 language teachers across four foreign languages: French, German, Japanese and Korean. Every semester, they create and update the learning content of some 20 course modules catered to over 1,000 students. The media objects and the HTML5 lesson files are shared among the modules to a great extent.

As it is built in-house based on the HTML5 standard, the tool is highly extensible and scalable. It can grow to include more features and functionalities if need be. Indeed, by taking full advantage of the web community where an abundance of open source HTML5 templates, JavaScript snippets and CSS libraries are available, our authoring tool has grown into a powerful tool just nice and fit for our language teachers.

Results and Discussion

The major benefit of building our own tool is that it allows us to custom-make exactly the features and functionalities that we need. This helps to cut down on the time we would otherwise need to spend on exploring the full capability of a commercial package before we could use it effectively. Furthermore, our eLearning content can achieve a unique brand image and consistent user experience in terms of look and feel across all our language courses.

Conclusion

Our experience shows that it is possible to build eLearning content rapidly and directly on HTML5 without relying on third-party tools or add-ons. With our own authoring tool, language teachers only need to focus on certain features and skills required to create their learning content, thus avoiding the learning curve and heavy runtime overhead as entailed by the use of commercial tool packages.

Acknowledgement

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NURTURING PRE-PROFESSIONALS BY SCAFFOLDING 21ST CENTURY BUSINESS LITERACY SKILLS THROUGH AUGMENTED REALITY

C. Pang[*,a], W.M. Kong[b] and M. Goh[a]

[a] School of Business Management, Nanyang Polytechnic, Singapore
[b] School of Engineering, Nanyang Polytechnic, Singapore

*Chris_Pang@nyp.edu.sg

Abstract

Foundational literacy skills in critical reading and writing can impact pre-professionals' employability and career prospects. Classroom instruction alone is often insufficient and self-directed learning is essential for mastering literacy skills for future business success. This is because practice must extend beyond formal instructional hours for skills mastery. Few studies have specifically explored the issue of literacy skill attainment in business studies using new technologies. Most studies focus on language acquisition or content knowledge rather than literacy as a skill. For preparing 21st-century professionals, a technology-integrated approach is just as essential as workplaces become increasingly digitalised. This study explored how augmented reality (AR) could improve digital business literacy skills so that pre-professionals gained a future career advantage. AR holds the potential for the contextual embedding of literacy instruction scaffolds. An AR learning app was thus developed to provide self-directed learning using Vuforia and Unity 3D. The developed AR learning scaffolds included three types of contingent or just-in-time learning interactions, which learners could trigger – displayed explanations, guided instruction, and self-assessment. A randomised controlled trial with pre- and post-proficiency tests was used. The experimental group used AR while the control used printed materials. It was found that the experimental group significantly improved their literacy skills compared to the control groups. It is thought that the experimental group achieved higher literacy proficiency due to AR being more intuitive and the different scaffolds allowed for a greater immersion into logical and critical thought. The learners that benefitted the most was those who achieved lower proficiency scores in the pre-tests. Contingent AR scaffolds enable learners to quickly and intuitively receive digital content, which facilitates skill development for self-directed literacy improvement. The triggered just-in-time access to visual information and instructions supplemented with text, guided learners towards higher proficiency attainment. AR shows promise as an emerging educational technology. This is significant because integrating new technologies like AR can help prepare pre-professionals who are increasingly differentiated at the workplace by their ability to communicate and work with digital information.

Keywords: *Augmented reality, Business literacy, Critical reading, Critical writing, Scaffold, Self-directed*

Introduction

Both the World Economic Forum (2016) and OECD (2016) reported that higher foundational literacy proficiencies are linked to better wages and lower unemployment in the knowledge economy. It is often not disciplinary technical content attainment that usually holds learners back. Rather, it is their ability to read and write critically that failed them. Thus, learning how to improve business-related literacy skills independently can lead to improved career outcomes (Bentham, 2015). In order to succeed in the modern digital workplace, numerous studies have also found that self-directed learning for business achievement is strongly related to mastering literacy skills (Akhras, 2012; Abram, 2006; Leu et al., 2017; Storksdieck, 2016; Tompkins et al., 2014). Rapid technological advances in the future workplace have also led to the rise of 'digitalised literacy' and the much sought-after ability to work productively with digital information. Literacy instruction, as more researchers now attest, not only need to be embedded in sociocultural business practices and learnt contextually, but must also now be integrated with technology and Web 2.0 to be effective (Ali & Katz, 2010). To prepare future-ready pre-professionals, it holds that developing literacy skills must involve technology that can scaffold self-directed learning. In doing so, it achieves the dual goals of learning about and working with technology.

As such, this study's core purpose is to explore how augmented reality (AR) can improve digitalised business-related literacy skills so that pre-professionals gain a future career advantage. AR is recognised for its ability to provide on-demand self-triggered learning scaffolds. The focus is on understanding how contextual, just-in-time AR learning scaffolds can lead to increased literacy proficiencies. The study has two hypotheses:

H1: Learners using the AR-learning app will exhibit higher literacy proficiency in critical reading and writing due to self-directed contingent scaffolds.

H2: AR can assist learners of different starting initial proficiencies to achieve higher literacy proficiency attainment in critical reading and writing.

Few studies have specifically explored the issue of literacy attainment in business studies. Moreover, AR holds the potential for the contextual embedding of literacy instruction scaffolds into disciplinary content. Thus, this emerging educational technology requires further research to guide pedagogical practice.

AR and Literacy

Literacy underachievement is thought to be a result of disengagement with the learning content, which learners perceive as uninteresting. This can be linked to the rise of digitalised text as more recent literacy technologies have reshaped how text is generated and consumed and has subsequently changed learning preferences (Chun et al., 2016). A closely related emerging theme is the need for contingent scaffolding in literacy instruction. Scaffolding should ideally promote greater learner autonomy as it is essential in promoting academic and literacy competence (Meichenbaum & Biemiller, 2017). Contingent scaffolding provides on-the-spot interaction, just-in-time feedback and just-enough support (Daniel et al., 2015). The same researchers also emphasise the need to incorporate new technologies into literacy instruction. This leads to a growing recognition that literacy is shifting away from behaviourism towards constructivism and the goal is to support greater independent learning to build fluency (August et al., 2014; Gunning, 2013; Tompkins et al., 2014). It is perceived that independent or self-directed learning can be achieved using self-supportive scaffolding. It is believed that mobile computer-assisted learning can be used to achieve this.

Coupled to the rapid adoption of digital text is the rise of augmented reality (AR) which has the potential to provide immersive, experiential, contextual learning for learners mastering skills. AR confers the capability to trigger overlays of rich media onto the real world through web-enabled devices, thereby reducing cognitive overload by providing students with “perfectly situated scaffolding” in real-time. (Bower et al., 2014). In this respect, AR can be utilised to help learners who require timely guidance to improve their literacy proficiency while concurrently developing digital literacy. The opportunity to address a literacy gap with an emerging technology has immense forward-looking value for education. It addresses the demand to prepare tertiary students for the digital age that leverages their preferred use of technology for learning.

Methods

An AR learning app with self-directed learning scaffolds was developed for mobile devices using software, Vuforia and Unity 3D. The developed AR learning scaffolds included three types of contingent or just-in-time learning interactions, which learners could trigger. These were namely: i) Displayed Explanations, which was a pop-up information layer providing basic literacy explanations; ii) Guided Instruction, which was a layer showing how inferences and insights are connected and derived in a visual manner, and iii) Self-Assessment, which was a feedback layer that allowed the comparison of completed assessment exercises with the model solution with explanations.



Figure 1 AR Worksheet for Critical Reading and Critical Writing Skills

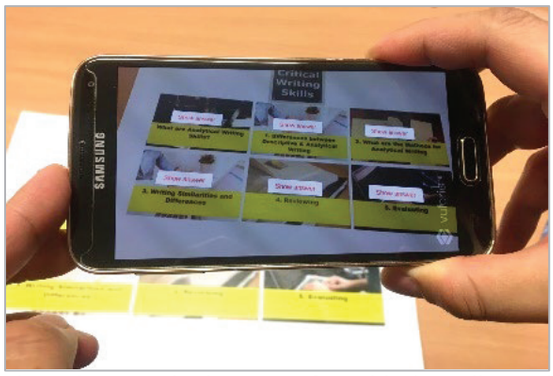

Figure 2 Customised AR App for Critical Reading and Critical Writing Skills

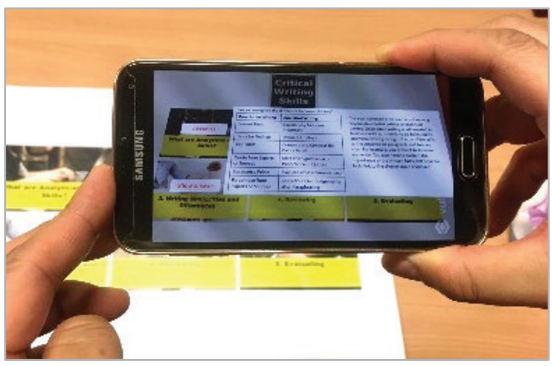

Figure 3 Triggered AR App for Critical Reading and Critical Writing Skills with Scaffolds

The participants were 40 first-year business learners aged between 17-21 years who have all completed a foundational 60-hour business writing skills course. A randomised controlled trial was used. Twenty learners were randomly selected to be in the experimental group

and used the AR learning app for critical writing and reading for 45 mins. The randomly selected control group of 20 learners used a print-only text with call-out boxes and answers at the end, for 45 mins. The learning content were identical and covered the principles of critical writing and reading with self-assessment exercises. Pre- and post-proficiency tests involving performance tasks were used. In the first part, the performance tasks involved a critical reading scenario where learners were tested on the ability to spot critical reading principles and to make insights and inferences. The first part had 10 multiple choice questions. In the second part, learners were required to review a 100-word paragraph to identify critical writing principles. They then wrote a short paragraph based on a given topic. The second part had five fill-in-the-blanks and one free-writing exercise. The proficiency tests were online tests which learners completed in a computer lab within 45 mins. The proficiency tests were based on the OECD Programme for the International Assessment of Adult Competencies (PIAAC) literacy frameworks (OECD, 2016b).

Results and Discussion

The study sought to determine if learners using the AR-learning app would exhibit higher literacy proficiency in critical reading and writing due to self-directed contingent scaffolds. It was found that the experimental group significantly improved their literacy skills more than the control group for the post-tests (t-test 2.77, p=0.009). The experimental and control groups showed no significant differences for their pre-tests (t-test 0.14, p=0.891).

Table 1 Comparison between AR and Traditional Groups

	Group	N	Mean	Std. Dev.	Std. Error Mean
Pre-Test	Control	20	19.45	4.3586	.97461
	Exp.	20	19.65	4.8152	1.07673
Post-Test	Control	20	20.50	2.9469	.65895
	Exp.	20	23.05	2.8741	.64267

While both groups exhibited improvements, it was the AR experimental group (23.05/30 (76%)) that outperformed the control group (20.50/30 (68%)) in the post-test. It is thought that the experimental group achieved higher literacy proficiency due to AR being more intuitive and the different scaffolds allowed for a greater immersion into logical and critical thought (Chiang et al, 2014).

Further comparisons between the AR experimental and control groups produced mixed results. The AR experimental group was statistically significant for critical reading (t-test 2.30, p=0.029) and for free-writing (t-test 2.37, p=0.023) compared to the control group in the post-test. Critical writing was not significantly different (t-test 1.82, p=0.244) for the AR experimental group in the post test.

Table 2 Comparisons of Critical Reading, Writing and Free-Writing Test Components

	Group	N	Mean	Std. Dev.	Std. Error Mean
Critical Reading	Control	20	7.85	.8750	.19568
	Exp.	20	8.75	1.5174	.33931
Critical Writing	Control	20	2.65	1.0399	.23255
	Exp.	20	3.05	1.0990	.24575
Free-Writing	Control	20	10.00	1.7770	.39736
	Exp.	20	11.25	1.5517	.34698

The increased performance in critical reading and free-writing could be explained by the AR scaffolds used. Triggered explanations with displayed pop-outs illustrating key critical reading concepts like previewing, scanning and keywording helped learners master key strategies to improve reading comprehension. Guided instruction further assisted learners in training their eyes and minds for critical reading. Guided instructions were helpful for developing free-writing as it provided AR prompts that showed learners sequentially on the type of evidencing and sentences needed for developing topically sound paragraphs. It would also seem that the current AR learning scaffolds used were less effective for developing reviewing and evaluating literacy skills. In critical writing, learners were taught to differentiate between descriptive, analytical and argumentative/positional writing. The nuances were harder to bring forth with the current AR scaffolds used. Therefore, a rethink is necessary to redesign AR learning experiences to develop this particular literacy skillset. AR self-assessment scaffolds were also insufficient to develop reviewing and evaluating skills. In hindsight, the AR scaffolds for reviewing and evaluating required comparative layers illustrating key differences between different writing styles so learners can overlay for comparison to better visualise the nuances. AR allows for multiple layers of content to be presented separately or all at once.

The study also sought to determine if AR could assist learners of different starting literacy proficiencies to achieve higher literacy proficiency attainment in critical reading and writing. The AR experimental group was clustered into different literacy proficiency tiers of high (>80%), average (70%-79%) and low (<69%) based on their pre-test scores. The post-test performance of each clustered subset were compared against their pre-test scores. The learners in the AR experimental group that benefitted the most was those who achieved lower proficiency scores in the pre-test. Learners with average or higher initial literacy proficiencies had less significant differences comparatively. The lower literacy proficiency attainment scores in the control group can be attributed to a lack of interest in using printed text. Learners were noticeably less enthusiastic reading the printed text. Digital nativity might be at work here.

Table 3 Performance Improvements within the AR Experimental Groups

Literacy Proficiency	Group	Pre-test Mean Score (100%)	Post-test Mean Score (100%)	Change (%)
High Proficiency	Control	85.0	81.7	-4.1%
	Exp.	86.7	90	3.7%
Average Proficiency	Control	73	72.6	-0.6%
	Exp.	72	80	9.8%
Low Proficiency	Control	52.2	61.9	14.6%
	Exp.	47.1	66.7	**29.2%**

It is believed that contextual and contingent scaffolds benefitted weaker students more as they were able to review and revise learning content repeatedly at the point where immediate clarification was most needed. This immediacy led to better retention and thus, bridged the learning pathways to higher order proficiencies. In other words, AR demonstrated the ability to facilitate the learning pathway necessary for better literacy performance when working with digital information. Learners with weaker proficiencies shared that they were able to grasp the concepts more readily as they could access learning instruction at the point of need and application. They also favoured using the AR self-assessment scaffolds as it allowed for repeated attempts. For the weaker learners, repeated drills and practice might be necessary for skill development. It is recognised that learners were using AR for literacy for the first time. They have experienced AR in other disciplines and in personal contexts like games and social media before. While learners are not new to AR, the element of a novelty still exists. This might have prompted greater initial engagement.

Conclusions

This study investigated whether learners could achieve improved business-related literacy skills through the use of AR, especially for preparing pre-professionals who must now cope with a digitalised form of literacy in the modern workplace. It also sought to explore if learners could improve literacy skills independently, without the need for an instructor-led face-to-face facilitation as lifelong learning is necessitated by self-directedness. It can be concluded that contingent AR scaffolds enable learners to quickly and intuitively receive digital content, which facilitates skill development for self-directed literacy improvement. The triggered just-in-time access to visual information and instructions supplemented with text, guided the learners toward higher proficiency attainment. It is interesting to note that AR scaffolds have the potential to allow weaker learners to catch up with stronger learners by providing contingent or just-in-time learning support and this is critical in ensuring more learners attain the desired competency proficiency levels. AR thus, can have an equalising effect on skill achievement.

AR shows promise as an emerging educational technology. It can be used effectively for business and soft skills and this is significant because pre-professionals are increasingly differentiated at the workplace by their ability to communciate and work with digital information. This study recognises that the controlled trial was modest in scale and was designed more to probe specific hypotheses to better understand the nature of AR scaffolds. A pilot is necessary as it avoided costly trial and error. Also, as research in AR use for business literacy skills is limited, a pilot exploratory study provides critical guidance. The controlled trial pointed to the opportunities AR presents for technology-integrated learning beyond STEM applications. A future research direction is to conduct a broader study with a large participant size. The key learning points from the controlled trials can help facilitate such future studies of scale.

Acknowledgements

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AN EDUCATIONAL TOOL DESIGNED TO DELIVER A VIRTUAL WORLD IN ORDER TO OBSERVE COSMIC RAYS ON EARTH

I. Takemoto[a], H. Tenzou[*,a], Y. Komatsu[a], K. Yokoyama[b], A. Nagoshi[b] and Y. Kunimi[b]

[a] National Institute of Technology, Kagawa College/Department of Electronic Systems Engineering, 551 Kohda, Takuma-cho, Mitoyo-shi, Kagawa, 769-1192, Japan
[b] National Institute of Technology, Kagawa College/Advanced Course in Electronics, Information and Communication Engineering, 551 Kohda, Takuma-cho, Mitoyo-shi, Kagawa, 769-1192, Japan

*tenzou@es.kagawa-nct.ac.jp

Abstract

It's important to develop educational tools to observe cosmic rays in order to enhance learners' interest in particle physics or astrophysics. The learners will be able to confirm interactions of primary cosmic rays and production, transportation, and propagation of the secondary cosmic rays if the observations are performed at different altitudes (sea level, at mountain level, or in balloon born experiments). Cloud chambers or spark chambers are common tools to observe tracks of high-energy charged particles directly. However, it is difficult to take learners and these chambers at the different altitudes and to distinguish among each kind of particles in the tracks generated by charged particles. Besides, effective volumes of the chambers are limited so that it takes lots of time to measure the flux of cosmic rays at each different altitude. Therefore, our purpose of this study was to develop an educational tool designed to deliver a virtual world in order to observe cosmic rays on Earth. An Oculus Rift was selected as the head mounted display to show the virtual world and Unity was used to produce CG animations. The tools can change the altitude and select the kinds of target cosmic rays. The tool can provide 360 degrees panorama image at various angles of view for the learners so that learners can understand the differences of flux at each altitude immediately and intuitively. The zenith angle θ of each falling cosmic ray is generated by random number according to a probability density function. The n is determined by the kinds of cosmic rays. The flux and energy of each particle are also generated by random number according to measurement data of the flux and the energy spectrum pf each particle at each altitude. Virtual concrete walls were prepared at sea level in the virtual world to make learners feel the differences in energy attenuation of charged particles by concrete. As the results, it was demonstrated that the system can create the virtual world and it was confirmed that cosmic rays were well reproduced at sea level.

Keywords: *educational tool, cosmic rays, unity, virtual reality, muon, Oculus Rift*

Introduction

Cloud chambers or spark chambers are common tools to observe tracks of high-energy charged particles directly. It is, however, difficult to take learners and these chambers to the different altitudes and to distinguish among each kind of particles in the tracks generated by charged particles. Besides, effective volumes of the chamber are limited so that it takes lots of time to measure the flux of cosmic rays at each different altitude. Therefore, the purpose of this study was to develop an educational tool that can observe cosmic rays on Earth in virtual spaces. Table 1 shows a comparison with the conventional chambers.

It is important to be well reproduced the characteristics of cosmic rays in this study in order to enhance learners' interest in particle physics or astrophysics. In our VR educational tool, it's no need preparation for observation of cosmic rays except for a PC and a HMD. The observation points with two different altitudes were implemented. Cosmic rays energy spectrum was also well reproduced based on the experimental data set for each different altitude.

Table 1. Comparison with Conventional Chambers

	Conventional Type		VR Educational Tool
	Cloud Chamber	Spark Chamber	
Reality	◎	◎	△
Event Rate	○	○	○
Preparation	△	△	◎
Any Place	×	×	◎
Energy	×	×	◎

When primary cosmic rays caused by galactic activities hit on the atoms in the atmosphere, secondary cosmic rays are generated and the each direction of motion is changed. Cosmic rays with extremely high energy over several hundreds of GeV caused particle

generation repeatedly called an air shower phenomena one after another. The muon occupies about 75 [%] of the cosmic rays falling on the surface of the Earth. The general angular distribution of muon I is approximately described as is follows (1):

$$I = I_0 cos^2\theta \qquad (1)$$

where, θ is the zenith angle and I_0 is the flux at zenith angle 0[°]. The zenith angle θ of each falling cosmic ray is generated by random number according to a probability density function. The flux and energy of each particle are also generated by random number according to measurement data of the flux and the energy spectrum of each particle at each altitude.

System Overview

The purpose of this study was to develop an educational tool to support learners to understand basic characters of muons intuitively by using a head mounted display. Figure 1 shows an overview of this system. This system was composed of virtual reality head mounted display "Oculus Rift" (Oculus Rift 2018), a pair of Oculus Touch, and a Windows PC. A DELL ALIENWARE Area-51 15Q42 and the graphic board GeForce GTX 1080 Ti GAMING X 11G were selected to create and draw 3DCG objects in real time. Oculus Touch was used to manage both the movement of the learner and the line of sight in virtual world. The system was implemented by using Unity version 2018.1.0f2 (Unity 2018). The code was written in C# language. Unity is the useful game engine to create a virtual reality space. 3DCG graphics of the muon and landscapes at Sea level, at mountain level or altitude of international airline flight.

Figure 2 is a sample of landscape on learner's HMD in a virtual mountain lodge. The red lines mean muons created by 3DCG. The learner can change the angle and position in the mountain lodge in real time. The learner can learn with feeling as if they entered the virtual reality space, and move freely within the spaces by operating Oculus Touch.

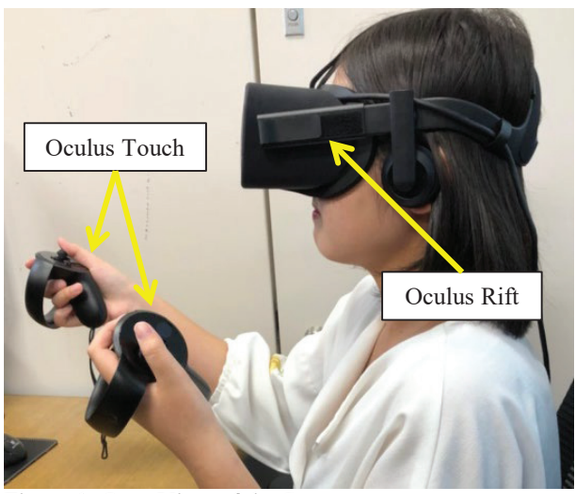
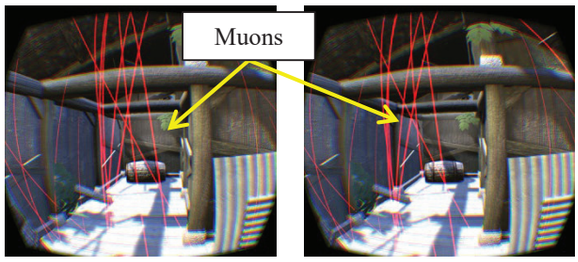


Figure 1. Over View of the System



(a) Left Lens (b) Right Lens
Figure 2. A Landscape on Learner's HMD

Figure 3 is the data flow diagram of the system. A simulation software EXPACS can calculate atmospheric cosmic-ray spectrum (T. Sato 2016). EXPACS was used to reproduce the muon flux and energy spectrum at different observation sites with different altitudes. The muon flux and energy spectrum was pre-calculated and the cumulative distribution function based on the probability density functions were prepared to generate random number based on science experimental data. Figure 4 is EXPACS calculation result of the flux [muons/cm^2/s] from 0[km] to 13 [km] altitude at latitude 34 [°], longitude 133 [°]. Figure 5 means a probability density functions to generate zenith angles θ of muons proportional to $cos^2\theta$ and the cumulative distribution function.

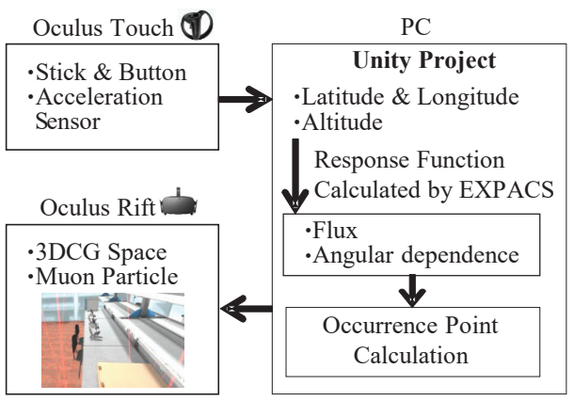


Figure 3. Data Flow Diagram of the System

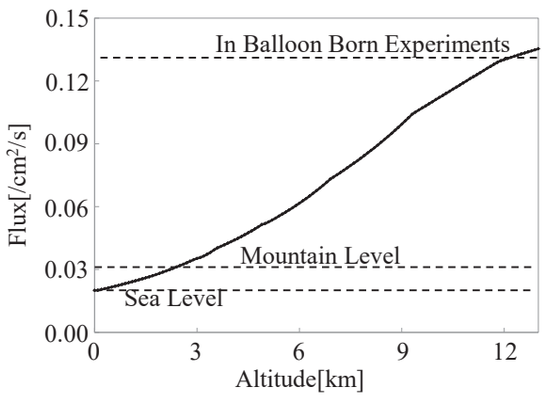


Figure 4. Calculation Flux by EXPACS at Latitude 34[°] and Longitude 133[°]

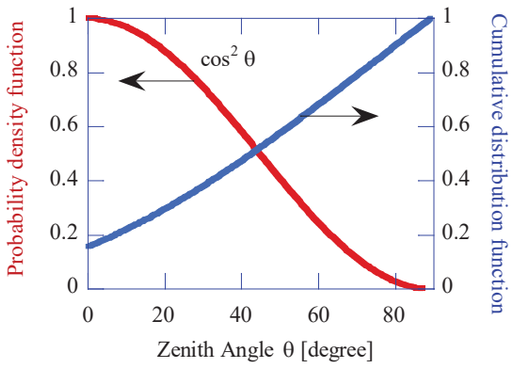


Figure 5. PDF for Zenith Angle and the CDF

Generation of Muon CG graphics

Figure 6 shows how to create a muon CG graphics. The muon falling through the coordinates (X_1, Y_1, Z_1) in a plane was obtained by two random functions, and the angle θ is decided based on the approximate random number obtained by the distribution of $cos^2\theta$. The rotation angle φ of the cone is in the range of 0 [°] to 360 [°]. The generation point (X_0, Y_0, Z_0) was decided by the zenith angle θ and the rotation angle φ with the coordinates (X_1, Y_1, Z_1) as a base point. The muon was reproduced by drawing a line from the generation point (X_0, Y_0, Z_0) to the coordinates (X_1, Y_1, Z_1). Three virtual spaces (sea level, at mountain level, or in balloon born experiments) were created by Unity. Each altitude were assumed to be 0 [km], 2.7 [km], 12 [km] and the flux were 0.02 [/cm²/s], 0.033 [/cm²/s], 0.13[/cm²/s], respectively. The drawing region was limited to 4[m²] around the learner under the limitation of draw rate so that the 3DCG of mountain lodge or experimental room less than 4[m²] was used. Figure 7 is the result of a draw rate for muon CG graphics at 0[km]. We can also see a peak around 15[ms] and the tails. These are frame buffer draw events occurred by our graphic board. The average draw rate was 1.3[ms]. Muon flux at 0[km] altitude is about 800[cps] in the area less than 4 [m²] so that it's confirmed that the system has enough capacity to draw 3DCG objects of muons in the CG world.

Figure 8 is the zenith angle distribution at 0[km] for elapsed time 1, 5, 10, 20 [s]. A $cos^2\theta$ curve was fitted to a given data set of 20 [s]. We can see that the zenith angle distribution was close to $cos^2\theta$ curve proportional to elapsed time. Figure 8 is zenith angle distribution at 0[km] for elapsed time 1, 5, 10, 20 [s]. A $cos^2\theta$ curve was fitted to a given data set of 20 [s]. We can see that the zenith angle distribution was close to $cos^2\theta$ curve proportional to elapsed time.

The overhead view of virtual spaces is shown in Figure 9. An experiment room shown in Figure 9 -(a) and mountain lodge shown in Figure 9 -(b) were selected at sea level and mountain level, respectively. The difference of flux at different altitude is shown in Figure 10. The flux in Figure 10 -(b) is about 1.6 times than the one in Figure 10 -(a). The learner can observe visually that the zenith angle of the muon follows the angle dependence of $cos^2\theta$ and the number of irradiated muons depends on the altitude.

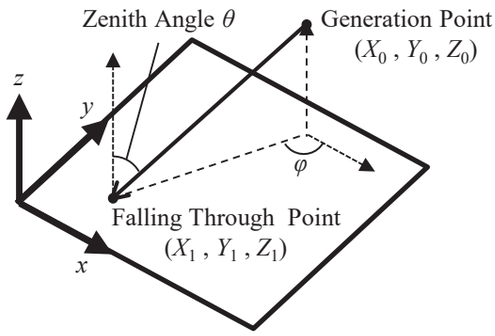


Figure 6. Example of Muon CG Graphic

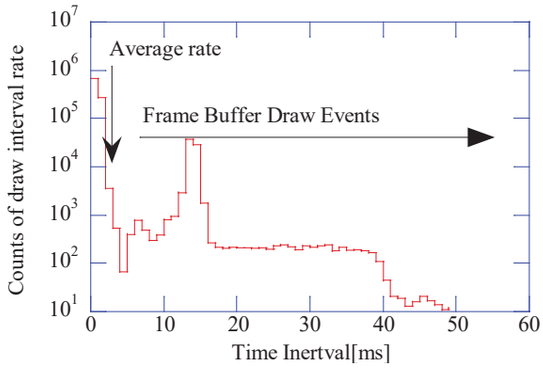


Figure 7. Average Rate of Muon CG Graphics at 0[km]

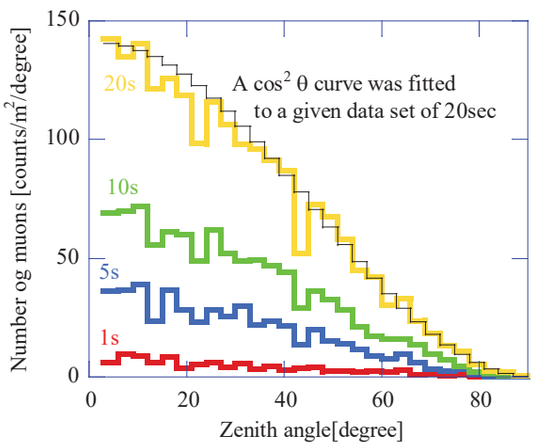
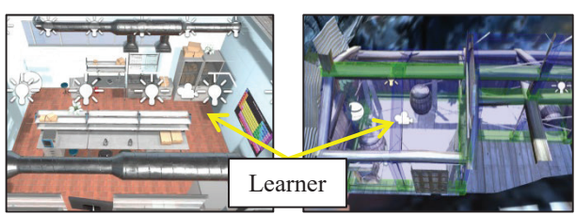
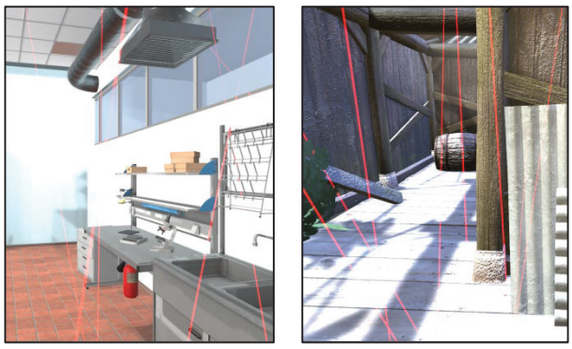


Figure 8. Zenith Angle Distributions



(a) Sea Level (b) Mountain Level

Figure 9. Overhead View of Virtual Spaces



(a) Sea Level (b) Mountain Level

Figure 10. Change in Muon Flux Due to Altitude

Questionnaire

A questionnaire was taken to survey in order to assess learning effects. This survey was taken for 96 students in National Institute of Technology, Kagawa College. As the first step, the students watched a movie about a spark chamber that was taken in High Energy Accelerator Research Organization (Stylograph601 2012). As the second step, the students wacthed movies in case of 100 [muons/s] and 1000 [muons/s] while listening to the explanation about the correct number of muons. As the last step, four items were tested for the 96 students as follows. As the first item, "How many muons you can see?" was asked after the students had watched two movies about our system in the case of 0 [km] and 2.7 [km]. Figure 11 was the their replies.The points of arrowed lines are the correct answers for both cases. It was confirmed that the learners can understand the number of muons intuitively. The second item was "Do you think muons intensities have zenith angle distribution?". Figure 12 was the result. The learners more than 87% can understand zenith angle distribution of muons. The third item was "Do you think CG objects of virtual muons in this system was well reproduced real muons observed in the spark chamber?". Figure 13 was the result and it was confirmed that more than 78% learners agree to be able to reproduce real muons falling. The fourth item was "Do you think that the system can support learners to understand the characteristics of muons?". Figure 14 was the result. It was revealed that more than 79% learners think the tool has possibility to support to learn muons characteristics.

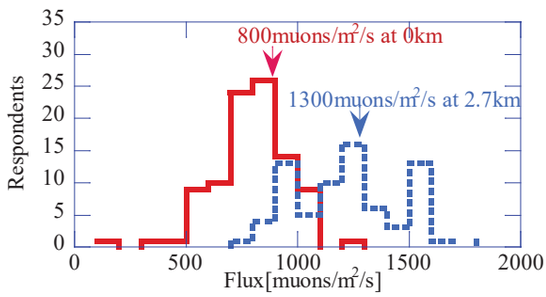


Figure 11. Q1. Distribution of the Number of Muon

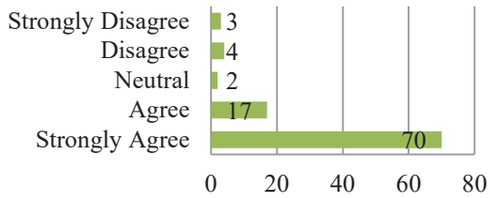


Figure 12. Q2. "Do you think muons intensities have zenith angle distribution?"

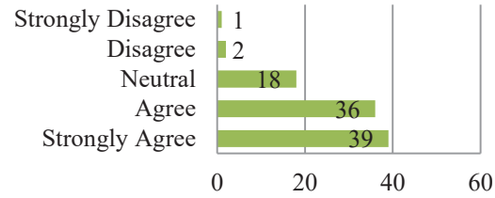


Figure 13. Q3. "Do you think CG objects of virtual muons in this system was well reproduced real muons observed in the spark chamber?"

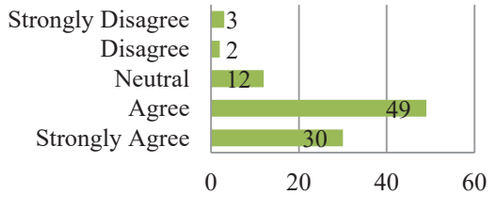


Figure 14. Q4. "Do you think that the system can support learners to understand the characteristics of muons?"

Conclusions

In this study, the educational tool to observe virtual muons in order to enhance learners' interest in particle physics or astrophysics was developed and demonstrated for 96 students in NIT, Kagawa College. It was confirmed that the system was able to reproduced the angular dependence distribution and flux based on experimental data in virtual space. The questionaire was taken to assess the learning effects. The results show that the learners can understand both the number of muons intuitively and the zenith angle distribution.

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QUALITY DIMENSIONS AND STRATEGIES OF MOBILE LEARNING

Jason Chui*, Zhen Zhen Leow and Cally Ng

Nanyang Polytechnic, School of Information Technology, Singapore

*jason_chui@nyp.edu.sg

Abstract

The proliferation of mobile devices among especially the younger generations has led to a change in expectations and appetite when it comes to learning. Learners now prefer to learn "on-the-go" and to have the learning contents literally at their fingertips. It is hence imperative that educational institutions evolve accordingly by making more of their contents "mobile friendly". However, robust frameworks and design strategies for mobile learning are still in the nascent stages of education research. This research builds on existing literature in the field of mobile learning pedagogy to propose novel mobile learning quality dimensions and strategies, which instructors can use to design their own courses.

The research is conducted on 120 identified learners from 2 faculties, School of IT and School of Health Sciences who were undertaking their respective core modules. The participating instructors designed mobile learning packages in accordance with the proposed mobile learning quality dimensions and strategies and disseminated the packages to the learners. The authors collected feedback from learners via survey questionnaires on a four-point Likert scale to measure the level of learners' satisfaction with the mobile learning packages. The authors also examined the module learning outcomes through classroom observations coupled with discussion with the instructors to gauge the level of instructors' satisfaction as well as the level of attainment learners achieved in the required competencies.

Both qualitative data and sentiments are collected from survey and classroom observations have been encouraging. The qualitative data collected measured the effectiveness of the proposed design strategies against various quality dimensions for mobile learning from existing literature. Collection of sentiments has shown that the positive acceptance of the proposed strategy by both the learners and instructors.

This research has established a fundamental set of quality dimensions and design strategies dedicated for developing mobile learning content. The preliminary results demonstrate that the design strategies are effective and mobile learning appeals to the modern learners' appetite for convenience and flexibility to learn "anywhere, anytime".

The quality dimensions and strategies recommended are to be adopted by the instructors when designing mobile learning contents for their module.

Keywords: *Mobile Learning, Elearning, Mlearning, Quality Dimensions, Design Strategies*

Introduction

Mobile electronic devices have come a long way, from being a niche technology to being an almost ubiquitous tool that touches a myriad of fields in the world. In the realm of education, schools and educators are incorporating mobile learning into their curriculum steadily to tap on the affordances of mobile devices as well as the availability of these devices in the hands of learners.

In the past two decades, research into mobile learning has picked up pace, with numerous frameworks for mobile learning being suggested by different groups of researchers. At the same time, multiple reports have shown that there is a gap between the translation and adoption of research results and theories into actual practice, be it in education or other fields of studies.

This paper attempts to bridge this gap by presenting "middle layers" that can be introduced between the theoretical frameworks and the concrete steps that educators can adopt to implement the rich body of research on mobile learning to their own curriculum design. These "middle layers" are split into 1) quality dimensions that are framework-facing, and 2) mobile learning strategies that are practice-oriented. Mobile lessons based on these "middle layers" were created and data were gathered to assess their effectiveness.

Background

The number of mobile phone users have steadily climbed throughout the years and is expected to exceed 5 billion in 2019 (Meena & Kumar, 2017). Though originally created for adults for business use, young people has adopted mobile technology so readily that

the mobile phone has already become an essential component in their lives, even more so than adults (Campbell, 2005), so much so that Ling (2000) even stated that the mobile phone is "at cross purpose with the mission of the school". Forward-looking researchers and institutions have accepted the paradigm shift, and many have embarked on incorporating mobile learning into their curriculum (Kljunić & Vukovac, 2015; Oberer & Erkollar, 2013; Taleb & Sohrabi, 2012; Wang, Shen, Novak & Pan, 2009).

It is Sharples et al. (2009), who have one of the more encompassing definitions of mobile learning, unpacked mobile learning into 1) mobility in physical space, 2) mobility of technology, 3) mobility in conceptual space, 4) mobility in social space, and lastly 5) learning dispersed over time. Regardless of the definition, it is commonly recognized that mobile learning is a subset of electronic learning (elearning) with its own characteristics and constraints (Parsons & Ryu, 2006).

In the past two decades, research into mobile learning has picked up pace, with numerous frameworks for mobile learning being suggested by different groups of researchers. Koole's (2009) FRAME (Framework for the Rational Analysis of Mobile Education) model "describes mobile learning as a process resulting from the convergence of mobile technologies, human learning capacities, and social interaction." It is a comprehensive framework that takes into account not only the technical affordances of mobile devices, but also the social and personal aspects of learning. In this paper, we propose two middle layers between Koole's FRAME model and actual practice to simplify the theory for instructors to implement in their mobile lesson design. Two middle layers are proposed instead of one so that there is less information dropped at each layer.

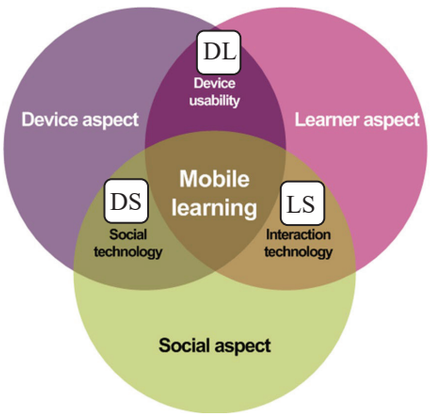
Proposed Quality Dimensions

Using Koole's FRAME model as the framework for choice, we crafted quality dimensions as rhetorical guiding questions that could be mapped from the overlaps between the circles in the FRAME model. As shown in Figure 1, we are using Koole's terminology where the three intersections are abbreviated by the terms DL (Device-Learner intersection, which points to device usability), LS (Learner-Social intersection, which points to interaction technology), and DS (Device-Social intersection, which points to social technology). These questions were based on multiple research on mobile learning and aim to condense the knowledge and wisdom of these research yet not be too shallow and inflexible.

These nine questions comprise the quality dimensions that this paper proposes to aid instructors in designing mobile lessons, by providing them rhetorical questions to anchor their design in the theoretical framework. However, taking human behavioural science into consideration, we went one step further to create a mnemonic that gives instructors a "chunked" checklist to use when designing mobile lessons. We term the breakdown of this mnemonic "mobile learning design strategies".

Proposed Design Strategies

The design strategies proposed (see Figure 2) are extracted from both Koole's FRAME model as well as the quality dimensions discussed above. They are grouped together via the mnemonic MOHICANS to facilitate instructors' retention and encourage usage. The first three design strategies are general design considerations that stem from the FRAME model directly, while the next five strategies are drawn directly from the quality dimensions.



Koole's FRAME
mobile learning framework

Quality Dimensions of Mobile Learning

DL
1. Are the learning outcomes clear and concise?
2. Are the contents in "short nuggets"?
3. Are the contents easily navigable?
4. Are the contents readable on a mobile device?
5. Can contents be downloaded to the mobile device and accessed easily?
6. Is the progress of the learner tracked?

LS
7. Are there social interactions for learning between learners and between learners and instructor?

DS
8. Are there formative/self-check and summative assessments?
9. Are there timely and constructive feedback to support learners' learning?

Figure 1: Mapping of Koole's FRAME to Quality Dimensions

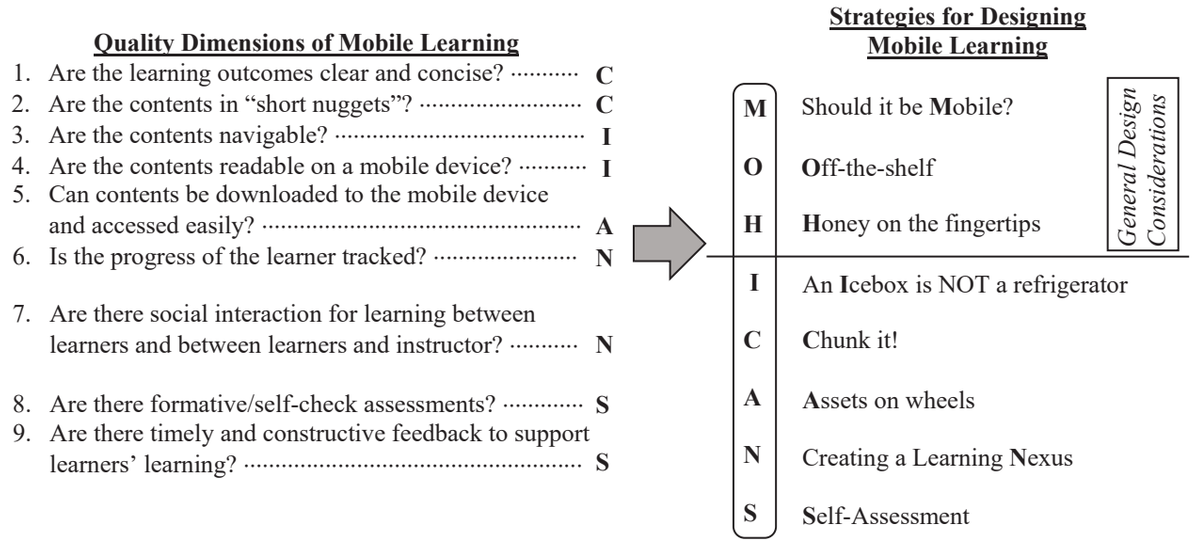


Figure 2: Mapping of Quality Dimensions to Design Strategies

i. M is for "Should it be Mobile?

The very first general design consideration strategy for instructors when contemplating to create a mobile lesson will be to consider the most pertinent questions: Is it based on a timely and relevant topic that learners would like to have a quick refresher on while on-the-go? Would this lesson be better presented if delivered in a device with a larger form factor or in a physical class?

ii. O is for "Off-the-shelf"

The next general design consideration is for instructors to consider off-the-shelf solutions before creating materials from scratch. For example, it would be more useful to embed a video containing animation that could present the materials in a more visually appealing manner than for the instructor to put the contents in textual form.

iii. H is for "Honey at the fingertips"

The last general design consideration is for instructors to remind themselves to design their mobile lessons to be interactive so as to keep the attention of learners. Instructors would want to design their mobile lesson so that the lesson seems to be like "honey" which learners would like to "taste" from i.e. make it enticing to learners.

iv. I is for "An Icebox is NOT a refrigerator"

This is the first design strategy drawn from the quality dimensions, namely dimensions 3 and 4 (readability and navigability). Although it is true that mobile learning is a subset of elearning, it has such distinct features that simply claiming that one has an elearning lesson means that it can be counted as a mobile learning lesson is a very shallow claim. We hope instructors can use this visual metaphor for an icebox versus a refrigerator to remind themselves to not confuse desktop elearning with mobile learning.

v. C is for "Chunk it!"

To facilitate retention for learners of a mobile lesson, research on psychology suggests that chunking large amount of information into small parts helps people to remember things better. For this reason, mobile lesson designers are reminded to chunk both their learning outcomes and contents into small "nuggets" of information to aid learning, vis-à-vis quality dimensions 1 and 2 respectively.

vi. A is for "Assets on wheels"

Unless a school or institution started off by creating mobile lessons, educators most probably have their materials in the form of slides or text documents. Transiting to mobile lessons necessitates instructors to put these educational "assets" on "wheels" i.e. unhinged them from the original presentation format (slides or documents) and plug them into the mobile lesson. This is akin to the separation of the presentation from the data in the Model-View-Controller (MVC) architecture in the realm of computer science (Davis, 2008; Heidke, Morrison & Morrison, 2008).

vii. N is for "Creating a Learning Nexus"

With regards to quality dimensions 6 and 7, which suggest respectively that the learner's progress be tracked and social interaction for learning be introduced, we recommend that the mobile lesson be integrated into a Learning Management System (LMS) to tap on the LMS's in-built login system, discussion forum etc. This will lessen the burden of the instructors to dabble with

networking aspects, while at the same time adhere to the MVC framework.

viii. S is for "Self-Assessment"

Lastly, quality dimensions 8 (assessment) and 9 (timely feedback) are mapped unto the strategy of self-assessment. Mobile lessons should have both in-content mid-lesson quizzes for milestone checks, as well as summative assessments to gauge the overall learning outcomes of the learners. If these assessments could integrate feedback into the answers that learners gave, it would constitute the timely feedback that they need to close the loop on their learning.

Methods

Participants in the present study consisted of 120 identified learners from 2 faculties namely, School of Information Technology and School of Health Sciences. The participating instructors designed their mobile learning contents in accordance to the mobile learning quality dimensions and strategies that was highlighted in this paper. This study aims to find out how quality dimensions and strategies can enhance the quality of learners' learning. Each learner was surveyed to answer the following questions:

1. The learning outcomes are clear and concise.
2. The content is bite-sized for learning on-the-go.
3. The content is easily navigable.
4. The content is readable on a smart device.
5. The content helped me in fulfilling the assessment required for this topic.
6. There are timely and constructive feedback to support learning.
7. The mobile learning contents have been helpful to me in my learning.
8. The mobile learning contents are self-paced, self-directed and relevant.
9. Overall, I find that mobile learning is good way of learning for me.

Besides the survey results from the learners, the authors examined the module learning outcomes through classroom observations coupled with discussion with the instructors to gauge the level of instructors' satisfaction as well as the level of attainment learners achieved in the required competencies.

Results and Discussion

In this section, we will discuss the results that was derived from the methods that were explained above. The results from the survey shows that the learners felt that mobile learning contents has helped them in their learning. Results has also shown that 90% of the learners felt that the mobile learning is good way of learning for them.

The following are the key results of the responses collected from the survey.

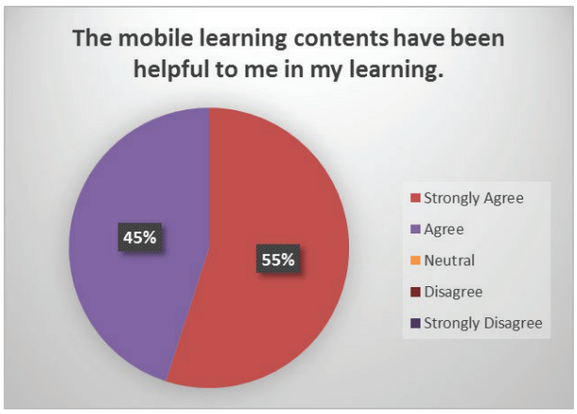


Figure 3: The mobile learning contents have been helpful to me in my learning.

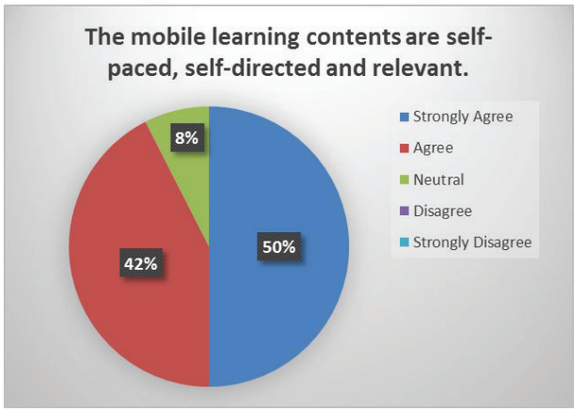


Figure 4: The mobile learning contents are self-paced, self-directed and relevant.

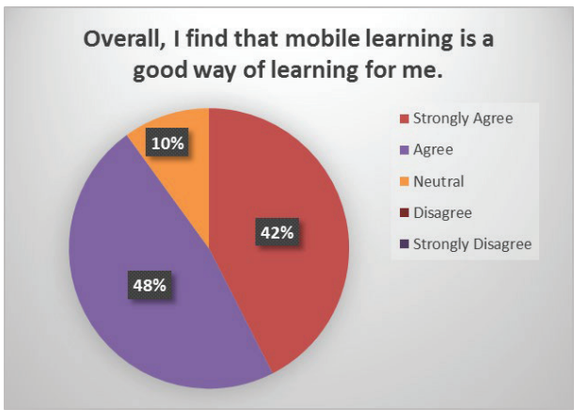


Figure 5: Overall, I find that mobile learning is good way of learning for me

Table 1: Summary of responses to Q1-Q6

Question	Response
The learning outcomes are clear and concise.	Strongly Agree (58.3%) Agree (41.7%) Neutral (0%) Disagree (0%) Strongly disagree (0%)
The content is bite-sized for learning on-the-go.	Strongly Agree (58.3%) Agree (41.7%) Neutral (0%) Disagree (0%) Strongly disagree (0%)
The content is easily navigable.	Strongly Agree (52.1%) Agree (39.6%) Neutral (8.3%) Disagree (0%) Strongly disagree (0%)
The content is readable on a smart device.	Strongly Agree (62.5%) Agree (31.3%) Neutral (6.3%) Disagree (0%) Strongly disagree (0%)
The content helped me in fulfilling the assessment required for this topic.	Strongly Agree (54.2%) Agree (39.6%) Neutral (6.3%) Disagree (0%) Strongly disagree (0%)
There are timely and constructive feedback to support learning.	Strongly Agree (58.3%) Agree (31.3%) Neutral (10.4%) Disagree (0%) Strongly disagree (0%)

Both qualitative data and sentiments collected from survey and classroom observations have been encouraging. Sediments from the feedback gathered has indicated that the positive acceptance of the proposed strategy by both the learners and instructors.

Analysis of the collected data revealed that Mobile Learning was effective than the use of traditional teaching pedagogy to achieve the learning outcomes of the topics that the contents are developed in mobile learning packages. Results of the present study have also proved that by using these quality dimensions and design strategies dedicated for developing mobile learning content, there is an increase of interest in learners' learning and has enriched the learners' experience. The instructors have also feedback that the quality dimensions and mnemonic MOHICANS have provided them practical design strategies that helped them to design learning contents suitable for mobile learning. From the score that the learners have achieved in the summative assessment, it can be determined that the learners have achieved the learning outcomes desired of the mobile learning contents. Most of the learners are able to score above 80% after going through the mobile learning contents.

Conclusions and Recommendations

With the proliferation of mobile devices and millennials today have shorter attention span, it is evident that traditional learning content no longer works. They value timely information and rapport with their instructors ("How to engage millennials: 5 teaching strategies for millennials that will work!," 2017). This study aims to address the learning needs of this new generation by bridging the gap between research theory and actual practice with a set of practical quality dimensions and design strategies.

The learner's experience on a mobile device is also very different from any other traditional eLearning platforms (e.g. desktop). This calls for a specialized design strategy for mobile learning. This research has proposed a 2-middle-layer-approach built upon Koole's FRAME model with quality dimensions (1st layer) and strategies (2nd layer) that lead to a sound mobile lesson design. The results collected from the survey demonstrated the effectiveness of the recommended strategies on mobile learning.

The present study is administered to analyze the advantages of using mobile learning design and strategies that was recommended in this paper. The outcome is measured from the learner and instructor perspective. Quantitative feedback are collected through survey conducted with the 120 learners. 6 instructors are requested to develop mobile learning content based on the quality dimensions recommended for the modules that they teach respectively. 120 learners from 2 faculty contributed to the survey results. Qualitative feedback are collected from the instructors through classroom observations and interviews. Overall, the survey has shown more than 85% of the respondents responded with 'Strong Agree' or 'Agree' for each question. Therefore, the summarized findings of this study reveal that our proposed approach is effective and practical for learners learning on-the-go, anytime and anywhere.

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ENHANCING LEARNING IN PHARMACEUTICAL CARE SERVICES WITH AN E-LEARNING PLATFORM

P.H.K. Mok*[,a], K.C. Cheung[b]

[a] Department of Applied Science, Hong Kong Institute of Vocational Education (Chai Wan), Hong Kong
[b] Department of Applied Science, Hong Kong Institute of Vocational Education (Kwai Chung), Hong Kong

*philiphkmok@vtc.edu.hk;

Abstract

A two-year government-funded project is aimed to enhance the learning experiences of post-secondary students in pharmaceutical care studies in Hong Kong with e-platform support. A project-website and a related mobile app are set up for registered users to access online lectures with multimedia content (audios, videos and animations) and hyperlinked reference materials via personal computer, tablet, and smart phone with commonly employed search machines and operating systems. Moodle, a free and open-source system, is adopted as the learning management system (LMS) for managing the project teaching and learning materials with additional integrated features, such as an online game with live score results. Based on a well-established, higher diploma curriculum in dispensing studies, two-level learning programs with carefully selected topics are designed and developed to facilitate self-learning for post-secondary students with a diverse science background and at different levels of English proficiency. Concepts and knowledge in natural science are integrated into the teaching and learning materials so as to enhance students' understanding on professional knowledge, skills and techniques in pharmacy practice. Word parts and roots, many of which are of Greek or Latin origin, are introduced in order to facilitate students tackleing difficult scientific and medical terms as well as English vocabulary. Learning and memorizing drug names becomes easier with audio pronunciations available on demand to users with online access. Each lecture with suitable multimedia content and quiz breaks is carefully planned and paced to optimize learning. On-screen hyperlinked lecture script in English with Chinese translation for selected vocabulary is available as the lecture video is streamed. To complement traditional face-to-face teaching and learning, the project aims to employ technology to enhance vocational professional education training (VPET) for better results. The project is funded by the Quality Enhancement Support Scheme (QESS) under the Self-financing Post-secondary Education Fund of the Education Bureau, HKSAR.

Keywords: *Pharmaceutical Care, dispensing practices, English, e-learning, self-learning, technology enhanced learning (TEL), Moodle, multimedia, vocational professional education training (VPET)*

Introduction

Due to the secondary education reform in Hong Kong, the basic entry requirement to higher diploma programs in Hong Kong Institute of Vocational Education (HKIVE) has been changed to students who have completed 6 years of secondary education instead of the previous 5 years and have obtained a minimum score of 2 in five principal subjects in Hong Kong Diploma of Secondary Education Examination (DSE). The corresponding duration of study of higher diploma programs has been reduced from 3 years to 2 years.

The change has a significant impact on the curriculum in a well-established 3-year, full-time program of Higher Diploma in Pharmaceutical Technology at the Chai Wan campus, which the core areas of study covering both pharmacy dispensing and pharmaceutical manufacturing. Two 2-year full-time Higher Diploma programs were launched in 2012-13, one in Dispensing Studies providing students as potential dispensers working in a pharmacy and the other one in Pharmaceutical Science serving the local pharmaceutical manufacturing industry.

With the reduced duration of study, a number of challenges for the teaching team in Dispensing Studies program surfaced. Firstly, there has been an overall change in the academic background of the students applying to the program; fewer students admitted have been those with a strong science background compared to the pre-DSE era. The teaching team realizes there is a growing need to bridge the knowledge gap as well as showing relationship between basic scientific knowledge and concepts in chemistry and biology and study of drug use for the incoming students. Secondly, the students have to assimilate basic knowledge in disease, pharmacology and dispensing practices, which involve acquisition of a large number of drug names and medical

terminology. They have to accomplish this within two years, instead of the previous three years. Ability to pronounce English words, including vocabulary and names, is vital to memorize drug names and medical terms. Websites with audio recordings of drug names and medical terms are available throughout the internet, which these links have been introduced to students. To incorporate these resources into the curriculum systematically can be challenging for the teaching team.

Long and difficult scientific and medical terms are made up of word parts that can be traced back to their Greek or Latin origin. Many word parts, such as hyper- and hypo-, repeatedly occurs in many commonly used medical terms. Recognition of these commonly used prefixes and suffixes as well as word roots and knowledge about the meaning of these word parts in any given vocabulary by the students have been incorporated in the curriculum since 2015-2016 with low success in terms of facilitating students to learn medical terminology. The list of word parts with meaning and sample terms for each word part is provided to the students; the list is long and hard to use effectively. How to use the list is introduced to the students in mass lectures supplemented with small group tutorial sessions. Availability of scheduled contact time is limited; the potential usefulness of the list is greatly hampered.

Lastly, industrial attachment is mandatory for graduation; students are assigned to different pharmacies in order to gain actual work experience during the summer break. With the shortened 2-year program, summer available for industry attachment has been reduced from two to one only. To compensate for the deficiency, an alternative is sought to supplement the reduced industrial exposure. Demonstrative videos can be an invaluable tool to enhance the learning experience of the students in order to gain competency in performing dispensing and pharmaceutical compounding.

Technology enhanced learning (TEL) is a much talk about topic in education. High definition video image capturing with high fidelity audio recording is a powerful tool for design and develop teaching and learning materials in this age of information technology. According to the 2017 Thematic Household Survey on *Information technology usage and penetration* from Census and Statistics Department of the Hong Kong Government, internet access via personal computer, laptop, tablet, and smart phone is extremely prevalent among the age groups which our students fall into. Internet is the platform of choice for dissimulation of lectures beyond the four walls of a classroom.

Funding was granted from the Quality Enhancement Support Scheme (QESS) under the Self-financing Post-secondary Education Fund of the Education Bureau, HKSAR. The project titled *Enhancing learning in pharmaceutical care services with e-platform support* is aimed at enhancing the learning experiences of our post-secondary students in our Dispensing Studies program as well as other students in related areas of study.

Materials and Methods or pedagogy

An information technology company is commissioned to design, develop, and maintain the project website and a related mobile app, which are searchable by commonly used internet search engines as well as via smartphones using the two most popular mobile operating systems. Moodle is chosen as the basis of the project learning management system with project-specific features. Moodle is a free and open-source learning management system (LMS), which is also adopted by HKIVE as the web-based platform for online communication and management of teaching and learning with all students under Vocational Training Council (VTC) of Hong Kong. The teaching team are already familiar with the LMS and can manage and expand the online contents with ease. The project website and the mobile app are expected to be launched in September 2018. Users are required to register for access to the learning materials.

A production company with experience in producing multimedia content and, more importantly, in developing educational online materials is selected to create and produce project-specific learning programs. PowerPoint-based lecture videos, demonstrative videos on pharmaceutical compounding skills, and animations and videos for pharmaceutic experiences for explaining scientific concepts are planned from June to November 2018.

Two programs are planned: A bridging program and a commentary-remedial program. The bridging program is aimed to equip incoming students with a weak science background. It covers basics in chemistry and biology as well as a reviewing English sentence structure. The commentary-remedial program is aimed to help progressing students in core study modules, which are Pharmaceutics, Pharmacology, Dispensing Practices, etc. This program covers key pharmaceutical concepts, areas in pharmacy practices and dispensing practices, pharmaceutical compounding and aseptic dispensing, word parts and medical terminology, medical and prescription abbreviations, and pronunciation of drug names.

Online quizzes are planned for each online lecture. In addition, a quiz-based game is planned for all users. The game is based on knowledge of word parts, abbreviation, and drug names. A live scoreboard will be published online to enhance the interest and participation from users.

ACTIVE LEARNING CLASSROOM APPLICATION FOR ENGINEERING

Pikulkaew Tangtisanon

King Mongkut's Institute of Technology Ladkrabang, Faculty of Engineering, Bangkok, Thailand

pikulkaew.ta@kmitl.ac.th

Abstract

Nowadays, the technology has been rapidly changed. Traditional teaching platforms cannot be applied with students in this era anymore since the students can search for any topic by themselves easily. Active learning is one of the solutions for the teacher to stimulate a student's attention. In this paper, a prototype application that help a teacher to assess students' understanding is presented. The application functions consisted of two parts: a teacher mobile application and a student mobile application. In order to evaluation the proposed application's performance, 107 students who used this application during the class were interviewed. In this paper, functions of the application are shown and the results from experiments are discussed. The result of a questionnaire-based evaluation showed that almost all the students rated the application in positive feedbacks. The negative feedbacks are mostly not related to functions in the application such as a poor Internet connection signal make it hard to submit an answer to a server.

The proposed application is one of the Classroom Response Systems (CRS) system focusing on computer engineering education. In this subject, it requires special function such as a laboratory queuing system to let students call for help from a teacher or TA in a good manner. The application was built with Native language to maintain a stability of system and to be able to contribute new functions in the future. The application was used by second-year students studying the Web-Technology subject at Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang in 2017. The experiment was divided into 2 parts: Practical testing and Evaluation of students' satisfaction. The result indicated that the students are satisfy with the application and willing to use it again. The impact of the application was examined by comparing students' score between 2016 and 2017 in the same subject. The result shows that an average class score of students in 2017 is better than those in 2016.

Keywords: *Android application, Active learning, Technology enhance learning, web-base platform, teaching*

Introduction

Presently, many teaching assistance tools such as Classroom Response Systems (e.g., Naismith et al., 2004), Audience Response System (e.g., Miller et al., 2003; Robertson, 2000) and Electronic Response Systems (e.g., Hall et al., 2002) are used as powerful tools for instruction in classrooms. It enables teachers to post an instant question during the lecture and students can submit their answer to the question in real-time.

Traditionally, CRS system consists of two ways communications between an instructor and students. The instructor can choose whether students can response to the question in anonymous mode or require them to fill in their identities. Penuel et al. (2004) proposed modern CRS system "Classroom Aggregation Technology for Activating and Assessing Learning and Your Students' Thinking" (CATAALYST). The system is not only allowing students to response to the instructor's question but also provide them opportunities to shape their critical thinking abilities.

The proposed application is one of the CRS system focusing on computer engineering education. It was used by 107 second-year students studying the Web-Technology subject at Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang in 2017. In this subject, it requires special functions such as a laboratory queuing system to let students call for help from a teacher or TA in a good manner. The application was built with Native language to maintain a stability of system and to be able to contribute new functions in the future. The experiment was divided into 2 parts: Practical testing and Evaluation of students' satisfaction.

Materials and Methods

Nature of the subject; Web Technology is a required subject for second year students to enroll. There are 90 and 107 students enrolled in this subject in 2016 and 2017 respectively. There is no course prerequisite in this subject. Students were divided into two sections, A and B in each semester. In 2016, enrollment in Section A was 45 students and increasing to 56 students in 2017. In 2016 enrollment in section B was 45 students and increasing to 51 students in 2017. The proposed of this subject is to introduce taxonomies, ontologies for web applications and technological issues to the students. This course was taught based on project-based learning (PBL). PBL is a

methodology for learning without exactly right answer. It provides open-ended problems and open-ended answer so the students' learning curve are stimulated by their curiosity (Schmidt 1983; Woltering, V., Herrler, A., Spitzer K., Spreckelsen C. 2009). This subject was consisted of 2 parts: lecture and laboratory. Before a final examination, the students must be able to build one web application as an evidence of their learning outcome.

Course description; The course consisted of two hours lectures and three hours laboratory per week for a total of 75 hours of classroom instruction. To implement PBL, students were divided into a group of three to five people throughout the semester. There are three examinations: quiz, comprehensive two hours midterm, and comprehensive three hours final. There were 500 total possible points during the semester, and the students' grades were calculated based on Criterion -referenced.

The proposed CRS environment; Traditional CRS system normally consists of a computer, receivers, and a handheld personal data transmitter (PDT) registered to each student while the proposed system requires only a smartphone with the Internet connection. The instructor can create a real-time test then edit, delete, or update it later on as shown in Fig. 1. Students can login and response to the question and keep records of their score. Computer laboratory is required in this course with approximately 50 students per one instructor. Special function was implemented in the proposed application to manage queuing problem. The application was divided into two parts: Instructor and Students. The instructor and student user-interface was shown in Fig. 2.

Instructor's functions; (1) List all questions, delete, insert, update or add new test. The questions can be both subjective or objective but the system can automatically check for objective test only as shown in Fig. 3. (2) List all students' scores as shown in Fig. 4. (3) Lock the quiz as shown in Fig. 5. The purposed of this function is for the instructor to control access to the questions by students. (4) Divide students into groups and view list of students calling for help as shown in Fig. 6 and Fig. 7.

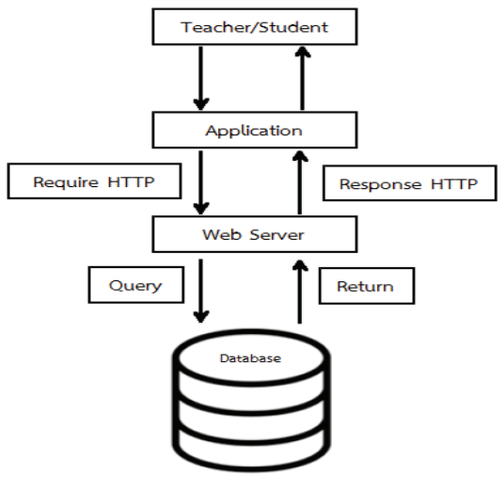

Fig. 1 System Flowchart.

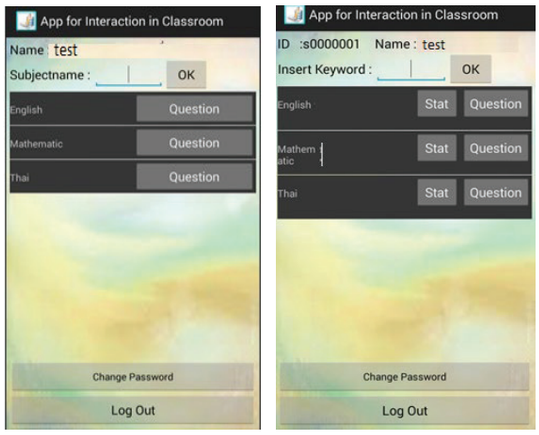

Fig. 2 Instructor (left) and Student(right) User-Interface (UI)

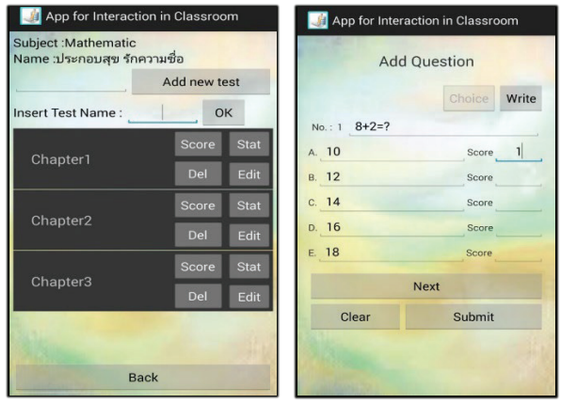

Fig. 3 List all question UI for instructor.

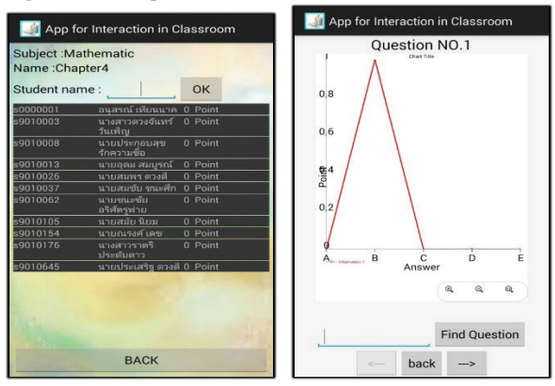

Fig. 4 Students' score listed by the instructor.

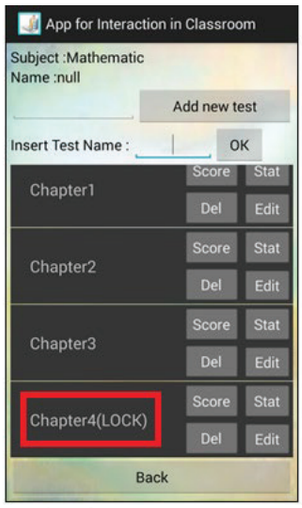

Fig. 5 Lock question feature.

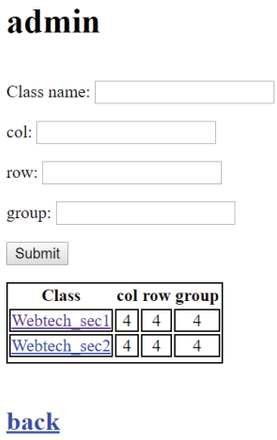

Fig. 6 Create group of students.

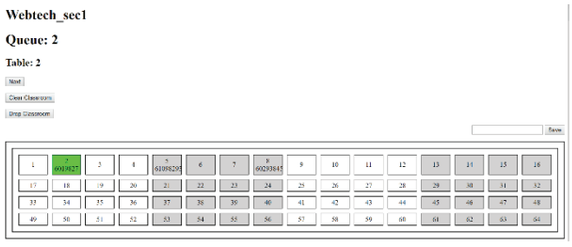

Fig. 7 A student queue viewing UI

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Students' function: (1) Response to the questions as shown in Fig. 8 (2) View his or her own score history as shown in Fig. 9 (3) Register a studentID to map with seat in laboratory room as shown in Fig. 10. If a student has a question to ask an instructor, he or she can select queue button to call the instructor as shown in Fig. 11.

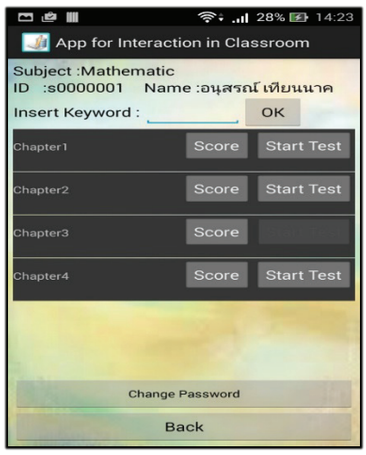

Fig. 8 Response to the question.

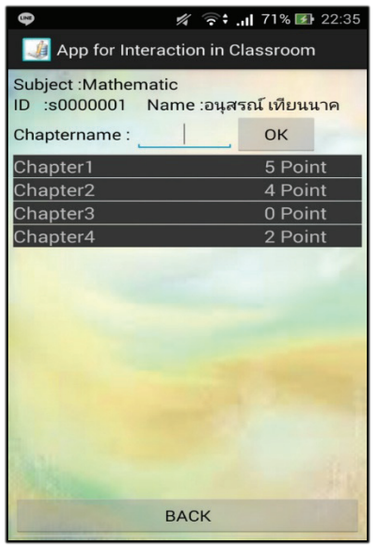

Fig. 9 List of a student's score history.

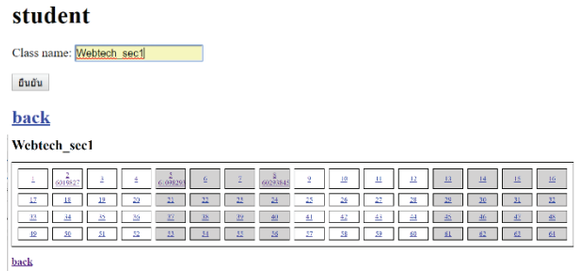

Fig. 10 Student entering classroom, name and StudentID.

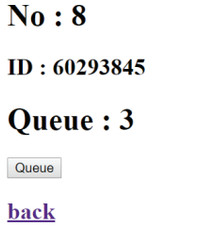

Fig. 11 Queuing system.

Implementation in the classroom; In 2016, paper based teaching approach was used to teach students. In 2017, CRS was implement to students. However, course syllabus, lectures, laboratory and examination questions are all the same in both years.

Experiment and Discussion

The goal of this paper is to examine the power of the proposed CRS application. The experiment was done by comparing a learning curve between students learning with CRS and without CRS. In both 2016 and 2017, 500 total possible points during the semester was divided into 100 points for quiz, 200 points for comprehensive two hours midterm and 200 points for comprehensive three hours final. CRS was not used by students in 2016 while in 2017 students in both section was taught using CRS. The student's scores from 2016 and 2017 were compared to examine whether this application help improve student learning ability.

Firstly, Students enrolled in 2016 and 2017 were requested to complete a pre-test about basic knowledge of web technology in a first week of the course. Figure 8 shows that from score 0 to 100, the students in both two years got the score in range 30 to 50 and average score range was 37- 40. The result indicated that the students have almost same fundamental skill in both years.

Secondly, the instructor was introduced CRS to the student in the first week. Students created their own account and practice using the application to ensure that all student understand how it works. After that, the instructor used this application as a tool to teach in every week.

Thirdly, in the last week of the course, a survey was given to all student to rate their satisfaction of the application on a scale of 1 to 5; with 5 being strongly satisfy; 4 somewhat satisfy; 3 satisfy, 2 strongly not satisfy; 1 not satisfy. One open-end question was included in this survey asking the students to express their feeling while using this application. The result of a questionnaire-based evaluation showed that almost all the students rated the application in positive feedbacks since the average satisfaction score of this application is 4.5. The negative feedbacks are mostly not related to functions in the application such as a poor Internet connection signal make it hard to submit an answer to a server. The students are willing to used it again in next semester.

Finally, total scores of the students from 2016 and 2017 were compared. The result shows that average score of student in 2017 is higher than in 2016. Moreover, Highest score in 2017 is higher than in 2016.

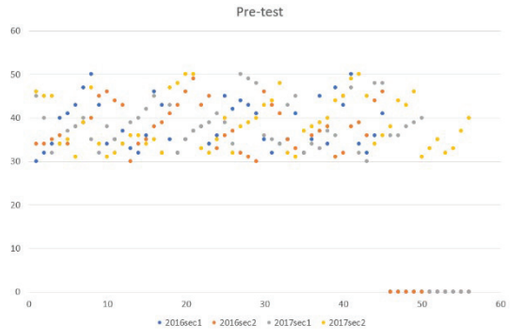

Fig. 8 Pre-test score in 2016 and 2017.

Conclusions

The proposed application was built with Native language to maintain a stability of system and to be able to contribute new functions in the future. The experiment was divided into 2 parts: Practical testing and Evaluation of students' satisfaction. The result indicated that the students are satisfy with the application and willing to use it again. The impact of the application was examined by comparing students' score between 2016 and 2017 in the same subject. The result shows that an average class score of students in 2017 is better than those in 2016.

Acknowledgements

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Robertson, L. J. (2000). Twelve tips for using a computerised interactive audience response system. Medical Teacher 22: 237–239.

USING GAMIFICATION TO ENGAGE STUDENTS FOR EFFECTIVE LEARNING IN PROGRAMMING

E.Kwok[*,a] and J. Chui[a]

[a] Nanyang Polytechnic/School of Information Technology, Singapore

*elaine_kwok@nyp.edu.sg

Abstract

Learning programming is a challenge for many students who have just made the transition from secondary school to the polytechnic education system. They are new to programming, and learning programming can be very demanding, requiring students to put in time and effort to practice. Therefore, in this action research project, we focused on enhancing students' engagement and motivation to learn programming by introducing Blackboard gamification in the classroom teaching of programming. The participants of this project were Year 1 students from the Diploma in Business Informatics in School of Information Technology, Nanyang Polytechnic studying the Web Application Development (WAD) module. Gamification is the process of game-thinking and using game mechanics to engage users and solve problems. Blackboard gamification consists of pre-determined achievement milestones and rewards; once these milestones are being achieved, students would be rewarded with the corresponding badges and bonus marks. In this project, milestones were pre-created in Blackboard which were tied to the students' completion of certain tasks or achieving certain grades in their assessments for their WAD module; students were rewarded with badges and bonus marks accordingly once these milestones were being achieved. Thus, this project postulated that gamification is an efficacious tool to enhance students' engagement and motivation in learning programming, which would result in students' improved proficiency in programming. The results of this study showed that generally students enjoyed learning and were motivated to improve their programming skills. However, the overall improvement in students' practical test mean score for the WAD module was statistically insignificant when compared to the previous cohort of students who studied the same module. In conclusion, while the hypothesis was inconclusive with respect to the insignificant improvement in the practical test mean score of the students, students' engagement and motivation had been enhanced with gamification. Challenges encountered in this study, such as the limitation of Blackboard gamification features, the limited attempts and time constraint given to students to complete the required tasks and the limited bonus marks awarded could be further enhanced to further improve students' engagement and learning and even their mean score.

Keywords: *Gamification, Programming, Engagement, Motivation, Achievement, Reward*

Introduction

In the School of Information Technology, the Web Applications Development (WAD) module is a 60 hours core module offered to all Year 1 students enrolled in the Diploma of Business Informatics (DBI). This module introduces students to the concepts of client and server based web application development, including web page design, mark-up languages, scripting languages, and server development technologies. Students learn how to create web pages using HTML and CSS, add hyperlinks and images to the web pages and build dynamic client based applications using JavaScript and are expected to be able to create interactive web sites upon completion of this module.

It has been observed that students generally find this module difficult to master, as they are new to programming. The learning of JavaScript is particularly demanding, as students have to learn the JavaScript syntax and variables, how to call JavaScript functions and how to write JavaScript programming codes that adds interactivity and validation to the web pages. Students often regarded learning programming concepts and complex syntaxes at the same time to be very confusing and challenging and are required to put in much time and effort to complete all practical exercises in order to achieve a minimum level of proficiency in this module. However, some students encounter problems completing the practical exercises and they often give up easily once their programs do not work. The lack of practice then become a vicious cycle as over time, they became less engaged and motivated to put in effort in learning this module.

How can we engage and improve students' motivation to learn programming? What are some ways to improve their learning of programming? To enhance students' engagement and motivation to learn programming, Blackboard (a learning Management System) gamification is being introduced in the classroom teaching of this module. Gamification is the process of game-thinking and using game mechanics to engage users and solve problems (Zichermann and Cunningham 2011). Blackboard gamification consists of setting pre-determined achievement milestones and rewards in Blackboard; once these milestones are being achieved, students would be rewarded with the corresponding pre-determined rewards. In this study, milestones such as students' attaining certain grades in their quizzes or completion of more challenging questions were pre-created in Blackboard, students were then rewarded with Blackboard badges accordingly once these milestones are achieved. By rewarding students upon their achievements, the aim is to increase their engagement and motivation to continue learning, which eventually would be reflected in an overall better academic performance in various assessments for this module.

Thus, the aim of this study is to determine the efficacy of using gamification to enhance students' engagement and motivation in the learning of programming by introducing the game mechanics of achievement milestones and rewards in classroom teaching. It hypothesizes that gamification is an efficacious tool to enhance students' engagement and motivation in learning programming, which would result in students' improved proficiency in programming.

Materials and Methods

In this study, the cohort of 104 DBI students who were enrolled to study the WAD module in Academic Year 2017 S1 took part in this gamification study, forming the experimental group. All students were exposed to gamified elements from week 11 to week 14 of the semester when the JavaScript topic was being taught. This study was designed with 2-tiered challenge to motivate and scaffold students to attempt the more advance programming questions. The concept of scaffold (Bruner 1975) is to provide students with assistance when they are learning new or difficult tasks. This assistance is gradually decreased as students demonstrate task mastery (Larkin 2002). In the first tier challenge, after each lecture from week 11 to 14, students were required to login to Blackboard to complete an online quiz comprising 7 basic questions and 3 intermediate questions on the topic taught during lecture for that week. Students were allowed 2 attempts at each quiz for them to try to score full marks for the quiz. Students were rewarded with a Full Marks Badge in Blackboard if they manage to achieve full marks for the quiz. In the second tier challenge, from week 12 to week 14, students were required to code 1 advance programming feature using JavaScript, and if their codes executed successfully, student would have earned a Special Achievement Badge which translated to 2 bonus marks. The first tier weekly online quiz challenge would provide hints and prompts towards students' completion of the second tier coding requirements challenge. In this way, scaffolding is provided to support students' learning to allow them to progress on their own. A maximum of 6 bonus marks could be earned in this second tier challenge, which would then go towards as 'merit' marks for their practical test for this module.

In Blackboard, each of the first tier online quiz challenge was setup together with its corresponding completion and full marks badges. Similarly, each of the second tier coding challenge was setup together with its corresponding Special Achievement Badge. Students were able to view all their rewards from the 'My Achievements' screen in Blackboard, in this way, students are able to keep track of their rewards earned.

At the end of the semester, all students were also encouraged to response to a short online survey on the use of gamification in the learning of the module. A scale of 1-5 was used for the Question 1,2 and 3 in the survey with 1 being least motivated/effective and 5 being very motivated/effective. See Table 1 for the survey questions.

Table 1 : Survey Questions

Qn	Survey on the Use of Gamification in the Learning of Web Application Development Module
1	How motivated are you towards achieving some or all of the Full Marks Badges?
2	How motivated are you towards achieving some or all of the Special Achievement Badges?
3	Overall, how effective are the badges and bonus marks in motivating you to improve your learning for this module?
4	How do you feel you have benefited from being rewarded with badges and bonus marks? • It makes me more focused on doing well in quizzes and assignment. • It makes me feel more engaged in my learning. • It makes me more motivated to do well in this module • I just want the bonus marks.
5	Overall, I enjoyed learning how to design and develop web sites. • Strongly disagree • Disagree • Neutral • Agree • Strongly agree
6	At the end of the module, I am now more motivated to improve my web development skills. • Strongly disagree • Disagree • Neutral • Agree • Strongly agree

Results

To examine the effectiveness of gamification in this experiment, the following data were collected and analyzed.

(1) Analysis of number of rewards earned for the experimental group

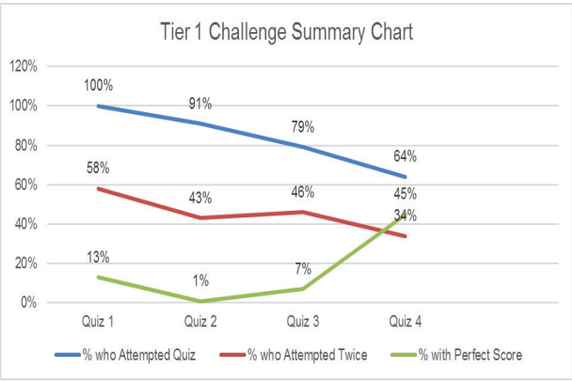


Figure 1: Tier 1 Challenge Summary Chart

As can be seen from Figure 1 above, the percentage of students who attempted each quiz decline gradually from Quiz 1 to 4. It is also noted that the percentage of students who attempted each quiz twice (in order to try to get full marks) also gradually decreased (although there was an increase in the percentage of students who attempted Quiz 3 twice). In addition, the percentage of students who were awarded full marks for each quiz is low, with only quiz 4 having the highest percentage of 45% of students (who attempted at least once) being awarded full marks.

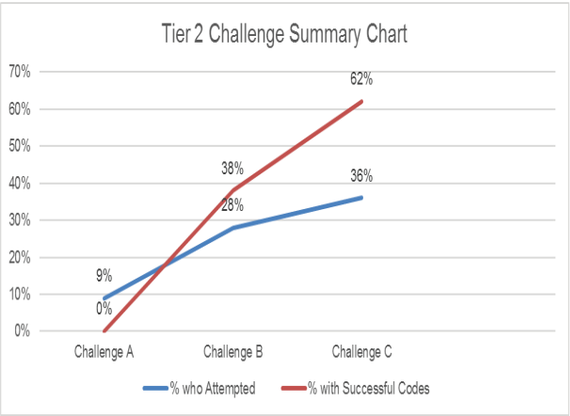
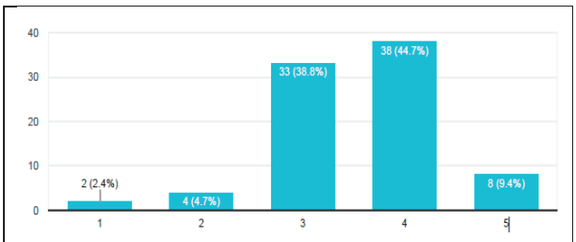


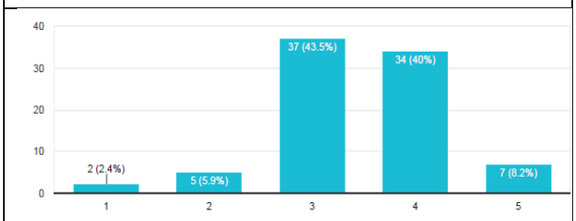
Figure 2 : Tier 2 Challenge Summary Chart

From Figure 2 above, the percentage of students who attempted the second tier challenge improved over the 3 challenges, with the percentage of students with successful codes improving over the 3 challenges as well.

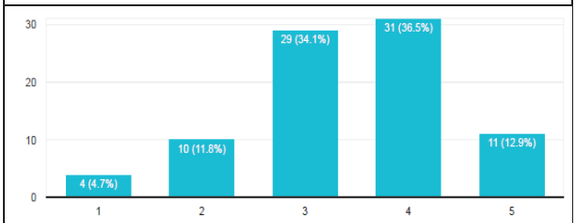
(2) Analysis of students' response to questionnaire on motivation and learning attitude towards programming for the experimental group



(1) How motivated are you towards achieving some or all of the Full Marks Badges?



(2) How motivated are you towards achieving some or all of the Special Achievement Badges?



(3) Overall, how effective are the badges and bonus marks in motivating you to improve your learning for this module?



(4) How do you feel you have benefited from being rewarded with badges and bonus marks?

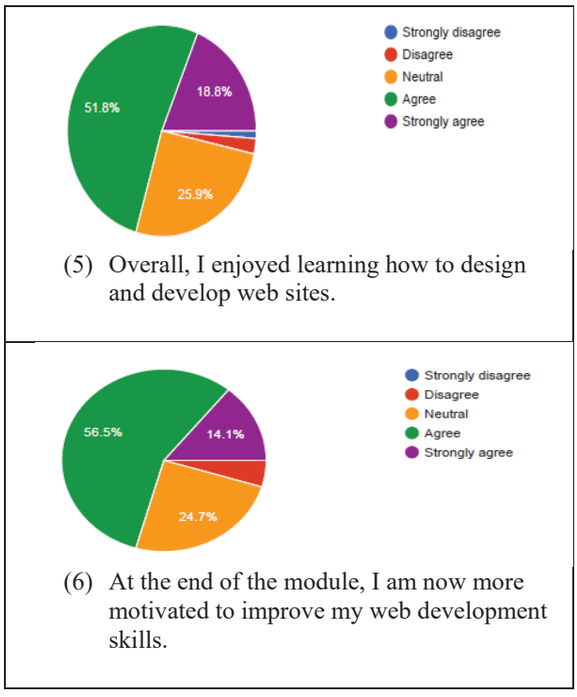


Figure 3: Survey Responses

As seen from Figure 3 above, from the responses to Questions 1-3, more than 45% of students feel that they are rather motivated to earn the various badges and to improve their learning. However, responses to Question 4 indicate that 35% of the students are really just keen to earn the bonus marks with another 45% of students feeling more focused and motivated to do well. The responses to Questions 5 and 6 indicate that more than half of the students generally enjoyed learning web development in this module and are motivated to improve their skills further.

(3) Analysis and comparison of practical test and final assignment mean score for both experimental and control groups

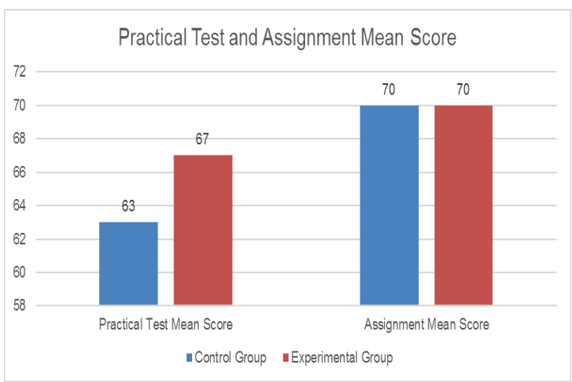


Figure 4: Practical Test and Assignment Mean Score

The practical and assignment mean score of the 2017S1 cohort (experimental group) was compared with the previous 2016S1 cohort (control group which did not experience Blackboard gamification) which also studied the same module. As Figure 4 above indicates, there is a slight improvement of 4 marks in the practical test mean score of the experimental group over the control group. Upon conducting a two-tailed, unequal variance t-test, the p-value is found to be 0.128867. Thus we can conclude that the slight improvement of 4 marks is statistically insignificant. In addition, there is no difference in the assignment mean score for both the experimental and control groups.

(4) Analysis and comparison of overall passing rate and mean score for the module for both experimental and control groups

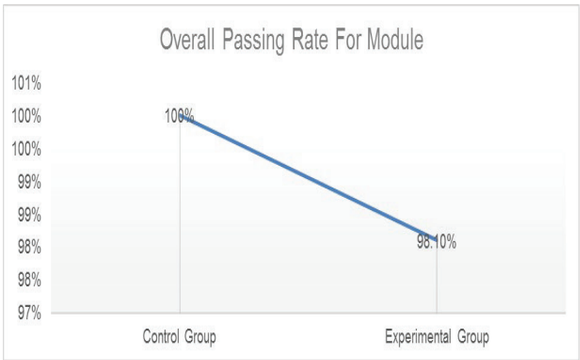


Figure 5: Overall Passing Rate For Module

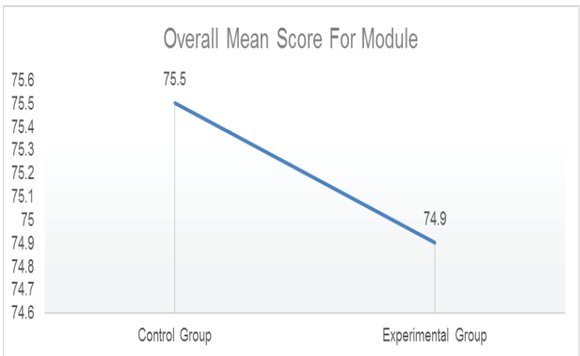


Figure 6: Overall Mean Score For Module

As Figure 5 and Figure 6 above indicate, there is a slight dip in the passing rate and overall mean score of the experimental group which experienced gamification.

Discussion

Gamification originated in the digital media industry and uses game design elements in non-game contexts (Deterding, Dixon, Khaled and Nacke 2011) with the intent of injecting fun, play and passion into tasks and processes (Wood and Reiners 2015). Game elements include game interface design patterns such as badges and leaderboards as well as game mechanics such as time constraint. Gamification applies the motivational properties of games to learning activities in order to integrate the human desire to communicate and share

accomplishment with goal-setting to direct the attention of learners and motivate them to action. (Landers and Callan 2011). For teaching and learning purposes, key learning objectives are used to apply the elements of gamification on activities that would enable participants to infer the rules for the key learning objectives. The learner would envision the activities in a 'playful' way where the participation is voluntary and fun, addressing the passion of the learner to intrinsically feel the obligation to achieve the objectives (Groh 2012).

In gamification, achievements represents the objectives and milestones for the learner and is an example of a game mechanic which measures success, achievements are in turn rewarded with badges which represent success. Being recognized for achievement is a core desire of human beings and achievement-recognition mechanics and rewards in gamification attempts to tap into this desire to motivate learners. In teaching and learning, gamification harnesses the motivational power of games and applies it to solve motivational problems in school. Understanding student's motivation is important to the success of gamification (Zichermann and Cunningham 2011) as the root of gamification is the student whose motivation ultimately drives the outcome.

Deci (1971; 1972) identified two types of motivation: intrinsic and extrinsic motivation. An intrinsically motivated person is one who engages in an activity for the activity itself; intrinsic motivation is important to sustaining interest and ensuring that learning is retained. According to the Self-Determination Theory (Ryan and Deci 2000), people have three innate psychological needs: Competence, Autonomy and Relatedness, and meeting these needs will increase intrinsic motivation. Competence is the ability to function effectively in the environment and evidence that student's knowledge and skills are increasing is the most important factor for influencing students' perception of competence and this explains why praise, meeting expectations, challenging activities are intrinsically motivating. In addition, the theory of operant conditioning (Skinner 1963) states that if a reinforcer is delivered after a certain behavior, then the particular behavior will be strengthened. Positive reinforcer such as praise, rewards, positive feedback, recognition and attention will thus increase the chances of the behavior happening again.

Thus, in this Blackboard gamification research study, positive reinforcer such as badges and bonus points were used to reward and recognize students for their achievements and to encourage their continuous engagement and effort to complete the weekly online quizzes and to attempt the more challenging questions. Successful completion of the more challenging questions would be evidence that their competence and skills have improved and this would improve student's perception of their competence; encourage them to take charge of their own learning and help them uncover their intrinsic motivation to learn programming.

In this study, while the survey responses showed that students are generally motivated to earn badges which translate to bonus marks, however it is noted that most students did not actually attempt to earn these badges as can be seen from the low level of participation in second attempts of quizzes in the first tier challenge and the low level of participation in the second tier challenge. This could indicate that the students need additional incentives to excite them. Perhaps students may need more than 2 attempts to try their hand at achieving full marks for each first tier challenge quiz or perhaps students were not able to find time to attempt each quiz twice. In addition, the bonus marks for the second tier challenge could be too low as well.

While there may be a slight improvement of 4 marks in the practical test for the experimental group over the control group (which is statistically insignificant), this did not result in an overall improvement of mean score for this module for the experimental group. Thus, the results of this study is inconclusive with respect to the insignificant improvement in the practical test mean score of the students. However, students' engagement and motivation may had been enhanced with gamification as more than half of the students had generally enjoyed learning web development in this module and are motivated to improve their skills further.

Many research studies have been conducted on gamification, its motivation effectiveness and its impact on performance. An analysis of 19 studies on gamification with the aim to identify similarities, differences and patterns and to search for common themes on the effect of gamification on student motivation and performance in post-secondary students was conducted (Lister 2015). Lister's analysis shows that 12 of the 19 studies reported a positive impact on students' motivation as a result of gamification and a small percentage (10%) of the studies reported no impact or negative impacts on student motivation. Additionally, some studies reported mixed results with respect to motivation. It was also found that of those studies reporting results related to academic performance, the results are mixed with some reporting improved students' performance, some reporting lower examination scores or found little evidence of impact either positive or negative on students' performance. In another study on the effect of the use of gamification on students' engagement and achievement in a theory based course, it was found that the mean scores of both experimental group (students who participated in the gamified module) and control group (students who participated in the ungamified module) was not statistically significant (Leaning 2015).

Conclusions

In conducting this study, a number of challenges were encountered. Firstly, it was noted that the Blackboard gamification features is limited with the use of badges to reward achievement. Blackboard's gamification is therefore static in nature and does not mimic the interactivity of a virtual game to excite and engage students.

Secondly, by limiting students to two tries to earn full marks for each first-tier challenge quiz, students may

deemed it to be almost impossible to score full marks on two tries only, thus not many students actually attempted twice for each quiz.

Thirdly, students may find the questions in the quizzes and programming challenges too tough, and thus many students did not actually succeed in earning full marks for the quizzes or the bonus marks in the programming challenges.

In conclusion, while the hypothesis was inconclusive with respect to the insignificant improvement in the practical test mean score of the students, students' engagement and motivation had been enhanced with gamification. Challenges encountered in this study, such as the limitation of Blackboard gamification features, the limited attempts and time constraint given to students to complete the required tasks and the limited bonus marks awarded could be further enhanced to further improve students' engagement and learning and even their mean score. A few ways to improve this study includes: (a) Using a gamification tool which has more interactivity and exciting features to engage students in learning; (b) Allowing students more tries or even unlimited tries at scoring full marks for each first-tier challenge quiz; (c) Simplifying the questions in the first-tier challenge quizzes and second-tier programming challenge to encourage students' participation and learning; and (d) Awarding more significant bonus marks to motivate students.

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TEACHING ARTIFICIAL INTELLIGENCE IN VOCATIONAL AND PROFESSIONAL EDUCATION AND TRAINING

Tak-chung Fu[*,a] and Yu-ho Kwok[**,a]

[a] Department of IT, Hong Kong Institute of Vocational Education (Sha Tin), Hong Kong

*cstcfu@vtc.edu.hk, ** kwokyuho@vtc.edu.hk

Abstract

Artificial Intelligence (AI) has always been an advanced topic in the field of Computer Sciences and only included in the senior year study of undergraduate degree programmes. It requires the students to have strong logical and mathematical background. The study involves a lot of logical proofs and algorithmic concepts. However, with the popularity of AI in the recent years, AI is no longer a research area but already included in many daily-life's applications. Therefore, it is necessary for the learners who are studying Vocational and Professional Education and Training (VPET) in the field of Information Technology (IT) to have exposure on this state-of-the-art technology. With the maturity and availability of public Application Programming Interfaces (APIs) from the world-class IT enterprises for building AI applications and easy-to-use frameworks for developing AI algorithms, it becomes a possible task to include AI in the VPET curriculum. In this study, we discuss on the selection of topics, review the existing tools and APIs for building AI applications and specify the essential background of the IT learners. Also, a few case studies will be discussed on the use of AI technologies in the final year projects of IT learners from VPET.

Keywords: *Artificial Intelligence (AI), Information Technology (IT), Vocational and Professional Education and Training (VPET)*

Introduction

It is no doubt that Artificial Intelligence (AI) is one of the hottest topics around the world. 2017 is claimed as "The Year of AI" (Venkatachalam, 2017). The acceleration of innovation in AI has made it becomes the main focus in the society, the government and the media. Everybody is talking about AI and it is used intensively in different industries already such as the mobile world, online customer support, smart home and city, and automobile and retail industries (MindMajix, 2018). Three-quarters of executives believe AI will enable their companies to move into new businesses. Nearly 85% of them believe AI will allow their companies to obtain or sustain a competitive advantage (Ransbotham, et al., 2018).

AI is growing in adoption especially in 2018. A recent report from IDC shows that Japan will have 74% expected projected growth from 2016-2021 (Manabe, 2018). The US is expected to have 49% compound annual growth, and Western Europe will be around 44% growth. The same report also predicted that around $57.6 billion will be spent in different industries on AI in the coming five years, with this spending set to increase employee productivity, deliver new business insights, and more workflow automation. All these lead to the increasing of AI adoption (Seiz, 2017).

In the education sector, Carnegie Mellon University, one of the AI education leaders, has launched the first undergraduate degree programme in AI, i.e. B.S. in AI, for the 2018/19 academic year, due to the forecast of manpower shortage of specialists in the field of AI (Bishop, 2018).

In Hong Kong, Innovation and Technology Bureau of The Government of the Hong Kong Special Administrative Region also announced the Smart City Blueprint on December 2017 (OGCIO, 2017). Although AI is already in use in thousands of companies around the world, most big opportunities have not yet been tapped (Brynjolfsson & Mcafee, 2017).

Vocational and Professional Education and Training (VPET) is one of the major sources to provide frontline workforce to the market. In the Information Technology (IT) industry of Hong Kong, it is showing that there is a constant manpower shortage at this educational level in the coming years (CITTD, 2016). Together with the promotion work on VPET IT education, smart component should also be introduced to the curriculum to provide not only in quantity, but also in quality of the related workforce to the market.

Based on the popularity of the AI applications, the many possible development directions and the expected to be one of the key skills of the IT graduates from VPET, this paper proposes to introduce the AI component to the curriculum of the current VPET IT education. AI is a very broad field and the scope of AI includes reasoning, knowledge representation, computation, symbolic representation and cognitive science, etc. For the IT learners from VPET, instead of teaching them the mathematical proofs of those

algorithms or the detail theoretical background of AI like undergraduate Computer Sciences degree programmes (Russell & Norvig, 2015; Kumar, 1998), it is expected that the teaching of AI should be focused on the application level of tools and algorithms. We will first discuss on the expected learning outcomes and the key learning contents. Then, the tools and development environment will be recommended. The essential backgrounds of the targeted learners will then be suggested. Case studies have been conducted to lead IT learners from VPET to develop projects with AI features to evaluate their capability to master the skill of building applications with AI features with appropriate guidance. Finally, we will conclude our proposal and study, and suggest future development of the AI education in VPET.

The Expected Learning Outcomes and Key Learning Contents

As mentioned, the mathematical proofs of the AI algorithms and the detail theoretical background of AI is not expected to be the main focus on AI education for IT learners from VPET. Instead, it is expected that the teaching of AI should be focused on the application level of tools and algorithms. The corresponding curriculum is expected to equip the learners with:

- the knowledge in the key areas of AI;
- the ability to understand and compare the functionalities and use cases of basic AI algorithms;
- analyze and apply appropriate Machine Learning (ML) APIs based on a set of business and technical requirements; and
- design and develop applications with basic AI features.

To achieve these learning outcomes, the proposed key learning contents of subject should include four main learning contents. They are (1) Overview of AI, (2) Current Trends and Applications, (3) Basic ML Algorithms, and (4) Introduction to Artificial Neural Networks and Deep Learning.

As a fundamental background, the different definitions and scopes of AI should be introduced to the learners. Also, the history and evolution of the field, the corresponding ethical issues when AI becomes popular and also the latest development and future expectation are the solid-base literature the learners should come across. Different categories of IA such as the strong and weak IA, the relationship of AI, ML (Mohammed et al., 2017) and Deep Learning (Patterson & Gibson, 2017) as shown in Fig. 1, and different types of IA technologies should also be introduced to the learners. As a starting point, the demonstration on playing board game (e.g. chess) is a good example to demonstrate the basic approach on solving problem using AI.

To equip the learners with the essential skills to development applications which embedded with AI features, the basic concepts on the current popular AI technologies on visual / image recognition, Natural Language Processing (NLP) / translation, Text to Speech / Speech to Text and conversation (Chatbot) should be introduced to the learners. More importantly, practical exercises should be included to guide the learners to build prototypes using the related online APIs.

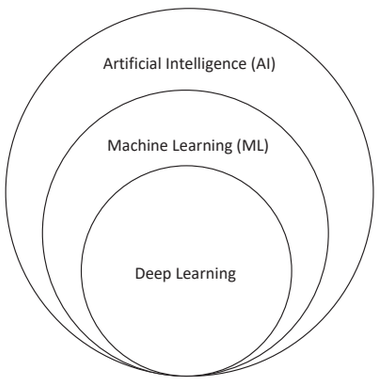


Figure 1. Relationship between AI, ML and Deep Learning

Nowadays, ML is the core components in the field of AI, different types of learning algorithms (i.e. Supervised Learning Algorithms, Unsupervised Learning Algorithms and Reinforcement Learning), the roles of data, the skills on data preprocessing and feature engineering are also important knowledge that learners should be captured.

As Deep Learning (Artificial Neural Network) is the most powerful approach and dominated in the field of ML, the basic concept, general architecture and the usages of typical deep learning models (e.g. Convolutional neural network and Recurrent neural network) should also be introduced to the learners. With the available of the development environment / frameworks, it is not difficult for the IT learners from VPET, who may not have strong mathematical background, to develop Deep Learning solutions according to different use cases. In addition, it is necessary to introduce the approaches to scale up the deep learning architecture to reduce the training time when tackling with large volume of data.

Unlike traditional undergraduate Computer Sciences degree programmes that the main focus is on introducing the learners with the theories and algorithms through mass lectures, it is expected that the AI education in VPET will be practical-oriented through hands-on laboratory workshops, demonstration and project-based learning. Lecture classes will only be served as the supportive role to give the basic background and concepts to the learners. In addition, workshop exercises, assignment and project should contribute to the major assessment components instead of written examination to reflect the level of practical skills of the learners obtained through the learning process.

Recommended Tools and Development Environment

The curriculum design in the previous section is based on the available of tools to assist the learning process. In this section, the common online APIs, which are provided by the world-class IT enterprises, for AI development and the famous ML development frameworks will be given and suggested if appropriated.

Available Online AI APIs

Many world-class IT enterprises developed online AI APIs and these APIs are available on their corresponding cloud platforms. These APIs are considered as Machine Learning as a Service (MLaaS). They include: Machine Learning on AWS by Amazon (https://aws.amazon.com/machine-learning/), Google Cloud Platform (https://cloud.google.com/), IBM Cloud (previously called Bluemix, https://www.ibm.com/cloud/) and Cognitive Services by Microsoft Azure (https://azure.microsoft.com/en-us/services/cognitive-services/).

There exist many types of AI APIs while four of them are proposed to be introduced to the VPET education due to their popularity and maturity. They are visual / image recognition, Natural Language Processing (e.g. extract information, sentiment analysis, and translation), Text to Speech / Speech to Text, and conversation (i.e. chatbot). Table I lists out the corresponding APIs from the mentioned IT enterprises.

Table I. Common AI related APIs / MLaaS

Visual Recognition	
Amazon	Rekognition Image
Google	Vision API
IBM	Watson Visual Recognition
Microsoft	Computer Vision
Natural Language Processing	
Amazon	Comprehend / Translate
Google	Natural Language API / Translation API
IBM	Watson Natural Language Classifier / Watson Language Translator
Microsoft	Text Analytics / Speech Translation
Text to Speech / Speech to Text	
Amazon	Transcribe / Polly
Google	Speech API
IBM	Watson Speech to Text / Watson Text to Speech
Microsoft	Speech to Text / Text to Speech
Conversation (Chatbot)	
Amazon	Lex
Google	Dialogflow
IBM	Watson Assistant
Microsoft	Azure Bot Service

Detail comparison can be found in (AltexSoft, 2017; Thakur, 2018). The later one compares on the features, code execution and output, and also the pricing models based on different features. Interested educators can select their preferred perform or even adopt different platforms according to different technologies to broaden the exposure of the learners.

By applying an account in the corresponding platform, most of them can be used directly and the IT learners from VPET should have the capability to manage them like the other online APIs. Moreover, most of these platforms will only charge the users with high usage. Therefore, it should be suitable on the purpose of demonstration of concepts, laboratory practices and college work and projects which limited usage is expected. Detail pricing models can be found in (Thakur, 2018).

Common ML Development Frameworks

With the popularity of AI and ML and the maturity of the algorithms behind, many ML development frameworks arose in recent years that support the corresponding development. Table II lists the most common frameworks on the market, its main support organization and the official website of them. Most of them are open source or at least free to use.

Table II. Common ML development frameworks

Caffe	UC Berkeley
http://caffe.berkeleyvision.org/	
Chainer	Preferred Networks
https://chainer.org/	
Deeplearning4j	Skymind
https://deeplearning4j.org/	
Microsoft Cognitive Toolkit (CNTK)	Microsoft
https://www.microsoft.com/en-us/cognitive-toolkit/	
MXNet	Apache Software Foundation
http://mxnet.incubator.apache.org/	
PaddlePaddle	Baidu
http://paddlepaddle.org/	
TensorFlow	Google
https://www.tensorflow.org/	
Theano	University of Montreal
http://deeplearning.net/software/theano/	
Torch	Ronan, Soumith (Facebook) Clément (Twitter) and Koray (Google)
http://torch.ch/	

Among these frameworks, TensorFlow (Hope, 2017) is the most recommended framework here. Besides it is the framework proposed by the IT giant, Google, with full documentation and walkthroughs, it is the most popular ML framework in the market as shown by all the rankings (i.e. stars, fork, issue and pull request) in GitHub (GitHub, 2016). Also, it has already been adopted by many IT and non-IT enterprises like Airbus, Twitter, IBM, and others mainly due to its highly flexible system architecture.

However, the TensorFlow interface may be a little bit difficult for the beginners to start with due to it is a low-level library and the concept on the tensor and flow may be difficult to understand. Therefore, it is proposed to start the learning process through the use of a lightweight, easy to use and straightforward library, Keras (https://keras.io/). It provides a simplistic interface for the purpose of quick prototyping by constructing deep learning models that can work with TensorFlow. It can even build a simple deep learning model by only a few lines of code. By accumulating experience on using Keras, the learners can transfer their skill learnt smoothly to develop more complex and highly customized deep learning models using TensorFlow.

Essential Background of the Learners

It is no doubt that programming skill is the fundamental skill the learners should be equipped with so that they can make use of the tools (i.e. APIs) and ML development frameworks effectively. Although most of the mentioned APIs support more than one programming languages, Python (https://www.python.org/) is the preferable language because of its simplicity and easy coding behaviour (Techtic Administrator, 2018). Python is also an open source and modular programming language with strong community support and extensive libraries. It is also the fastest growing programming language in 2018 (Heath, 2018). It provides abundant useful libraries for AI application development such as *NumPy* and *SciPy* for scientific computing (http://www.numpy.org/ and https://www.scipy.org/), *Pandas* for data analysis (https://pandas.pydata.org/) and *scikit-learn* for data mining (http://scikit-learn.org/). The suggested ML development frameworks in previous section are also Python-based and providing supporting interface (Chollet, 2018).

In addition, the manipulation of Javascript Object Notation (JSON, https://www.json.org/) is another key skill the learners should be equiped. JSON is a lightweight data-interchange format. Most of the mentioned APIs use JSON as the interface for data exchange especially on returning the results.

Data is the king in the ML paradigm. Large data set is always preferred to serve as the training data. To handle these kinds of Big Data, which have the properties of 3Vs (i.e. volume, variety and velocity), it is a benefit if the learners have prior knowledge on some kinds of Big Data frameworks like Hadoop, Spark, Cassandra or MongoDB.

Furthermore, ML always involves a long training process. To accelerate this process, some background knowledge on the computer architecture especially on the role of Graphical Processing Unit (GPU) and parallel computing is an advantage of the learners to deal with the scalability issue.

In summary, Python programming and manipulation of JSON should be essential skills for the learners to pick up the technical skills to build AI applications while the concepts on Big Data frameworks and computer architecture will help them to better learn the advanced AI operations.

Case Studies

To further obeserve if the current IT learners from VPET have the capability to learn AI and adopt it in application development through appropriate guidance, projects with AI features required are proposed to a few groups of learners (4 learners in a group) in the 2018/19 academic year to serve as their topics of the final year projects. In this section, two cases are shared to describe their learning process and the final deliverables.

Case One – AI Travel Planner

One group of the learners discovered that although there are many online travel planner applications to help travelers plan their trip, those applications cannot provide the traveler with a good travel plan to maximize their time. To resolve the current problem, the group decided to develop an AI travel planner which provides the users with a personalized travel plan. The system predicts the preference from the user personal information and provides a personalized travel plan.

The learners made use of AI on the prediction of user travel preference. And the trip plan generation relies on the prediction result. To achieve this, the learners used Keras to build a deep learning prediction module by inputting 50000 travel preferences. After that, the model was evaluated by cross-validation using the Python machine learning library *scikit-learn*. Due to the simple and straightforward design of Keras and the background of the learners, they have demonstrated their capability to complete the programme within a hundred line of codes by appropriate guidance from the supervisor and self-learning.

Throughout the development cycle, the major problem encountered by the learners was the source of data. There are no public data of people's travel preference. To solve the problem, the learners manually converted the data from existing travel review portal into traveler preferences. In addition, the learners developed a data collection portal to collect data as illustrated in Fig. 2.

At the end stage of the project, the learners developed a travel planner mobile application (Fig. 3a). The application uses the trained prediction model to predict the user's travel preference based on his/her gender, age, nationality, educational level and income. The predicted travel preference helps the trip plan generator to filter suitable attractions, allocate the portion of different kinds of visiting spot. A satisfactory travel plan is generated accordingly (Fig. 3b).

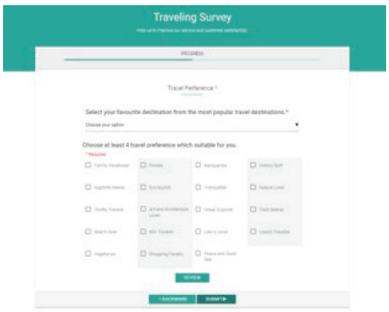
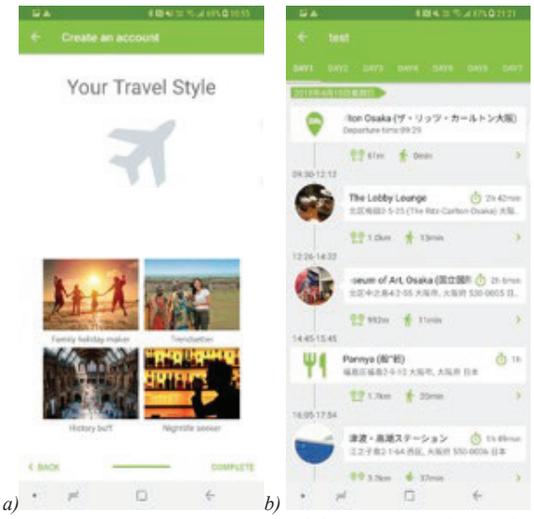


Figure 2. Screen capture of survey application to collect travel preferences



a) *b)*

Figure 3. Screen captures of the developed travel planner mobile application

Case Two - Eldventure

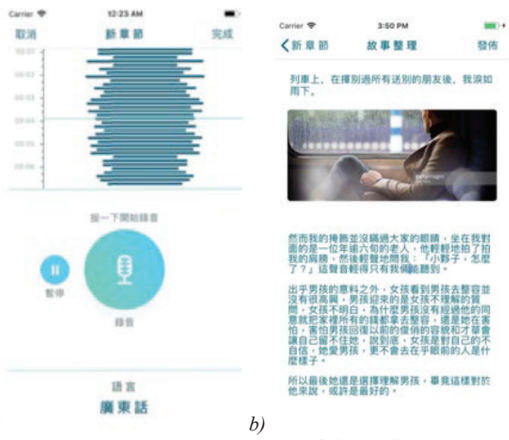
In Hong Kong, there is a sharp growth in the elderly population. Another group of IT learners also from the final year study of VPET focuses on the importance to the health of elderly and aims to provide them a happiness in life. As long as smartphones become popular nowadays, mobile apps are a huge opportunity to offer special services and bring convenience to the elderly. The group found that the elderly may willing to share their past stories and experience with others. Thus, the learners decided to develop a platform to let the elderly to share their stories and broaden their social life.

To make the platform friendly to the elderly, the project consists of speech recognition and key phrase extraction features. To the learners, they want to apply the technology instead of building the features from scratch. Thus, they integrated the system with third-party services.

During the development, the learners evaluated similar APIs from different IT enterprises. Because of the specific need of the environment, the APIs have to be able to recognize numbers of Chinese dialects. Besides, the learners have to evaluate the Chinese analyze power for the key phrase extraction system.

After evaluation, the learners chose iFLYTEK Speech Recognition API to implement translation of speech to text due to its ability to recognize all major dialects of Chinese Language. In addition, the learners applied the Cognitive Services by Microsoft Azure. They use the Text Analytics (Chinese) API for extracting key phrases from the translation.

Finally, the learners developed a Mass Open Online Course (MOOC) platform named Eldventure. The platform lets the elderly record their life stories (Fig. 4a). The voice recording was sent to iFLYTEK speech recognition API to translate speech to text, which is shown in Fig. 4b. The learners demonstrated that they have no difficult to adopt those online AI APIs to develop the mobile application because they have already learnt the skill to use online APIs.



a) *b)*

Figure 4. Screen Captures of the Eldventure Platform (a) audio recording, and (b) translation from the voice recording (in Chinese)

As seen in Fig. 5, the text analytic API extracted key phrases from the translation. The key phrases were used as a hint to the user for further recording.



Figure 5. Screen Capture of the result of key phrase extraction from a translated recording of Elventure Platform (in Chinese)

After studying these two cases, IT learners from VPET demonstrated they have the capability to learn AI for developing practical application solutions. It is worth to extend the AI education to all the learners in the field of IT from VPET to better prepare them for the latest job requirement in the market.

Conclusions

In this paper, it is proposed to introduce the AI component to the curriculum for the IT learners from VPET. The proposed learning outcomes and key learning contents, tools and development environment recommended, and the essential background of the learners are described in detail. Two case studies are presented and they already demonstrated that the targeted learners are ready to take up this challenge.

AI is a large field and it includes multiple disciplines and a variety of tools and platforms. It is more than programming languages, tools and algorithms and can be adopted across different domains and industries. Therefore, studying AI opens a world of opportunities to not only IT learners but all the learners from VPET. In the shortcoming future, it is necessary to further investigate the feasbility to develop a generic AI curriculum to introduce AI to all the learners from different disciplines of VPET. At an entry level, the learners should learn the basic idea on the key areas of AI, understand the systems that they interact with on a daily basis and even have a taste on building simple AI-embedded application prototype with the assist of tools. The ability to anticipate and prepare for the future skills will be one of the critical factors for the success of VPET.

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USING A MACHINE LEARNING APPROACH TO EVALUATE THE EFFECTIVENESS OF LEARNINGANTS ON STUDENTS' LEARNING

Soh Ying Ying[*,a], Edna Chan[a], and Fedor Duzhin[b]

[a] Singapore Polytechnic, School of Mathematics and Science, Singapore
[b] Nanyang Technological University, School of Physical and Mathematical Sciences, Singapore

*SOH_Ying_Ying@sp.edu.sg

Abstract

Evaluation plays an important role in enhancing our understanding of, and ultimately, improving different aspects of the teaching-learning process. It is essential if we want to systematically judge the worth of a new potentially innovative practice, as it provides valuable feedback on the design, implementation and effectiveness of any learning tool or activity in terms of impacting student learning. Most importantly, it provides educators with specific feedback on the effectiveness of a particular learning tool or activity in achieving the desired learning outcomes. To conduct a proper evaluation, the gold-standard of a quantitative study is the setting up of a randomized controlled trial. However, randomized clinical-like trials are often not viable in educational contexts as valuable educators' resources are typically directed to actual teaching activities rather than 'experimenting' on students.

In this research, we carried out a study to evaluate the effectiveness of a learning tool on students' learning using a machine learning approach. LearningANTS, a system that supports differentiated learning and learning analytics, was deployed in an engineering mathematics module at Singapore Polytechnic. After the semester was over, possible factors that could contribute to students' initial level of preparation for the module were identified. Taking into consideration these factors, the effectiveness of LearningANTS on students' learning in the module was then evaluated by using a machine learning algorithm to construct a predictive model to predict students' performance in the module. Learning gain in the module was then determined by computing each student's Added Value, which was calculated by taking the difference of the student's Predicted Score from his Actual Score.

Between the group who had access to the system referred to as the "Treatment Group" and those who did not have access to the system referred to as the "Control Group", it was found that the mean Added Value of the Treatment Group was higher than the mean Added Value of the Control Group and this was statistically significant. This result suggested that students who had access to LearningANTS had higher learning gains when compared to those who did not.

While the results of this research study show that LearningANTS improves students' learning of the module, further research can be conducted to investigate whether the conclusion is consistent when a similar research is done on a different batch of students or on a different subject matter. This will provide a more comprehensive and reliable evaluation of LearningANTS.

Keywords: *Symbolic regression, machine learning, differentiated learning, learning analytics, predictive modelling, LearningANTS*

Introduction

It is common practice for educators to try out new pedagogies or implement new learning tools/activities in the classroom. Instead of rolling out the pedagogy or tool/activity in all classes of a module, educators often do a pilot study on a smaller scale to test its effectiveness. In a smaller scale pilot, it is easier for the educator to manage the logistics while gathering information as well as mitigate surprises during the study. To ascertain the benefits and drawbacks brought about by such education innovation, a well-planned evaluation therefore plays an important role as it helps educators gain insights into whether a particular intervention benefits students' learning. As Kemmis (1989) identified, evaluation is the process of delineating, obtaining and providing information useful for making decisions and judgements about educational programmes and curriculum.

To conduct a proper evaluation, the gold-standard of a quantitative study is the setting up of a randomized controlled trial. However, randomized clinical-like trials are often not viable in educational contexts as valuable educators' resources are typically directed to actual teaching activities rather than 'experimenting' on students.

If a random placement into a treatment and a control group is impossible, a simple solution for educators

conducting a quasi-experiment is to compare batches (Emke, 2015; and Sumarno et al.2017). While not questioning the validity of findings of Emke (2015), we argue that their research methodology is not transferrable to an experiment for teaching a mathematics course at the tertiary level in Singapore. Indeed, if a Singapore-based math educator were to directly compare results of two batches, the study would be contaminated by a selection bias called forth by at least two causes:

(1) Difficulty of final exams in mathematics can vary significantly across years. If students' scores were higher in one year than in the year before, one possible explanation could be that the paper was easier.
(2) Quality of intake varies over the years. For instance, a higher birth rate in dragon years (see Yip, 2002), results in greater competition for university placement.

Selection bias is a persistent, and often hidden, problem in educational research. It is the primary obstacle standing in between increasingly available large education datasets and the ability to make valid causal inferences to inform policymaking, research, and practice (Stuart, 2010).

A clever way to work around the selection bias was implemented in Hardy (2014). In order to eliminate the selection bias, the authors conducted a preliminary concept test in the beginning of each class, divided the whole cohort into four levels according to the test results and then analysed the four levels separately. However, the method of control for the initial level of students used by Hardy (2014) is less systematic and requires more data as compared to the method based on symbolic regression in Duzhin et al. (2018).

Another common technique of evaluating pedagogical efficacy is concept inventory, modelled after difference-in-differences in economics. A concept inventory is a special test on the understanding of basic concepts given to students before and after the course. The difference between post-scores and pre-scores is a measure of the overall pedagogical efficacy of the course. This technique is usually applied in large studies, such as Crouch (2001) and Beichner (2007).

While concept inventories can be extremely useful to measure the effectiveness of a course as a whole, this technique has some very serious limitations:

(1) It's hard to attribute the gain in a concept test to a particular teaching approach or an instructional tool utilized by the educator.
(2) Concept inventories involve extra tests that need to be administered for the sake of research, i.e., they disrupt the normal teaching and learning process.

Summarizing all the above, we see that traditional experiment designs in education are suitable for education researchers rather than practitioners who are mainly interested in finding out whether their teaching approaches are effective in their classroom for their students. For instance, studies conducted by education practitioners without proper training in statistics and experiment design are often contaminated by selection bias and are not trustworthy while studies conducted by professional researchers are scarce and chances are that a practitioner won't be able to find a relevant one.

Machine learning algorithms for predicting students' grades

A number of authors have developed machine learning algorithms to assist educators. The central theme of this research is predicting students' performance – see, for example, Lykourentzou (2009), Zafra (2009), Cortez (2008), and Xu (2017). There even exist prototypes of software for predicting students' performance – see Livieris (2016).

The problem of predicting a response variable's value from a number of observations of predictors and the response variable is the central question of supervised machine learning. A number of algorithms for supervised machine learning are known – see, for example, Friedman (2001) or any other textbook on machine learning. Among a variety of algorithms, such as kth nearest neighbour, random forest, support vector machine, artificial neural network etc., we chose symbolic regression for our study.

To justify the choice of symbolic regression, let us discuss the desired properties of a machine learning algorithm for predicting students' scores from their initial level:

(1) The response variable is numeric, i.e., we need regression rather than classification.
(2) Educational datasets are small and therefore algorithms that are prone to overfitting would not be a good choice since they require splitting the data into training and test datasets, i.e., they do not work well for small datasets.
(3) Educational datasets usually have missing values (due to students skipping a test).
(4) It is desirable to have transparent models so as to be able to only select relevant variables and to check whether the models make sense.

A strong predictive power is not necessary, for if students' performance could be predicted from initial level with high accuracy, then the choice of learning activities would not matter and the whole idea of experimenting with pedagogy would be futile.

Table 1 summarizes (Friedman, 2001) properties of five popular machine learning algorithms and clearly shows why symbolic regression is, indeed, the most reasonable choice.

	Symbolic regression	*k*th nearest neighbour	Random forest	SVM	Neural network
Predictive power	weak	weak	strong	strong	strong
Handles missing values	yes	no	yes	no	yes
Small data sets	yes	yes	no	yes	no
Transparent models	yes	no	no	no	no

Table 1: Desired properties of popular machine learning algorithms.

Furthermore, among various available implementations of symbolic regression we chose DataModeler – an add-on to Wolfram Mathematica.

Our methodology is based on predicting students' grades with the purpose of control for selection bias in a natural experiment in education. (Duzhin et al., 2018).

Case Study

In this research, we carried out a study to evaluate the effectiveness of a learning tool on students' learning using symbolic regression. LearningANTS, a system that supports differentiated learning and learning analytics, was deployed in an engineering mathematics module at Singapore Polytechnic. (Chan et al., 2017)

Four recap topics on Differentiation were identified - Sum and Difference Rule, Chain Rule, Product Rule, and Quotient Rule - and rolled out in the system. Students taking this module had already covered these topics in a pre-requisite module. Students would need to make use of what they had learnt in the pre-requisite module for the new differentiation topics covered in the current module.

Students had access to the system right up to the day before their final exam. At the end of the semester, 89 students used the system. We then proceeded to determine if there is any value-add to students' performance in having introduced such a system to the module by comparing between the group who had access to the system referred to as the "Treatment Group" and those who did not have access to the system referred to as the "Control Group".

To allow for comparison between the two groups, we introduced a variable termed "Added Value", which is computed using the expression:

Added Value = Actual Score – Predicted Score.

"Actual Score" refers to the final score that students obtained for this module, while "Predicted Score" is what a student was expected to score for this module based on a statistical model built using the test and exams scores of his previous mathematics module and the scores he obtained for his mid-semester test of the said module.

By calculating Added Value, we were able to control for much of the selection bias because Added Value can't be contributed by factors such as motivation, diligence, and talent since these factors would have affected the students' initial level in the same way as they would have affected their performance in the said module.

Data

A sample of the data is shown in Table 2. It shows students' scores together with a categorical variable indicating whether the student belonged to the Control Group or the Treatment Group. The summary of the data is shown in Figure 1.

ID	Group	p1	p2	p3	p4	p5	v1
B0083	Control	56	58	65	2.68	68	47
B0084	Control	89	82	87	3.91	72	66
B0085	Control	67	81	78	3.73	83	75
B0086	Control	83	67	71	2.5	33	20
C0001	Treatment	84	73	76	2.88	78	70
C0002	Treatment	65	66	67	2.29	61	67
C0003	Treatment	72	68	70	3.13	64	46

Table 2: A sample of the data. Here, "ID" refers to the student ID, "group" is either Control Group / Treatment Group; "p1", "p2", "p3", "p4", "p5" are predictors - results of tests indicating the students' initial level; "v1" is the exam score.

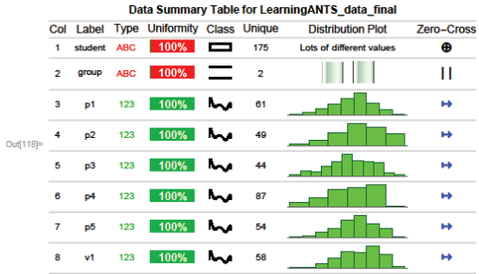

Figure 1: Summary of the data

Referring to Table 3, it appears that the Treatment Group is, on average, weaker than the Control Group since the mean scores of all the predictors, i.e., p1, p2, p3, p4 and p4, are lower than those of the Control Group. Interestingly, the Treatment Group achieved a higher mean exam score (see Mean v1) when compared to the Control Group.

Group	Mean p1	Mean p2	Mean p3	Mean p4	Mean p5	Mean v1
Control	60.38	67.57	69.24	3.08	61.55	52.47
Treatment	55.98	66.06	67.37	3.07	59.37	56.25

Table 3: The mean of each of the metrics in the Control Group and in the Treatment Group.

Modelling

We applied symbolic regression and constructed the models that predicted the response variable v1 (exam score) from predictors p1, p2, p3, p4, and p5 – metrics of students' initial level. Refer to Figure 2 for the models. Each model is an explicit formula that approximates the response variable in terms of the predictors. Every point in Figure 2 represents such a formula on the Complexity-Accuracy plane. Models that are unsurpassed by either accuracy or complexity form the so-called Pareto front. Models that are too complex or too imprecise are discarded. Figure 4 shows a few models selected to form the model ensemble that is actually used for prediction.

For models included into the ensemble, we have $1 - R^2 \approx 0.42$ or $R \approx 0.76$, i.e., the accuracy of the models is about 76%. There were 7 statistical outliers – 2 students whose actual score far exceeded the prediction and 5 students whose actual score fell far below the prediction, as shown in Figure 3.

Note that only the variables p3, p4, and p5 appeared in the models. This results suggest that p1 and p2 were not relevant and therefore could be discarded. For instance, one could check if the response variable is an increasing function of each of the predictors, which makes sense in education. This happens to actually be the case – the ensemble's prediction is, indeed, an increasing function of each of the variables p3, p4, and p5.

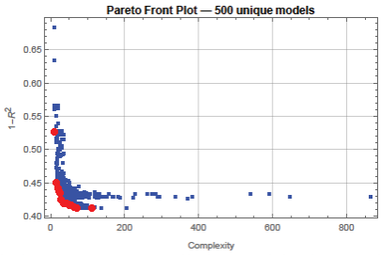

Figure 2: Each dot represents a predictive model. The coordinates are accuracy and complexity. Models that are closer to the left are simplest and models that are closer to the bottom are most accurate.

Out[142]=

v1

Outlier Rank	Data Record	Index	Strangeness	Outlier Distance	p3	p4	p5	Prediction	v1
1	B0008	8	40.45	3.20	81	3.91	68	66.45	26
2	B0078	78	35.82	2.78	68	3.09	50	50.82	15
3	B0072	72	−28.13	−2.03	67	2.46	43	43.87	72
4	B0039	39	26.06	1.89	67	2.96	51	50.06	24
5	B0035	35	25.58	1.85	80	3.47	84	69.58	44
6	B0073	73	−24.41	−1.70	79	3.73	60	61.59	86
7	B0034	34	22.71	1.59	75	3.33	59	57.71	35

Figure 3: Outliers of the predictive model, i.e., students whose actual score either far exceeded or fell far below the predicted score.

Out[139]=

v1

	Complexity	$1-R^2$	Function
1	27	0.425	$33.87 - \frac{1460.08}{p_3} + 6.37\,p_4 + 0.38\,p_5$
2	31	0.430	$-32.58 + 5.28\sqrt{p_3} + 6.56\,p_4 + 0.39\,p_5$
3	34	0.420	$-58.72 + 2.42\,p_3 - \left(1.62\times10^{-2}\right)p_3^2 + 0.13\,p_4\,p_5$
4	41	0.429	$-88.12 + 6.48\,p_4 + 0.38\,p_5 + 38.99\sqrt[8]{p_3^2}$

Figure 4: Model ensemble.

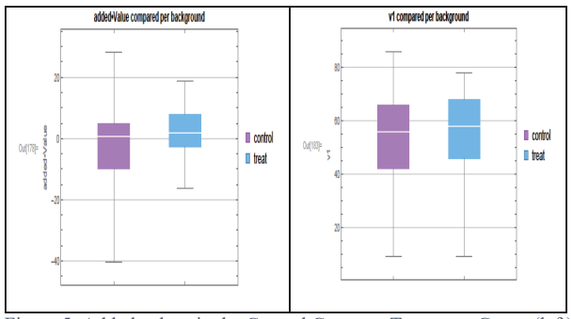

Figure 5: Added values in the Control Group vs Treatment Group (left) and raw scores in the Control Group vs Treatment Group (right).

Comparing non-randomly assigned groups

Recall the following definition:

Added Value = Actual Score – Predicted Score

Thus Added Value provides a means to consider students' initial level of preparation. Whisker charts of added values and raw exam scores in the Treatment and Control groups are shown in Figure 5.

Table 4 shows the mean and the median raw scores and Added Values in the Treatment Group and Control Group. We have tested the following four hypotheses:

(1) The mean raw scores in the Treatment Group is not equal to that in the Control Group vs the null hypotheses that they are equal."
(2) The mean Added Values in the Treatment Group is not equal to that in the Control Group vs the null hypotheses that they are equal.
(3) The median raw scores in the Treatment Group is not equal to that in the Control Group vs the null hypotheses that they are equal.
(4) The median Added Values in the Treatment Group is not equal to that in the Control Group vs the null hypotheses that they are equal.

Note that we have applied the t-Test for means and the Mann-Whitney u-Test for medians. From result shown in Table 4, we can conclude that hypothesis should be accepted with the usual significance level of 0.05 if we look at Added Values but should be rejected if we look at raw exam scores. It means that the machine-learning based method of controlling for initial level of students' preparation provided means for improving statistical significance of the findings.

	Mean		t-Test p	Median		u-Test p
	Control	Treat		Control	Treat	
Raw scores	52.42	56.25	0.1088	56	58	0.1166
Added values	-2.71	2.62	0.0005	0.78	1.8	0.007

Table 4: Mean and median results in the control and treatment group and measure of statistical significance of comparing the two groups.

Results and Discussion

We have seen from Table 4 and Figure 5 that the intervention have been, on the average, effective for the Treatment Group. This suggested that students who had access to LearningANTS had higher learning gains compared to those who did not.

Diving deeper into the results show that there are always students whose performance exceeded expectation (positive Added Value) and there are always students whose performance falls behind expectation (negative Added Value). This could be explained by a variety of factors, such as personal affection towards the teacher, the subject or the way the subject is taught or, on the contrary, by family issues that distracted the student from studies in that particular semester.

As shown in Table 4 and Figure 5, the increase in the average score is mainly due to the following fact: while there were students who underperformed the prediction in both the Control Group and the Treatment Group, such "under-performers" in the treatment group underperformed by a smaller margin as compared to their peers in the control group. In colloquial terms, the intervention helped students who could not or did not want to devote sufficient time to studying for this course. They still did not perform according to their level, but it could have been worse without the intervention.

Conclusion

While the results of this research study suggest that LearningANTS improves students' learning of the module, further research can be conducted to investigate whether the conclusion is consistent when a similar research is done on a different batch of students or on a different subject matter. This will provide a more comprehensive and reliable evaluation of LearningANTS.

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VIRTUAL REALITY ASSISTED IN ARBORICULTURE TRAINING

K.C. Ho[*,a], C.T. Leung[a] and H.L. Au [a]

[a] Department of Applied Science, Hong Kong Institute of Vocational Education (Sha Tin), Hong Kong, China

*chriskcho@vtc.edu.hk

Abstract

Chain saw operation is one of the most common tasks that used by the arborists, tree climbers and tree workers in daily tree care operation. However, it is also the most dangerous operation in arboriculture and tree management for people without proper training. This reveals that proper chain saw safety training is crucial to all arboriculture practitioners before conducting chain saw operation.

A virtual reality (VR) training system has been developed to provide proper occupational safety and health training in using chain saw to students who are studying Higher Diploma in Conservation and Tree Management. Real life immersive experiences are provided in this VR training system, thereby allow replica of hazardous situations on chain saw operation in simulated environment and enable visualized training on procedures in daily tree work operations so that to increase their awareness and understanding of the causes of accidents and how they can be prevented. This training system is based on the safety check of potential dangers in daily tree care operation. The effectiveness of using VR training system in chain saw safety training has been evaluated by dividing two groups of students, one group of students was trained by VR training system, another group was trained by traditional lecture session. Performance of student was compared after conducting pre- and post- training tests. All students have scored much higher after they learned by the VR technology or the traditional teaching. This result indicated that VR training system is feasible to aid both arboriculture practitioners and pre-employment students in learning various dangerous tree care works and operations. More immersive training experiences are recommended to provide for practitioners as well as pre-employment vocational training of arboriculture sector.

Keywords: *Virtual Reality, Immersive Training System, Arboriculture, Arborist, Tree Worker Operation, Chain Saw Operation, Occupational Safety and Health, Tree Felling, Pruning*

Introduction

Chain saw is a mechanical equipment with a saw chain which rotates around a guide bar. Due to the efficiency, chain saw is the most commonly used mechanical power-driven equipment in arboriculture industry. The tasks of using chain saw including tree felling and removal, pruning, limbing and bucking. However, it is also a dangerous equipment; kickback occurs when the tip of the guide bar touches any object. With reference to the U.S. Consumer Products Safety Commission, there are about 36,000 people treated in the hospitals for chain saw injuries in USA each year.

Providing lectures and on-site practical workshops are the traditional training on the safe use of chain saw, the contents of face-to-face lecture sessions include the introduction of various parts of chain saw, operation procedures, daily maintenance and the safety requirement. In order to facilitate the understanding of trainees, tutors may display photos as well as play video to trainees. During practical workshops, after wearing proper personal protective equipment (PPE), learners usually have a chance to control a chain saw to conduct a simple pruning task. During training, when the learners are careless, do not follow the safety instruction and procedures during operating chain saw or if the tip of the guide bar touches an object, kickback and injuries may occur.

A virtual reality (VR) training system has been designed and developed to provide a real life immersive experiences, so that hazardous situations on chain saw operation in simulated environment can be replicated and enable visualized training on procedures in daily tree work operations so that to increase the awareness and understanding of the learners the causes of accidents and how they can be prevented. Six scenarios have been designed in this VR training system, namely, personal protective equipment for chain saw operation, safe environment when using chain saw, safe use of chain saw, prevention of chain saw kick back, traffic control during tree care operation, and tree felling and removal. Through experiencing these scenarios, learners have an opportunity to have a comprehensive understanding the safe use of chain saw during daily arboriculture tasks which chain saw is needed to use.

This VR assisted training system is developed and integrated into the curriculum of a pre-employment vocational training programme, Higher Diploma in

Conservation and Tree Management (CTM) offered by Vocational Training Council, this higher diploma programme is a full-time 2-year 5-semester programme aims to equip students with the necessary technical and professional knowledge and skills, initially at paraprofessional level, via the blending of theoretical knowledge and practical application, to enable them to pursue a career in conservation, tree management and arboricultural services.

Materials and Methods or Pedagogy

Study participants included 61 students from CTM who took an Occupational Safety and Health in Arboriculture module in February 2017. To evaluate the effectiveness of using this VR training system in chain saw safety training, students were divided into two groups. Of the 61 students, 43 participated in the VR training system, and 18 participated in traditional lecture. Contact hours of both training methods were six.

A pre-test and post-test was arranged for both student groups before and after traditional training method and VR-assisted training respectively. For each of the training methods, mark results (in numerical expression) of pre- and post-tests were compared to evaluate the performance of students. In addition, the results of post-tests were compared between two different training methods using *t* test.

Results and Discussion

Table 1 shows the range, mean and standard deviation of the pre- and post-tests results of the two groups of students.

Table 1. Pre- and Post-test Results Summary

Group	Pre-test		Post-test	
	Range	Mean ± standard deviation	Range	Mean ± standard deviation
VR	24 - 68	43.44 ± 10.62	64 - 100	89.21 ± 8.99
Traditional	24 - 72	41.56 ± 12.30	64 - 100	85.33 ± 12.51

Results show that all the participants in both student groups scored much higher after they learned by the VR technology or the traditional teaching method. The result indicated that instead of traditional teaching, VR training system is also a feasible and effective training method to aid learners in learning various dangerous tree care works and operations. In addition, using VR training system as teaching method can provide a safe environment, a repeatable training and avoid the injury when trainers conduct the wrong procedures.

Conclusions

Based on the result of present study, VR assisted in teaching the safe use of chain saw is effective and feasible. There are several benefits of using VR system in arboriculture related training, and therefore, it is recommended to develop more immersive training system to the practitioners as well as pre-employment vocational training learners of arboriculture sector in the future.

Acknowledgements

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EFFECT OF SECURITY EDUCATION USING GAMIFICATION

N. Tansho [a], Y. Takeichi [a], J. Sato[*,a], K. Yajima [b] and K. Yonemura [c]

[a] National Institute of Technology, Tsuruoka College, Yamagata, Japan
[b] National Institute of Technology, Sendai College, Miyagi, Japan
[c] National Institute of Technology, Kisarazu College, Chiba, Japan

*jun@tsuruoka-nct.ac.jp

Abstract

It's the important problem in which a cyberattack cooperates with increasing industry closely to bring the human resources who could excel OT security up. The educational effect in the multiple practice and a problem of KIPS based on Gamification theory were considered. More than one performance contributed to the simple educational effect as a result of the experiment, and some things knew a possibility of the affirmative skill move, but KOSEN where the educational contents which can close a gap of more than one practice are needed has the big mission which renews a curriculum of a practice base all the time.

Keywords: *security education, gamification theory, operational technology, ICT*

Introduction

The cyberattack of industrial equipment is getting really hot in the industry. Japan's National Institute of Technology (KOSEN) has produced many high-quality industrial engineers in the industry. Last year, we started a cyber security education project and developed an educational system faced with the threat of cyberattack. The fact that KOSEN's students have security skills and knowledge leads to strengthening of cyber security in the field of OT (Operational Technology), so that students can contribute to the industry. Although we have promoted ICT security education using our own educational content, we believe that it is not easy to learn OT security at that time, cybersecurity developed by ourselves. Since many OT security can be learned by actual operation, there is an aspect that it is difficult to obtain the expected educational effect without actual industrial equipment and environment.

KIPS (Kaspersky Interactive Protection Simulation), which has developed by Kaspersky Lab, is the board game using Gamification Theory that we can experience the cyber security practice and will be possible to carry out actual practice by simulating realistic scenarios. In our security educational project, we are advancing the education using KIPS, and examined the relationship between the educational effect using the security contents we developed and the effect using KIPS [1].

It was possible to confirm the difference between to consider the security educational effect which practiced the “Enterprise scenario (Corporate version)” which is KIPS where we are toward ICT security and the “Plant scenario (Water Plant version)” which is KIPS where we are toward OT security and practice a ICT security skill and to practice a OT security skill there. we got the very useful knowledge to consider future's educational policy for the technical college which produces human resources to the industrial world.

The industrial world tries to practice KIPS more than one times targeted for the technical college rawness which acquires a basis of the engineer who can play an active part in such flow this time. When the effect of practicing KIPS more than one times is admitted, the framework to take in during educational policy and excrete stronger human resources effectively can be strengthened. The relation between the skill of OT security and the ICT security skill is also considered in more than one times of implementation. Consideration on this relation will be something to grope after a possibility of the skill transfer with effective OT security and ICT security, and we contribute to improvement of future's educational practice as expected.

Gamification Theory and KIPS

We describe two topics that support the fundamental direction of practice of education using the contents applying the gamification theory which is essentials of our investigation.

A. Gamification Theory

The definition of Gamification has been used as "the use of game-play mechanics for non-game applications" [2] and it is used in many areas such as education, business and medicine. One of the important features of learning by using Gamification or Game-Based Learning is that students actively learn problems and take solutions by facing problems. Problem solving with gamification is also noted to be an important benefit of using games in education [3, 4]. A problem-solving mechanism built with a game-based strategy enables both knowledge acquisition and its application throughout the learning process.

B. KIPS (Kaspersky Industrial Protection Simulation)

KIPS is the cyber security practice by team battle which designed to enhance analytical skill about problems on the cyber security and the risk about latest computer system in operation [5, 6]. Educational targets are executive managers including business managers, departmental managers and information security administrators.

The purpose of KIPS is that to prevent the profit maximally and to preserve the trust during exposure to a series of unexpected cyber threats. The aiming is that to develop and run the cyber defence tactics by selecting best suited plan out of cyber security countermeasure prepared preliminarily (see Figure 1).



Figure 1 KIPS (Kaspersky Interactive Protection Simulation)

Subsequent deployment and final profit and expense of company change, in response to countermeasures against security events pouring in waves. Each team analyse a situation considering priorities of engineering against damage by cyber-attack, business and security, making a tactical decision based on uncertain information, a limited budget and feasible measure. Each scenario is decided based on security events changed by the situation each team is in, so it can not only simulate a situation occurred cyber incidents actually, but also verify the decision making based on appropriate tactics and effectivity of selected measures in real time.

KIPS is the cyber security practice based on gamification which has the following characteristics:

(1) Completing in a short time (two hours) while concentrating and having fun in the form of a game
(2) Building up cooperativeness crossover the organization by teamwork
(3) Train upping the autonomy and analytic skill by re-experiencing realistic security events

Practical Procedure and Results

KOSEN students who belong Dept. of Electrical and Electronic Engineering practiced KIPS. They played it total four times. First they played the Water Plant version (see Figure 2) of KIPS twice and then played the Corporation version (see Figure 3) of KIPS twice. Concretely, they played the Water Plant version again after three days of first playing the Water Plant version. And they played the Corporate version of KIPS after four days of second playing of the Water Plant version and then they played the Corporate version again after seven days of first playing the Corporate version.

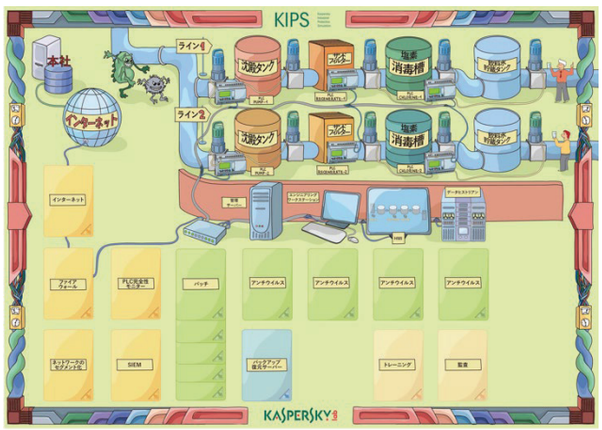

Figure 2 Water Plant version of KIPS

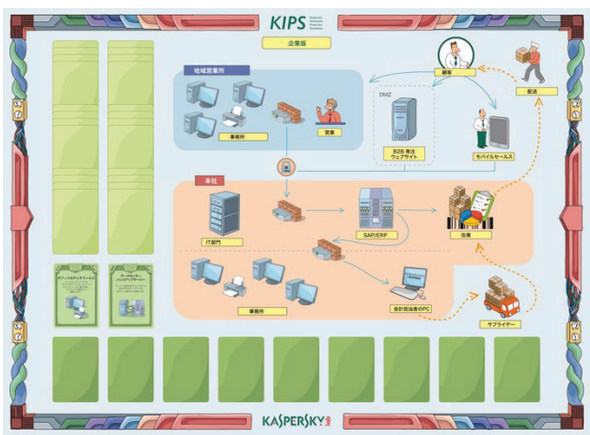

Figure 3 Corporation version of KIPS

We can confirm the effect of embeddedness of OT security skill and knowledge on multiple playing by examining the score of first playing the Water Plant version of KIPS twice. And we can examine the possibility of skill transfer between OT security and ICT

security which have different fundamental by examining to compare the score of second play of the Water Plant version with the score of first play of the Corporation version (that is third playing as a whole). Finally, we can also confirm the effect of embeddedness of ICT security (this is the point which is not OT security, that is the ICT security) skill and knowledge on multiple playing by comparing the score of first playing the Corporation version of KIPS twice (the third and fourth playing as a whole) as is the case with examining on twice playing of the Water Plant version.

A. The results of first and second playings of the Water Plant version of KIPS

Figure 4 shows both score of first playing of the Water Plant version and second playing of the one on the scatter diagram. These scores have already standardized, and we said here that subsequent scores were standardized, too. As this result, we can confirm that second score is higher than first one significantly (tow-tailed t-test, $p < 0.05$) and multiple playing makes the effect of certainly embeddedness of skill which they learned (a result of decorrelation test shows that coefficient of correlation had comparatively strong correlation with significant).

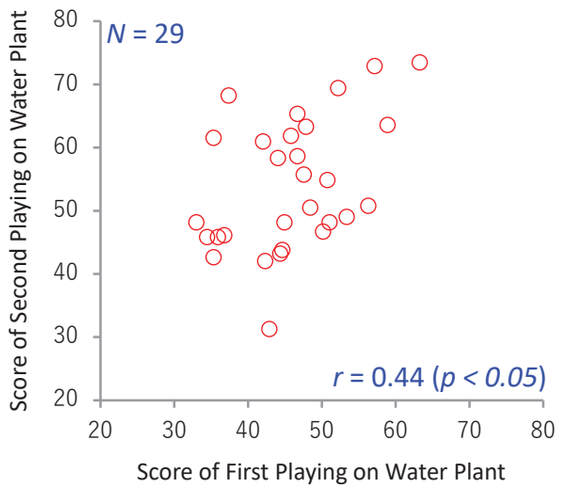

Figure 4 Scatter diagram of the scores about first and second playing the Water Plant version

B. The result of second playing of the Water Plant version of KIPS and first playing of the Corporation version of KIPS

Figure 5 shows the scatter diagram between the score of second playing of the Water Plant version of KIPS and the score of first playing of the Corporation version of KIPS (which was third playing of KIPS as a whole). We didn't compare the magnitude relationship between both scores here because they are different version, so we can't compare simply. The point of view is that weather the skill and knowledge which they learned from playing the Water Plant version can transfer to playing the Corporation version, and then we confirmed the possibility that the result has the effect (a result of decorrelation test shows that coefficient of correlation had weak correlation with significant). However, the factor resulting from this transfer is wide-ranging, so we can only say that that possibility was suggested.

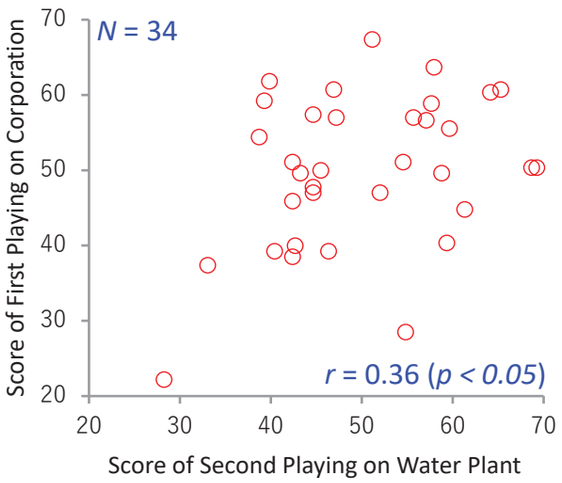

Figure 5 Scatter diagram of the scores about second playing the Water Plant version and first playing the Corporate version

C. The result of third and fourth playing of the Corporation version of KIPS

Figure 6 shows both score of first playing (third playing as a whole) of the Corporation version and second playing (fourth playing as a whole) of the one on the scatter diagram. It is peculiar to which we can't recognize the positive correlation and we can find negative correlation with no significant although the score of second playing is higher than first playing in totality differ from the comparison of Water Plant versions (a result of decorrelation test shows that coefficient of correlation had on significant). This result showed that a lot of reversal case on which the score of second playing is simply higher than the first playing occurred, and that result makes we can't simply confirm the effect of multiple playing.

These results show that the possibility of the difference of difficulty between the versions on KIPS and the possibility that is different from simple effect that playing number of times influenced the score on the educational effect concerning operational skill and the skill based on knowledge about OT security and ICT security. This result was the important findings while we examine the educational effect and concept in the future. That is, we can suggest the possibility that we need the educational contents which can complement effectively between the multiple playing.

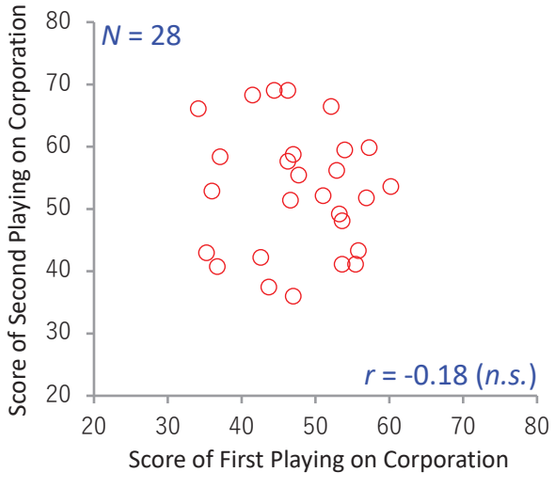

Figure 6 Scatter diagram of the scores about first and second playing the Corporation version

Conclusions

To produce human resources who are good at OT security is important task for KOSEN which is closely cooperation with the industry on which faces increasing cyber-attacks. To incorporate the educational effect using Gamification theory which KIPS has can contribute to accomplishment of original goal on which we have operated our (KOSEN) original security education. In this time, we examined the effect and issues on multiple practicing of KIPS while we advance a series of research to examine the security educational effect using KIPS. Multiple playing made that we can confirm simple positive effect on our practicing the version which has domain of OT security skill mainly. Moreover, we can find that the possibility which OT security skill can transfer to ICT security skill. However, we can't confirm simple embeddedness of security skill and knowledge by multiple playing while we practiced the version which has domain of ICT security skill mainly. This result showed the needs of educational contents which can complement effectively the gap of multiple playing, and we obtain a great future works to develop such some effective educational contents and to measure that effect at the same time.

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PROPOSAL FOR REDUCING PATTERN POSITION ALIGNMENT ERROR OF A SIMPLIFIED PHOTO LITHOGRAPHY METHOD FOR EDUCATION

S. Nagaoka*,[a], M. Yamamoto[b], T. Tsuji[c], K. Matsuda[d], T. Shimizu[a], R. W. Johnston[a], T. Shikama[b], F. Shimokawa[e] and H. Horibe[f]

[a] NIT, Kagawa College / Dept. of Electronic Systems Engineering, Mitoyo, Japan
[b] NIT, Kagawa College / Dept. of Electrical & Computer Engineering, Takamatsu, Japan
[c] NIT, Suzuka College / Dept. of Electrical & Electronics Engineering, Suzuka, Japan
[d] Tokushima Bunri University / Dept. of Nano and Bio Material Engineering, Sanuki, Japan
[e] Kagawa University / Dept. of Intelligent Mechanical Systems Engineering, Takamatsu, Japan
[f] Osaka City University / Dept. of Applied Chemistry, Osaka, Japan

*E-Mail nagaoka@es.kagawa-nct.ac.jp

Abstract

Reduction of alignment error (AE) was studied for a simplified lithography process that was named "Alignment Less Lithography process (ALL)" that can be used make semiconductor devices in the average science laboratory. Heretofore, ALL had been proposed and successfully demonstrated to make a simplified silicon bipolar transistor and MOS FET. However, the typical average AE among the circuit patterns was as large as approximately 50μm. It is recognized that the AE has to be reduced for making integrated circuits (IC), since a number of photo-masks are used. It is expected that the AE can be reduced to zero if the set of photo-masks whose physical sizes are exactly the same can be prepared, and the circuit pattern position on each photo-mask was also exactly the same. Furthermore, if the substrate can also be set at the exact same position every time, perfect pattern matching of the IC can be achieved without using sophisticated apparatus, such as an XYZθ stage. Photo-masks were designed and printed on plastic transparent sheets for over head projectors. Precise physical size control of each photo-mask was achieved by polishing with waterproof abrasive cloth with nano-meter sized polishing materials. A simple alignment jig was prepared for the photo-mask setting by applying the concept of a mechanical pin alignment method. As for the results, it was successfully demonstrated that the AE was reduced to within 10μm with approximately 200μm resolution. In addition, the distribution of the positioning was also successfully reduced by a specially designed simple transportable UV exposure system. It is understood that this method will be useful for cultivating scientific minds for engineering education, as the educator can prepare a program for students to learn how to make an idea and how to solve the problem through reliving achievements of our predecessors, such as the world's first IC by using this method

Keywords: *Photo Lithography, Alignment, Fabrication Process, Semiconductor Device*

Introduction

We have been studying to develop a totally simplified fabrication process that can be applied to a variety of semiconductor device fabrication to help students obtain deep understanding of semiconductor device physics through their own practical experience. A simplified method has been considered to establish a device fabrication laboratory that has been named "A Nanotechnology Platform Established for the Normal Science Laboratory" in average educational organizations. We understand that there are three important fabrication processes, which are "fabrication of the thin films", "control method of dopant introduction" and "lithography methods".

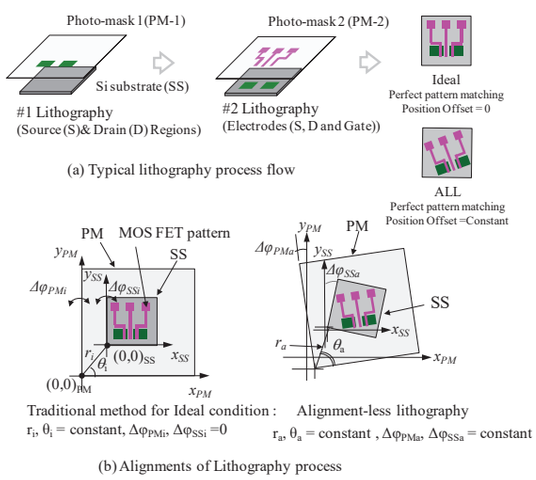


Figure 1 Hypothesis of the Alignment Less Lithography (ALL) Process

It is understood that basically, planar type semiconductor devices are fabricated by this set of processes, even in new state of the art devices, or for even the world's first integrated circuit. Therefore, it is most important to simplify these three processes. We have successfully achieved simplification of the control method of dopant introduction by the thermal diffusions of the Phosphorus and Boron using the Phosphorus Silicate Glass (PSG) and Borosilicate Glass (BSG) thin films, respectively under a normal air environment. Silicon oxide thin film as the insulator for a MOS device fabricated under normal air environment was also proposed and successfully demonstrated. In addition, an electrode fabricated by the Ag past patterned by a screen printing method under a normal air environment that can perform the same as a thin film electrode prepared using a vacuum apparatus was also proposed and demonstrated.

Therefore, if we achieve the simplification of the lithography process, we can finally achieve a simplified nanotech platform for the average science laboratory. A method was proposed and demonstrated to achieve simplification of the lithography process using transparent plastic sheets for overhead projectors (OHP sheet) in which the device patterns were printed by laser printer. However, the relatively large value of the alignment error of the photo-mask pattern has remained a problem.

In this study, a method to determine the positions of the circuit patterns exactly the same on the OHP photo-mask set was proposed and that by lapping and polishing the mask edges, and it would be possible to eliminate the position error of the patters to near zero.

Hypothesis of Alignment-Less Lithography

In general, the device circuit pattern is divided into several parts. Each of the parts are fabricated by the lithography process. The total device circuit patterns are overlapped and laminated onto the substrate in the order shown in Fig.1(a).

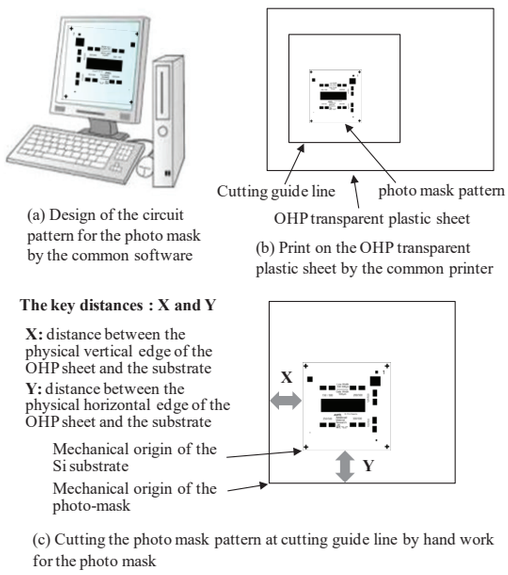


Figure 2 Photo-mask making process

The photolithography process is the process for making the circuit pattern using a photo resist which is a specially designed polymer including a photo sensitizer, before the fabrication of the part of the circuit pattern by the etching process. Therefore, the following two position alignments are required. The first is "absolute pattern alignment" to achieve setting of the photo resist pattern at the target position on the substrate and the second, "relative position alignment" to achieve setting the photo resist patterns to coincide exactly where they are superimposed on the circuit patterns.

During the traditional integrated circuit fabrication process, a XYZθ stage is used to achieve both of these demands at the same time. However, it is difficult for the average educational organization to introduce such specially made equipment as same as the measurement apparatus that have been equipped and have been used in a normal experimental class room, for example, PC's, multi-meters, breadboards, etc. In addition, it is also difficult to prepare a glass photo-mask set which has been commonly using to make photo resist patterns with the stage.

Therefore, to achieve a simplification of the lithography process, the two simplifications which are the simplification of the lithography apparatus and the simple photo-mask preparation method, design, fabrication, and revising the photo-mask set are required as the most important issues. It means that the photo-mask set fabrication from pattern design, fabrication and revising to be finished easy and quickly under limited circumstances by students themselves. To achieve the simplification of the photo lithography process for the fabrication of the simplified device fabrication process, it was recognized in "absolute pattern alignment" that the device circuit pattern set at the center of the silicon substrate without any circuit pattern rotation error is not necessary, and that "relative position alignment" is only necessary for the device fabrication.

Under this understanding, if the positions of all of the circuit patterns on the photo-masks are designed and fabricated very accurately and the physical size of the photo-mask substrates also are fabricated to the exact same size, in addition, the silicon substrate and the photo-mask can be set to the exact the same position every time, the relative position alignment between the each of the circuit patterns on the photo-masks and the circuit patterns that have been already fabricated on the silicon substrate is achieved with no alignment error in principle.

This hypothesis means that the sophisticated XYZθ stage can be avoided, and the lithography apparatus can be drastically simplified. It means that the simplified photo-mask alignment can be achieved to only focus on the mechanical positioning of the substrate and the photo-masks. The positioning errors of $\Delta r=r_a-r_i$, $\Delta\theta=\theta_a-\theta_i$, $\Delta\phi_{PM\square a}$, $\Delta\phi_{SSa\square}$ could remain. However, it is recognized that it is not an important issue, because it only causes an offset of the whole circuit pattern on the silicon substrate.

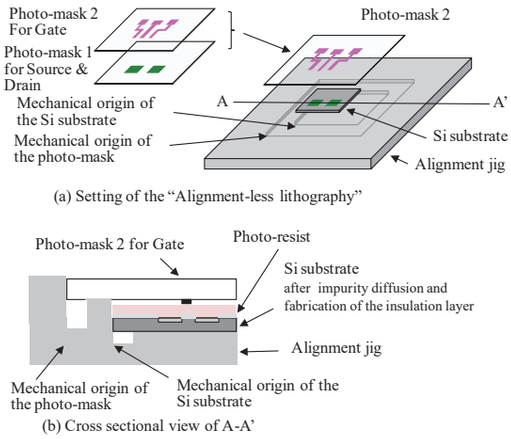


Figure 3 Photo Lithography Process with ALL

This method has been dubbed, "Alignment-less lithography". The errors are determined by the accuracy of cutting and printing apparatuses. It is recognized that the photo-mask fabrication is the key issue to achieve this hypothesis. To achieve this photo-mask fabrication, it expected that it will make the physical position error compensation of the circuit pattern on each of the photo-mask possible through the polishing of the photo-mask itself. However, it is difficult to apply this method to the traditional glass photo-mask. Therefore, we propose to use plastic transparent sheets on which the circuit patterns are printed to make the polishing possible.

Experimental Method

Fig. 2 shows a brief overview of the fabrication process about the photo-mask making. It is necessary to establish the circumstance of the design, fabrication, testing and revising of the photo-mask set to make it easily and quickly in any time at anywhere by one's own design and by oneself. The mask patterns were designed and revised using the CAD function included in the common presentation software, like "Power Point(PP)" by Microsoft corporation. The students can learn all of the processes regarding to the photo-mask fabrication using their own PC or the PC prepared for the practise use for the programming and the simulation use, in the class room, or in anytime and at anywhere. The transparent plastic sheet for the over head projector (OHP sheet) was used as the photo-mask blanks. And the circuit patterns for the photo-masks were printed by n commercially available normal laser printer. The perfect physical position matching of the divided circuit pattern among the photo-masks is recognized as the key issue of the fabrication, i.e., it is the most important point to achieve two distances X and Y of each of the photo-mask by cutting, exactly the same. The term X and Y here means the distances between the vertical and horizontal edges of the photo-mask and the pattern edges of the substrate. Firstly, the circuit pattern for the photo-mask was arranged accurately by CAD function of the software. X and Y can be determined to cut the cutting guide line, which is the minimum size to print by the laser printer. The printed circuit pattern on the OHP sheet was cut by the simple method to focus on the simplification of the process, for example, hand work using several types of the knifes, cutter knife, design knife, guillotine cutter, etc. The estimated position error is measured by the optical microscope. It is estimated less than 100μm. To eliminate the remained position error, which is understood as "relative position error", grinding and polishing method were used, and the treatment was proceeded until zero position error was achieved using the water proof abrasive papers by cut and try method with checking the actual position error using a general optical microscope and also using the travelling microscope. Approximately from 20μm to 0.5μm grain size of abrasive papers were used. It is recognized that the photo-mask set with the same relative position error can be achieved by this method. It is also very important to set the same positions for the photo-masks and the substrate at every lithography processes. In the lithography process, there are two accuracies, one is repeat accuracy and the other is overlay accuracy. It is understood that it makes the high repeat accuracy of the circuit pattern alignment in the ALL process possible, the ALL process with high accuracy of the circuit pattern alignment can be achieved, since the photo-mask set with almost no alignment error is obtained. Therefore, the pin alignment is applied to achieve the ogy was proposed, the simple mechanical alignment process was tested to achieve the high repeat accuracy without photo-mask alignment.

Figure 3 shows the schematic overview of the ALL process. The alignment jig for ALL process has double recessed stage structure to insert the photo-mask and the substrate. A substrate with photo resist coated is fitted into a deeper recessed section at the center of the jig. The photo-mask thereon is fitted into a shallower recessed section of the jig as shown in the Fig 3(a). The origin indexing work to set mechanical origin positions of photo-mask and substrate are simply performed to fit the left side and bottom edges to the left side and bottom walls of the recessed sections respectively as

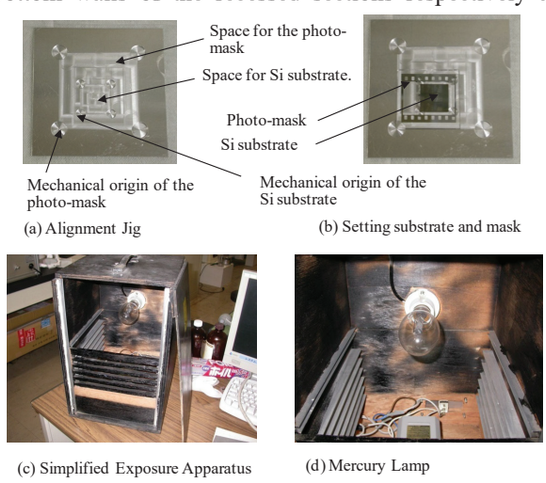
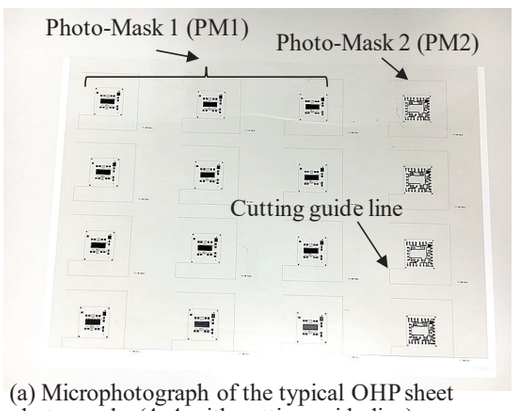


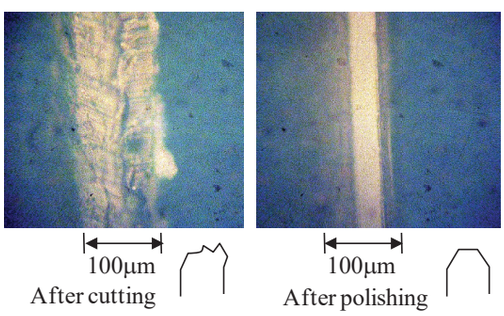
Figure 4 photographs of the Al alignment jig and exposure system

shown in the Fig.3 (b). The position and rotation errors, Δx, Δy, $\Delta\theta$, $\Delta\phi$ are remained, but they are constant value. Therefore the perfect position matching of the circuit patterns are achieved for the contact/proximity exposure methods, though the pattern are offset shown in the Fig. 1 (a). In addition, the exposure apparatus can be drastically simplified.

Fig. 4 shows an example of the alignment jig fabricated by this concept. Fig 4 (a) shows the alignment jig itself and the Fig. 4 (b) shows the condition that the substrate and the photo-mask were set at the right positions. It is recognized that the alignment of the substrate and photo-mask were successfully finished. Fig. 4 (b) shows the simplified exposure apparatus consisted by the Ultra Violet (UV) lamp which is a commercially available germicidal lamp and the simple system to determine the distance between the UV light and the jig. In general, the parallel rays are required for the exposure system to avoid decreasing the resolution. The rays from the UV lamp of the system are not parallel rays, but radiating all directions from the line spot. and the shape of the light source is rectangle-shaped pattern. The common commercially available Ultra Violet (UV) lamp was used as the light source for the exposure system. The UV light radiation is not parallel ray, but radiating in all directions from the line shaped light source. It is understood that all of these are the cause to decrease a resolution of the photo resist

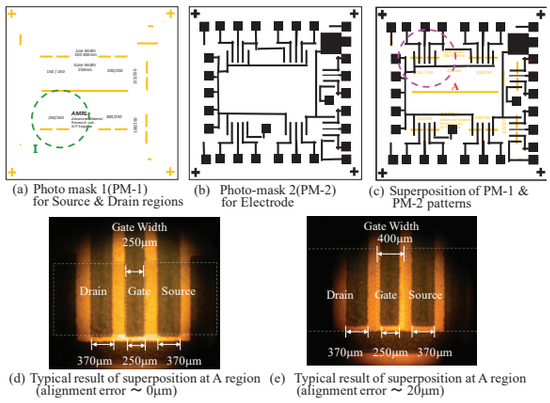


(a) Microphotograph of the typical OHP sheet photo-masks (4x4 with cutting guide line)



(b) Microphotographs of the cross sectional view of typical grinding and polishing treatments at the edge of OHP sheet photo-mask

Figure 5 Microphotograph of the OHP sheet photo-mask and the treatment



(a) Photo mask 1(PM-1) for Source & Drain regions (b) Photo-mask 2(PM-2) for Electrode (c) Superposition of PM-1 & PM-2 patterns

(d) Typical result of superposition at A region (alignment error ~ 0μm) (e) Typical result of superposition at A region (alignment error ~ 20μm)

Figure 6 Typical result of the ALL using modified OHP sheet photo-mask

pattern. However, the maximum resolution is approximately several tens microns in the resolution in this process. Therefore, it is expected that the influence to the resolution is negligible small in this condition.

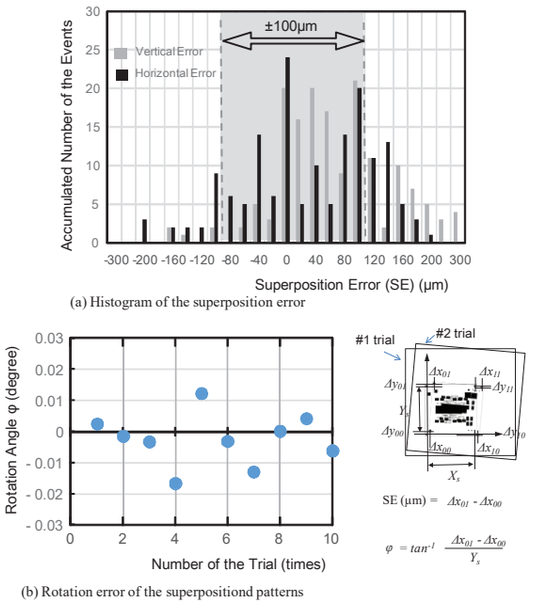
Experimental Results

Fig 5 shows a typical fabrication result of the OHP sheet photo-mask. A series of photo-masks was printed in-line on the same sheet to be intended to the remained width of the cutting lines same after cutting in a row of the photo-masks shown in the Fig. 5(a).

Fig. 5 (b) shows cross sectional view of the photo-mask edge after cutting, grinding and polishing. The burr of the OHP sheet was generated after the cutting. It is expected to be a cause of the alignment error. There is no significant difference among the cutting methods. It was obtained that the hand cutting by simple device, such as razor, cutting knife could play an expected role in the preparation. Approximately 1μm grinding per one stroke was achieved by hand working using about 20μm grain size of the polishing water proof paper, and a mirror polishing was also achieved by using approximately 0.5μm grain size of the polishing water proof paper, respectively.

Fig 6 shows the result of ALL process by using 2 photo-masks. It was obtained that three circuit photo-mask patterns to consist the fundamental structure of the MOS FET were perfectly matched by ALL process. It was demonstrated that ALL process performs as a new simplified lithography method to the device making. The photo-mask set design and fabrication method with photo-mask polishing method to achieve the perfect pattern matching of the photo-mask.

Fig 7 shows the histogram analysis of the superimposition error using two photo-masks in ALL process by 4 average students who have no experience to handle this work. Each student performed the trial 10 times, and evaluated the superimposition error 4 points in each trial. This is the result of 160 times evaluation results. It was obtained that approximately 15% was zero error, and the standard deviation (STD) was ±40μm. However, approximately 50% was over 100μm.. It is obvious that it is the result big enough to be

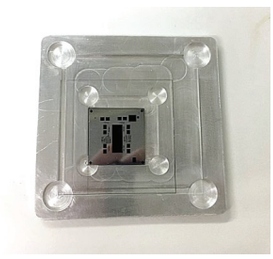


(a) Histogram of the superposition error

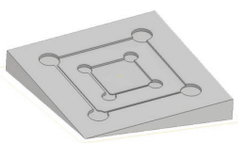
(b) Rotation error of the superpositiond patterns

Figure 7 Typical variation of the human errors in the ALL process

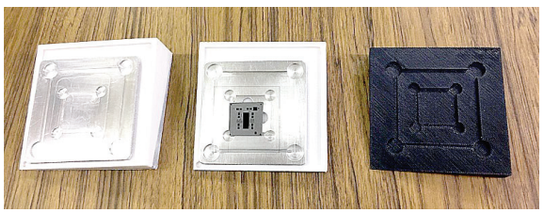
checked by looking and to be decided to try again. Therefore, we focused the results under ±100μm errors, and re-evaluated. As the results, the average values of superimposition error and STD were approximately 30μm and ±18μm in the vertical axis and approximately 4μm and ±24μm in the horizontal axis, respectively. The rotation error also evaluated by calculating using two data 30mm separated positions in X and Y axis. It was obtained that the rotation error was within ±0.02 degrees. It was obtained that the error in vertical axis was larger than the error in horizontal axis. This is the common result that was realized in each of the personal data. The difference of the grinding and polishing condition may be the a cause of this result.



(a) Aluminum jig for ALL process

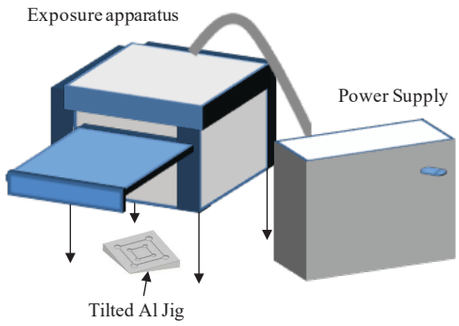


(b) Tilted jig for ALL by 3D printer (typical slope angle : ～10°)

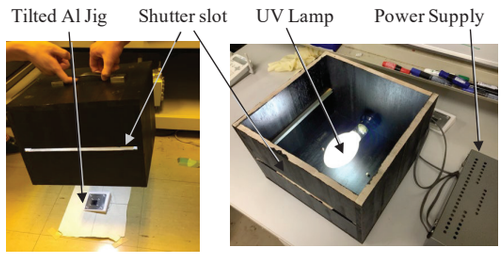


(c) Tilted stage jigs (white color) with Aluminum jig and Tilted jig (black color) fabricated by 3D printer

Figure 8 Tilted jigs (“Self positioning jig”)



(a) A schematic of the portable simplified UV exposure apparatus



(b) The simplified UV exposure apparatus

Figure 9 Potable UV exposure system for avoiding the source of photo-mask positioning error

Discussion

The alignment error was much larger than the value we expected that should be almost zero. It is expected that the position of the substrate and photo-mask may accidently be moved by the mechanical shock during the setting in the exposure process. Therefore, to avoid the influence, the tilting stage for the alignment and tilting jig shown in theFig 8 were proposed and fabricated by 3D printer.

Furthermore, the potable light source shown in Fig 9 was proposed to avoid the jig is manually moved as shown in Fig 8. It is understood that this is unique idea using characteristics of the ALL process. These ideas make the ALL process possible without moving the jig after setting of the substrate and photo-mask to avoid the possible position error.

Fig 9 shows the evaluation result of the double exposure lithography process with ALL process using the tilted jig and the portable light source. The double exposure lithography process was applied to avoid the influence of the variation of the grinding and polishing process of the photo-mask.

The almost zero error pattern matching was demonstrated by this method as shown in the Fig 10. It is demonstrated that both two ideas are very useful for ALL process to improve the alignment error. It is demonstrated that both two ideas are very useful for ALL process to improve the alignment error.

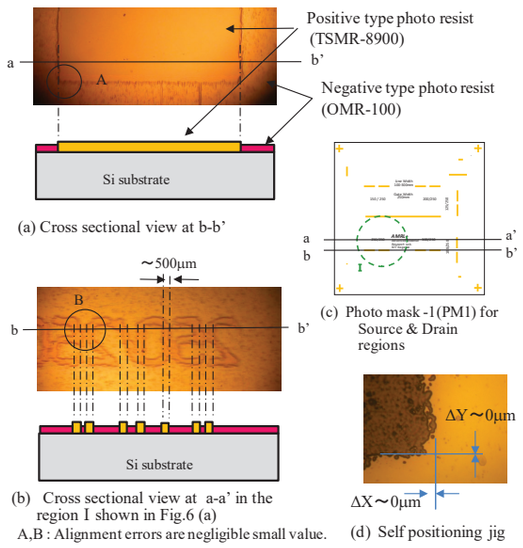


Figure 10 Typical superimposed alignment result of ALL process with the modified setting jig and apparatus

Conclusions

To establish the semiconductor device fabrication circumstance, we named "NANO Tech Platform Established at the Average Science Laboratory", we investigated the feasibility to apply the simplified new lithography method, "alignment-less lithography (ALL)" on the educational program. To improve the accuracy of the mask alignment, the following ideas was tested:

1. Grinding and polishing the edge of the OHP sheet photo-masks to achieve the perfect pattern arrangement on the circuit patterns among the OHP sheet photo-mask set.
2. Tilting jig and the portable UV light source for the exposure system to avoid to be generated after the setting the photo-mask dislocation.

As the result, approximately 20μm of photo-mask alignment error including about 15% of the zero alignment error and negligible small rotation error was successfully achieved without relying the skill level of the students about the lithography process. It was successfully demonstrated the usefulness of the ALL process.

It is expected that the total simplification of the device fabrication process would achieve by our simplified processes, such as impurity diffusion, fabrication of the thin films for the insulation and electrode without using vaccum aparatus under normal air environment, and this ALL process.

Furethremore, it is expected that the improovment in each of the process can procced, even the integrated circuits can be made by the improoved totally simplified fabrication process we proposed. And "A Nanotechnology Platform Established for the Normal Science Laboratory" would be possible to establish.

Acknowledgements

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THE INTEGRATION OF MIND MAPS AND FLOWCHARTS IN UNDERGRADUATE TEACHING

Kleddao Satcharoen

King Mongkut's Institute of Technology Ladkrabang,
Faculty of Engineering, Bangkok, THAILAND

E-Mail : kleddao.gmail.com

Abstract

The aim of this research is to improve teaching effectiveness of Bachelor-level human-computer interaction courses by integrating visual learning techniques, including mind mapping and flowchart techniques. The research is an extension of an earlier study, which incorporated mind mapping during a semester-long course. The research included 83 students enrolled in the 2017 course. A pre-test/post-test mixed methods design was used for the study, with students tested before and after the mind mapping technique on their initial knowledge of HCI concepts at the start of the course. The intervention consisted of a teaching session on the mind mapping and flowcharting techniques, and students were encouraged to use these techniques in their independent and group study. The techniques were also modelled in lectures. The results showed an improvement in the post-test scores, with all students achieving passing scores. These findings imply that incorporating mind mapping and flowcharting is effective for undergraduate learning.

Keywords: *Mind mapping, Flow chart, Teaching Technology, Undergraduate Students*

Introduction

One of the critical problems of computer science education is that despite the very high demand for programmers and other CS professionals, there is a very high dropout rate from undergraduate programs (Giannakos, Pappas, Jaccheri, & Sampson, 2017). There are a lot of reasons for this high dropout rate, including perceived challenge of the program and potential deficits in teaching quality as well as personal values and intellectual challenge among others (Giannakos, et al., 2017). One of the potential factors that leads to a high dropout rate for CS students is study skills that are inadequate or poorly suited to the learning demands of the program (Howles, 2009). This problem can become apparent in the early stages of CS education, as students encounter materials and learning demands that are unlike the learning challenges they faced in their secondary education. For example, students may not be familiar with the visual learning techniques and collective learning approaches that facilitate technology learning (Howles, 2009). Thus, one of the key challenges for a CS educator is to provide students with the learning tools required to facilitate and enhance their learning. Furthermore, undergraduate CS students in some disciplines face special learning challenges. Human-computer interaction (HCI) is one of these fields. Undergraduate students do not have as much real-world experience as postgraduate students and may not understand the importance of HCI in usability (Calderón, 2009). They also may not understand how HCI works with system design (Pastel, Brown, Woller-Carter, & Kumar, 2012). Therefore, undergraduate students may require different teaching approaches and scope than postgraduate students when learning HCI (Pastel, et al., 2012).

This research investigated the integration of two visual learning techniques into an upper-level HCI course at a Thai university. Visual learning techniques have long been promoted as effective for science and engineering disciplines because they help students improve communication and help them connect concepts and theories, increasing interest and working with natural learning styles of many of the students (McGrath & Brown, 2005). This study extends an earlier research project, incorporating two visual learning tools (mind mapping and flowcharting) to improve the learning environment.

Visual Learning Techniques: Mind Mapping and Flowcharting

This research used two visual learning techniques: mind mapping and flowcharting. These techniques are similar in nature but have different levels of representational rigor and different symbolic approaches.

Mind mapping is a visual technique in which students or teachers create diagrams that represent key concepts and the connections between them (Davies, 2010). The mind mapping technique is a flexible technique, which can utilise either technological tools or pen and paper. The approach used is dependent on the student, since the main goal of using mind mapping is to help students remember and connect concepts and theories (Davies, 2010). Different symbols, colours and connections can be used depending on the student's needs to create a network of concepts and their connections (Davies, 2010). Mind mapping is not just a useful classroom learning tool, as it is also used in professional software engineering applications such as requirements engineering (Mahmud & Veneziano, 2011). Therefore, the adoption of mind mapping in the HCI classroom is useful both as a study technique and as a required professional skill. Previous research has shown that mind mapping is an effective tool for science and technology learners. For example, it has been shown to be effective at introducing creativity and facilitating conceptual learning for engineering students (Zampetakis, Tsironis, & Moustakis, 2007). These authors showed that mind mapping allowed engineering students a degree of creativity in learning and maintained flexible learning capabilities, which are critical for engineering skills but often ignored in the curriculum (Zampetakis, et al., 2007). Mind mapping can also be used effectively in conjunction with other learning techniques. For example, a study in computer science students in Malaysia has shown that it is effective at helping students learn analytical skills and logical thinking skills (Ismail, Ngah, & Umar, The effects of mind mapping with cooperative learning on programming performance, problem solving skill and metacognitive knowledge among computer science students, 2010). These authors showed that mind mapping was an effective tool for facilitating student cooperative learning, with significant improvements in test scores between students taught mind mapping and cooperative learning and those with no additional teaching techniques (the control group) (Ismael, et al., 2010).

Flowcharting is the second technique used in this study. Flowcharts are ordered and structured visual representations of processes, algorithms or other connected concepts, which are some of the earliest tools introduced in CS teaching (Reed, 2011). Unlike mind maps, flowcharts do not typically represent networks of concepts, but may instead represent processes and components (Reed, 2011). The flowchart was one of the earliest tools developed for visual representation in computer science, emerging in the late 1940s and early 1950s and being well-established by the 1960s when they could be represented using computer code (Knuth, 1963). Flowcharts are a common part of instructional design in CS programs, and are often used with pseudocode to represent programs and connect concepts (Ismail, Ngah, & Umar, 2010). They are critically important tools for teaching CS because of their ability to visually represent dynamic processes, although they can also be difficult to understand (Fouh, Akbar, & Shaffer, 2012). They are also commonly integrated into CS instructional technologies, which frequently enable students to construct flowcharts to represent concepts and as a preliminary step for implementation of algorithms and as part of their code design process (Santos, Gomes, & Mendes, 2010). For example, common programming teaching tools use flowcharts as part of their algorithm process and it is common for lecturers to use flowcharts to visually represent concepts (Santos, et al., 2010). However, these tools are often poorly explained and students may not be explicitly instructed in how to construct and use them efficiently (Ismail, et al., 2010). Therefore, flowcharts may not be as strong a teaching tool as they could be, depending on the process used to teach students about them. In fact, a study of student failure and student attrition in computer science points to inadequate instruction on how to use flowcharts, along with other common representational tools such as pseudocode, as one of the reasons why students may not be successful at computer science programs (Sarpong, Arthur, & Amoako, 2013). Therefore, even though the use of flowcharts is a potentially useful tool for CS students both in their classes and in later professional life, they may not be taught how to use the tools effectively. Thus, there is an opportunity to improve teaching effectiveness by offering explicit instruction on flowcharts, how they are constructed and what they mean.

Pedagogy

The study took place during the second semester 2017 teaching year, in an undergraduate introductory HCI course aimed at third and fourth year undergraduate students.

The evaluation began with an introductory assessment of knowledge about HCI, including 25 items that measured simple and complex concepts that would be addressed over the course of the term. This questionnaire also included additional items about previous experience with mind mapping and flowcharts. The same instrument was used during the pre-test period (first week of class) and post-test period (last week of class). Participation in the assessment was optional and it was presented as a self-assessment exercise. It was distributed as an online multiple choice quiz through the course's content management system (CMS). The quiz did not count toward the student's grade in the course, but a passing grade of 50% was established as the goal for ensuring the student would pass the course. Data was also collected using observations and informal interviews with students over the period of study.

The mind mapping and flowchart tools were presented and discussed explicitly during the seminar portion of the first week of the class. Following this introduction, a post-intervention questionnaire was

distributed, repeating the learning tool questions from the initial assessment. The introduction of the tools was accompanied by a comprehensive guide and tutorial distributed through the CMS system. Students were encouraged, though not required, to use mind mapping and flowcharts as self-guided learning tools and during group exercises throughout the course. Both tools were also used routinely in presentation of information, for example in lecture presentations and notes and in tutorial sessions.

Analysis of the pre-test/post-test assessments was performed using descriptive statistics, including average (mean and standard deviation) and categorical analysis of pass rates. The findings also contain a review of the overall performance of the tools in the teaching process.

Results

The pre-test assessments showed that 100% of students had encountered flowcharts in their coursework previously, but only 48 students (57.8%) were confident in interpreting flowcharts and only 22 students (26.5%) had previously used them in more than one class assignment. Mind mapping was less well-known, with 69 students (83.1%) encountering them previously, 36 students (43.3%) being confident in interpretation, and 17 students (20.5%) using them in more than one previous assignment. In the post-intervention follow-up assessment, 71 students (85.5%) reported feeling confident in interpreting flowcharts and 64 students (77.1%) reporting feeling confident in interpreting mind maps. Throughout the course, 56 students (67.5%) used flowcharts in their submitted work or during in-class exercises at least one time, while 79 students (95.2%) used mind mapping in their submitted work or in-class exercises at least one time. Therefore, it can be stated that in terms of teaching the mind mapping and flowchart techniques, the deliberate introduction of the material was successful.

The results of the pre-test/post-test assessments of HCI knowledge are shown in Table 1. As this table shows, the initial scores were relatively low, with 18 students (21.7%) scoring less than a 50% mark. During the post-test period, all 83 students passed the exam, with only one scoring below 65%. This performance was higher than the previous year's performance, where two students scored below 65%. Thus, there was a noticeable improvement in HCI general knowledge over the course of the semester for all students.

Table 1 Summary of pre-test/post-test outcomes for HCI knowledge assessment

HCI class in 2017	Pre-test		Post-test	
	Fail*	Pass	Fail	Pass
Number of students	18	65	-	83**
Percentage	21.6%	78.4%	-	100%
Remarks *Score lower than 50% means fail **Only 1 students achieved less than 65%				

Discussion

The findings showed that students became more confident and knowledgeable about flowcharts and mind mapping over the course of the semester and began to use the techniques more frequently as the term went on. The findings also showed that the students' general knowledge of HCI increased. These two factors cannot be directly correlated, since students were also absorbing knowledge from the lectures, coursework, and independent research and reading that was part of the course. However, the increase in knowledge and confidence about the two techniques suggests that there is a significant benefit to explicitly teaching students to use these techniques.

The success of introducing these techniques into an upper level class raises the possibility that it would be better to introduce these tools even earlier in the undergraduate curriculum. Lack of appropriate study skills and knowledge is known to be one of the main factors in student dropout from CS programs (Giannakos, et al., 2017; Howles, 2009). These problems become evident early, as students begin to struggle in their lower level courses (Howles, 2009). Therefore, it would be appropriate to teach the techniques at an even earlier stage, rather than to the third and fourth year undergraduates enrolled in the study course. This would help improve student performance and increase retention rates. It could also help students begin to develop visual understanding and help them identify the connections between concepts of HCI (Calderón, 2009). Furthermore, these techniques may be useful for students outside the CS program. Mind mapping is a general technique that can be used to visually explain connections between any complex network of concepts (Davies, 2010), making it an appropriate tool not just for science learning but also for other concepts. While flowcharts are perceived as a STEM tool (Reed, 2011), in fact they are ideal for representing complex dynamic processes (Fouk, et al., 2012). Therefore, they could also be useful in other disciplines as well. Therefore, this research provides continuing evidence that the use of such visual teaching tools could be more widely helpful in Thai undergraduate teaching.

Conclusion

The reason for conducting this research was to examine how undergraduate teaching for CS students could be improved by integrating two visual learning techniques – mind mapping and flowcharts. The outcomes of the semester-long intervention showed that when these techniques were specifically explained to students, they gained confidence in interpreting the representations and in using them to represent their own concepts and processes. The study also showed that student learning may have been enhanced, although as with any other classroom interventions there are multiple conflicting factors. However, the increase in use of the tools over the course of the semester does indicate that the tools are effective at improving learning.

This study provides some recommendations for CS teaching practice. Given the importance of both mind mapping and flowcharts in the professional life of CS graduates and the role of appropriate study techniques in preventing CS program attrition, it would be well worth introducing these tools during formal CS classes. This introduction should occur even earlier than the upper-level undergraduate course the study was conducted within, potentially within the first few courses in CS that undergraduates take. This is necessary because students may not gain confidence with these tools, meaning that they may lose a lot of learning resources that could be better used if they understood the teaching tools. It also implies that the integration of visual learning tools like mind mapping and flowcharts into course materials, lecture notes, and assignments can help students gain confidence in their use of the tools and increase the likelihood that they will be able to use these tools effectively, which would improve the student experience and learning.

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TEACHING BASIC PROGRAMMING TO PRE-UNIVERSITY STUDENTS THROUGH BLENDED LEARNING PEDAGOGY– A DESCRIPTIVE STUDY

Ramachandra Rao Vandana [a] and Heng Ngee Mok [b]

School of Information Systems, Singapore Management University, Singapore

[a] vandanarr@smu.edu.sg
[b] mok@ieee.org

Abstract

Students enrolling for undergraduate programmes in Singapore would have either finished their polytechnic diploma or completed Junior College (JC) studies. Most pre-university students coming through the JC pathway are not exposed to programming as computing is offered as a subject in a very few JCs. The authors of this paper conducted four runs of an introductory programing course between 2016 and 2017 for a research project funded by the Ministry of Education, Singapore. The project named "Let's Code!" was intended to introduce fundamental programming concepts to students and guide them to consider taking a computer-science related degree for their university education. Pre-university students who had no background in programming could enrol in one of the runs of the "Let's Code!" programming course. Blended learning pedagogy was adopted to deliver the course content in three weeks. The purpose of this study is to gain insights into the delivery of an introductory programming course to a heterogeneous group of pre-university students through a blended learning pedagogy. This paper analyses the survey responses and the test scores of the participants who attended the course in the two runs of June and December 2017. Based on the test scores taken on the final day of the course, it was found that (i) male students performed better than the female students regardless of whether they had prior programming exposure, and (ii) students who had exposure to programming performed better than those with no prior background.

Keywords: *introductory programming course, blended learning pedagogy, university education choice, computer science studies, open educational resource, student outreach.*

Introduction

Students applying for undergraduate university admissions in Singapore primarily come from two streams. They are either (i) students with a polytechnic diploma or (ii) students who have completed their A-level at one of the Junior colleges (JC) (Singapore Education - Pre-University, n.d.), or students with an International Baccalaureate (IB) diploma (International Baccalaureate – Programmes, n.d.). The IB diploma is considered equivalent to the A-levels in the pre-university education landscape; Bhardwa (2017) compares the two (A-levels and IB) in her article in the Times Higher Education. In most of the JCs in Singapore, "Computer Studies" is not offered as a subject. The authors of this paper hence decided to offer an introductory programming course to all JC students. The authors got funding from the Singapore Ministry of Education's "MOE Academies Fund" for the project, named "Let's Code!". The project's primary objective was to expose JC students to programming by conducting four similar runs of an introductory programming course in a span of two years in order to help them consider an undergraduate degree related to computer science. The secondary objective was to create awareness about the computer science-related degree options available at the Singapore Management University's School of Information Systems (the school the authors work at). The programming course was open to all students from the JCs, the IB diploma program, and students in their fourth year from the Integrated Programme at the secondary level (Other Programmes in Secondary School - Integrated Programmes, n.d.). This meant that the participants of the course were between the tenth and twelfth year of their school education.

The programming course was designed to cater to participants with no computing background. The focus of the course was problem solving. Only fundamental programming concepts such as variables, conditional and loop structures, functions, and arrays were covered. The Ruby programming language was chosen as the language of instruction.

The four runs of the course were scheduled in June and December (of 2016 and 2017) to coincide with the school holidays in Singapore in order to facilitate the attendance of school-going participants. Each run lasted for three weeks. The course content for the four runs of the course was identical albeit minor differences in the delivery.

A major portion of the project funds was used to pay the teaching assistants who assisted the instructors (authors of this paper) in the delivery of the course. The teaching assistants were first or second year Information Systems' undergraduate students and were selected by

the instructors. More than 500 pre-university students enrolled to attend one of the four runs.

The course content (video lectures, assignments) was uploaded onto the Singapore Management University's learning management system. The learning material was also made publicly available on a website created for this project (Let's code!, n.d.). The website that had the registration page was sent to all JCs and IB / IP schools in Singapore. The teachers in the schools helped to publicise the course before the beginning of every run. The participants of this course self-registered to one of the runs.

Initial data for this study comes from responses by the registrants to the survey questions. The purpose of this pre-course survey was to collect data regarding the profile of the registrants enrolling for the course (sex of the student, which school they were from, which year of study they belonged to, subjects taken at school etc.) as well as for the instructors to understand registrants' exposure and background in programming (Has the student experienced programming using Scratch, Alice, or other languages? What is the student's self-assessment of his experience in programming?). At the end of the course, participants provided course feedback. The post-course feedback survey followed a modified version of FACETS (Student feedback on teaching, n.d.), a survey instrument used at Singapore Management University for collecting teaching feedback. In addition to the above two sources (pre-course and post-course survey), data collected from the learning portal through the process of participants' course of study (online quizzes, attendance) and data from the results of the exam conducted at the end of the course (for every run) constituted the data for this study.

Although data for the four runs of "Let's Code!" programming course was available, this study analyses the data collected from the last two runs. This is because the last two runs adopted the same post-course feedback survey instrument (FACETS); the initial two runs followed a different instrument that was too long and discouraging for the students to fill. This study attempts to find answers for the following questions:

1. How effective is the delivery of the introductory programming course using blended learning pedagogy, related to students' learning and performance?
2. Do participants' prior programming experience affect their results?
3. Is there any other influencing factor that affected the participants' results?

Pedagogy

The participants who hailed from various schools (from 24 schools for the two runs in 2017) registered online for the programming course. All registrants were required to attend a briefing session during which the instructors briefed the participants about blended learning (BL) pedagogy adopted for this course. The instructors were well aware of the BL pedagogy (Mok, 2014). On the briefing day, the students were assigned groups; depending on the size of the group, up to two teaching assistants were assigned as mentors to each group. The students got help to set up their laptop with the programming environment on the briefing day. The briefing session also provided an opportunity for every student to know his mentors and peers.

During the briefing session, the students were given an online Multiple Choice Question (MCQ) quiz to test their programming exposure prior to taking the course as it was expected that a few students would have some programming knowledge. An almost identical test was given to them at the end of the course.

The topics covered in the course were categorized into four units and the students were advised to follow the learning material in sequence. Table 1 shows the topics covered in all the planned seven meet-up sessions of each run.

Table 1: Topics covered during the meet-up sessions

Meet-up session	*Topics covered*
1	Briefing and set up session
2	Variables, Types, Operators (Unit 1)
3	Decision and Loops (Unit 2)
4	Methods (Unit 3)
5	Arrays (including 2D arrays) (Unit 4)
6	Putting all concepts together
7	Debrief and exam session

Apart from the briefing session and the last meet-up session, that served as the exam and de-brief session, the participants were required to attend at least two of five other meet-up sessions (2 to 6) as a requirement to be eligible for a certificate of completion. During these meet-up sessions, tutorial type lessons were conducted. The first four tutorials had problems to be solved based on the new topic covered in the recent lecture videos of the corresponding unit, whereas the fifth tutorial had questions that helped students combine all the concepts taught in the previous units and also to prepare them for the exam.

Every unit required the students to watch online lecture videos, take the self-check quizzes and attempt assignment questions related to the unit. Figure 1 illustrates the learning plan recommended to the students for watching videos. The students were advised to attempt all self-check quizzes related to the unit before attempting the corresponding unit's assignment questions. Mentors provided support to students during this period of self-learning.

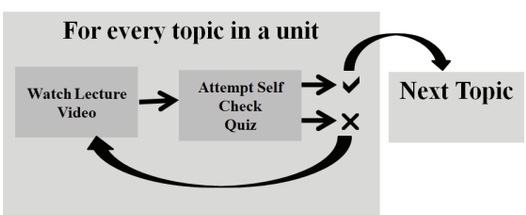

Figure 1: Recommended mode of learning

During the tutorial sessions, more questions pertinent to the topics covered in the recent unit were given to reinforce the concepts. Figure 2 shows the sequence of activities lined up for the student for every unit.

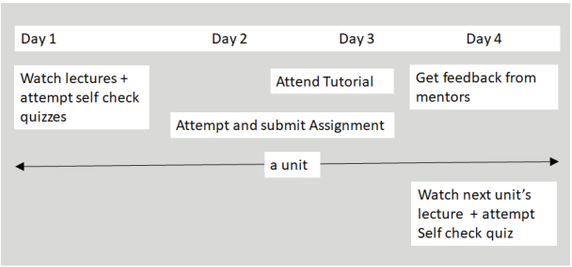

Figure 2: Sequence of activities per unit

During the tutorial session, instructors and mentors guided students on how to approach programming questions and compared various solutions to the same question. The meet-up sessions allowed the mentors to engage with the students and assist them with their assignments.

In the first three runs, the tutorial session served as a review session and was held on Day 3 as shown in Figure 2. However, for the last run, the tutorial was held just after the students watched the lecture video to help clear students' doubts on concepts (on Day 2) before they tackled the assignment questions. The change was implemented based on the feedback from the mentors, and our observation of students' inability to apply the concepts learnt to the assignment questions. The authors of this paper documented the experience of conducting the course, with all the implementation details, and the changes made across the four runs in Mok & Rao (2018).

Each of the first four tutorials corresponding to units 1 to 4 and the final tutorial that consolidated topics of all units had a corresponding assignment (summing to five assignments) that was required to be submitted. The mentors' responsibility was to provide feedback on the submitted assignments of students mentored by them.

The briefing session and the five tutorials were spread over three weeks with each week typically having two tutorials. The exam consisted of MCQs and programming exercise questions for students to solve. The students used their computers to write the solutions for the programming exercises. The MCQs were a mixture of online and paper based questions. As previously mentioned, the online MCQs were very similar to those given on the briefing day. In order to earn a "Certificate of Completion", the students had to meet attendance requirement (at least two out of five tutorials), submit five assignments, and attempt the exam. Students who fulfilled the requirements for the "Certificate of Completion" and passed the exam were given a "Certificate of Merit" in recognition of their good performance.

Methods and Materials

For this study, the sample data comes from 266 students who enrolled in the June and Dec. 2017 runs (out of a total of 535 participants across the four runs).

It was encouraging to observe that there was a good interest from female students to enrol in the course. The percentage of female students (47.4%) enrolled compared to male students (52.6%) did not show a huge difference indicating growing interest among female students to be in the STEM sector (More women working in science, engineering sectors, 2016). The interest could be attributed to Singapore's push to become a "smart nation" (Info-communications Media Development Authority, 2015) and the job opportunities available in the technology sector (Heng, 2017; Tegos, 2017). A review of the participants' responses to the pre-course survey question, "Describe your goals for participating in this course" asserted the above opinion. As examples, there were responses that read "I am interested in taking an IT related course in uni but I have come from a bio background since secondary 3 till JC, so I hope this course can firm my interest on IT and guide me into this path I hope to take.", "wish to learn and understand more about coding as it has always been emphasised as an essential skill in this 21st century…", "With the knowledge that Singapore is striving towards being a smart nation and that technology will definitely be an integral part of society in the future, I hope that through this course I would be able to grasp the basics and foundations of programming...".

Table 2 reports the demographic profile of the students in the sample. Most (85%) of the 266 students were either in their 11th or 12th year of education compared to 9% in the 10th year of education.

Table 2: Demographic profile of students from the June and Dec. 2017 runs

	Percentage	n
Gender		
Female	47.4%	126
Male	52.6%	140
Year of study		
JC1 or IB Year 5	33.5%	89
JC2 or IB Year 6	51.5%	137
IP year 4 or IB Year 4	9%	24
Graduated from JC / IB	6%	16
Prior Programming Exposure		
With Programming Experience	22.2%	59
No programming Experience	76.7%	204

Although this course was catered to students with no programming experience, we had questions in the survey related to the extent of exposure the students had to programming prior to joining our course. We used a binary measure to capture participants' prior programming exposure. Based on the students' responses, we considered those who had exposure to at least one programming language such as C, C++, Python, Java,

JavaScript and other non-visual programming languages as having had "programming experience" whereas those who mentioned that they have tried HTML, or Alice, or Scratch with no other typical programming language experience to be having "No programming experience". Based on this criterion, the percentage of students with programming experience was 22.2%, compared to 76.7% with no prior programming experience as shown in Table 2. Only 11.9% of the female participants had programming experience compared to 31.4% of the male participants.

Although the participants were required to attend only two out of five tutorials, we observed that a substantial number of students (60.9%, n = 266) attended at least four tutorials.

Among the 266 students who enrolled for the course in 2017, 215 (80.8%) completed the course and were eligible for the "Certificate of Completion". The attrition rate of 19.2% was considered low, as the students had no obligation to complete the course. Table 3 captures the course' completion rate statistics by gender in the two runs.

Table 3: Course completion rate statistics

	Percentage	n
Earned "Certificate of Completion"		
Male	77.9%	109
Female	84.1%	106
Total	80.8%	215
Earned "Certificate of Merit"		
Male	53.6%	75
Female	25.4%	32

Among the 266 students, 40.2% (n=107) were eligible for the "Certificate of Merit" which meant that they completed all the requirements for the "Certificate of Completion" and also passed the exam.

Results and Discussion

In order to measure the learning achievement of students, we compared the results of MCQs attempted by the students on the briefing day (beginning of the course) and compared it with their scores (out of a maximum score of 8) on the exam day when they attempted a similar set of MCQs (as on the briefing day). Data from the participants who had not attended one of the tests, pre-course or the post-course MCQ test was not considered. The mean difference between the scores before the run of the course (1.53/8 i.e. 19.1 %) and after the course (6.1/8 i.e. 76.3 %) was noted to be statistically significant with a p value less than 0.01 at 95% confidence level (n = 228).

In order to examine the impact of prior programming exposure of the students, we conducted the t-test again to compare the MCQ scores of participants who had no prior programming experience. Table 4 tabulates the result of paired two-sample t-test performed on the unfiltered and the filtered sample. The significant difference in the mean scores (pre-course 16.5 %, post-course 74.6 %, n = 174, p value < 0.01) for students with no prior programming background indicated that there was a positive learning achievement. The mean difference for those with prior programming experience (p value < 0.01, n=54) also seemed to be statistically significant indicating that even the group with prior programming exposure improved in their competence.

Table 4: Comparison of paired two sample t-test results

	n	Pre-course MCQ mean (in %)	Post-course MCQ mean (in %)
All participants	228	19.1	76.3
Participants with no prior programming experience	174	16.5	74.6
Participants with prior programming experience	54	27.8	81.0

The post-course online MCQ test constituted to about 1/6th of the total exam score. We then studied the data by comparing the total exam score of all students with no prior programming experience and those with prior programming exposure. The mean score for the sample data with "no programming experience" was 46.5%, "with programming experience" was 61.0%, and the mean difference was significant at $p < 0.01$.

We also compared the results of the total exam score by gender. It was observed that male students performed better (mean 58.1%) than the female students (mean 41.4%) and the t-test showed that the difference is significant ($p < 0.01$) at 95% confidence intervals. Table 5 shows the comparison of the mean exam scores for male and female participants by their prior programming experience.

Table 5: Comparison of exam mean scores for male and female participants

	Average Exam Score	
	Males	Females
Regardless of prior programming experience	58.1 %	41.4 %
No prior programming experience	54.7 %	40.0 %
With prior programming experience	64.8 %	50.9 %

Running the t-test taking only females and males with no prior programming exposure also showed better performance of male students ($p < 0.05$). In comparison, running t-test taking sample data of females and males with prior programming experience, the mean difference was observed to be 50.9% for females and 64.8% for males ($p < 0.02$).

We had attendance records of the students for every tutorial and explored the data to find if there exists a correlation between the number of tutorials attended by a student and his exam score. Table 6 illustrates the

average exam score by students in relation to the number of tutorials attended. The correlation coefficient showed positive relationship but the strength was not very high (correlation coefficient = 0.54).

Table 6: Mean Exam Score Vs Attendance at Tutorials

Number of tutorials attended	*Percentage of students*	*Mean exam score of students*
1	0.4 %	41.25
2	4.7 %	51.86
3	16.7 %	47.87
4	28.2%	44.79
5	50 %	53.37

The students provided data related to the average number of hours spent on the course per day during the three weeks. Putting the figures through multiple linear regression test showed that the variables - Number of tutorials attended, Sex of the student, Pre-course MCQ test score, Prior Programming Experience and Number of hours spent by the student on an average per day, determined about 34% of the variability in the exam scores. Figure 3 shows the multiple regression test result performed using Excel.

SUMMARY OUTPUT

			Dependant Variable: Exam Score
Regression Statistics			Independent Variables:
Multiple R	0.587012		Number of Tutorials attended
R Square	0.344584		Sex of the student
Adjusted F	0.33021		Prior Programming Experience
Standard E	17.50979		Pre-Course MCQ Score
Observatic	234		Average number of hours spent per day

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	5	36751.39	7350.277	23.97409	2.33597E-19
Residual	228	69903.11	306.5926		
Total	233	106654.5			

Figure 3: Multiple Linear Regression Analysis Result

Our research study was more exploratory in nature. Further study would be required to understand the differences in learning achievement between males and females. Perhaps studies that capture students' attitudes towards computer studies, learners' cognitive disposition, confidence level, motivation level and learners' persistence would help to understand the differences in the results.

Conclusions

This study showed that there was a significant improvement in student's learning based on the pre-course and post-course MCQ test. This suggests the effectiveness of using BL approach in teaching introductory programming to pre-university students. There were two findings that emerged from this study; male students performed better than the female students regardless of the prior programming exposure they had, and students who had exposure to programming performed better than those with no prior background. This could perhaps be because of the steep learning curve for those with zero background in programming. Further research is required to determine the cause of gender differences in order to address the gap.

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BENEFITS OF USE OF FREE ACCESS TECHNOLOGY TO BLENDED LEARNING AND STUDENT MOTIVATION AT A NATIONAL INSTITUTE OF TECHNOLOGY IN JAPAN

T. Ziemba

National Institute of Technology, Oita College, General Education (English), Oita, Japan

z-tomek@oita-ct.ac.jp

Abstract

The purpose of this research is to find effective and suitable methods of using technological advancements for the promotion and improvement of blended learning teaching at English as a foreign language (EFL) classes at a National Institute of Technology in Japan. The college at which the study was conducted has experienced previous unsuccessful attempts at incorporating learning management systems (LMS) specifically for EFL learning, and with near to no funding or support for implementation of newer efforts, a switch to free access technology was experimented with. A main website created on a free online provider was created without previous experience in HTML or other programming. The site was used for all communication with students outside of classes, including submitting homework, sharing documents, and providing extra content to lessons content from in class. Site traffic was monitored to see if how many students were actually using the site, as well as conducting surveys and exit interviews from randomly selected individuals on their perceptions of the effectivess of the site. It was found that a vast majority was satisfied with the use and existence of the site, and felt that the simplicity of navigation in particular to being mobile device friendly were key factors to repeated use of the environment. Some went as far to say that it was better than other LMS-based experiences from other courses in the college. Further improvements to the site are now being tested, such as including testing options and even full classes outside of teaching hours using pre-recorded and potentially live video distance education. It is hoped that other faculty at any institution can use similar methods for non-cost enducing educational technology enhanced teaching methods, and to also create a community of online education instructors to keep up to date with various methods found effective through previous experiences.

Keywords: *language education, student motivation, blended learning, mobile assisted language learning (MALL), English as a foreign language (EFL)*

Introduction

The use of technology in classrooms is quite common nowadays, regardless of subject and level. Even in Japan, the use of learning management systems and blended learning classrooms are increasing, especially at National Institutes of Technology (also known as Kosen). In a previous study, a group of students were observed in their reactions to blended learning-based English as a Foreign Language classes, and results were positive (Ziemba, 2017). However, in that same study, the use of LMS that was provided freely with the course textbook was based overseas and with seemingly endless amounts of problems arising throughout the year long course, it was found that using an original, mobile-friendly site was found to be more advantageous to students due to its ease of access by mobile devices, such as students' smart phones. An increasing number of studies emphasize the move from traditional Computer Assisted Language Learning (or CALL) to Mobile Assisted Langauge Learning (or MALL), which are expected to lead to greater educational benefits especially in motivation, much like what is detailed by McCarty, Sato & Obari (2017).

Surprisingly though, it is still quite common for other subjects to be taught by writing inconceivable amounts of notes on a blackboard and having students just copy down the same content in their notes in Japan (Tham & Tham, 2013). Some attempts to incorporate learning management systems in courses have been seen thanks to encouragement from the Ministry of Education (MEXT), yet most of these are only accessible on-campus or in the specific CALL classroom, leading to a lack of access from students' homes (Ono, et al., 2015). Furthermore, with this encouragement also comes various budget cuts, especially in humanities subjects at Kosen colleges, and instructors are forced to either return to paper-and-chalk methods or turn to free-access services to keep the MALL environment running. This research will go into details of proven successful intervention methods on a previously tested group of students aged 15 to 22 at a specific National Institute of Technology in Japan for mandatory and elective English as a Foreign Language courses taught by the author of this research.

Methods

What was initially created in previous research (Ziemba, 2017) for first and second year EFL classes was now spread to all courses taught by the same instructor, including those that were not entirely taught by one instructor. One of the courses that was divided into the four existing classes at the National Institute of Technology at hand, was split into two each between themselves and another English teacher due to class limit restrictions. As shown in other studies (Lander, 2015), incorporation of blended learning environments can also help students achieve greater scores on traditional Japanese test-based courses. This was ensured through the inclusion of practice tests and access to further content and discussion available on the created website, updated at the end of the week so students had access to materials before weekends.

The classes were mostly 40 students each, with the higher grades (equivalent to second and third grade at university) being elective subjects with a lower number of participating students. These were further changed in their instruction method by including various forms of continued discussion based on in-class materials, including linking to documentary films on YouTube, or creating content-specific pages leading to writing of opinion essays or creating original media themselves.

As the current second year students had previous experience in the implemented blended MALL English class environment, they were designated as the control group, and were monitored for their upkeep of motivation and access to the website. Other students' access to the free site was monitored and paper questionnaires were distributed with each midterm and final exam, which were open ended questions regarding their perceptions of the website, its effectiveness, and what improvements they felt would be necessary to increase learning and the online environment.

The website used for blended learning was based off Weebly, a free website making service, with an e-mail form for students to submit questions and written homework assignments in a contact box that would directly be delivered to the instructor. The benefit of this service is that some mobile providers in Japan block connections from mobile phones to PC-based addresses for security purposes, and by submitting via the website, a guaranteed submission can be confirmed.

Unfortunately, attachments cannot be provided, so in those cases it was recommended to use free file sharing services, like GigaFile, and to copy the link to the files in the e-mail form. The use of these uploading sites was also originally a source of concern for the files potentially having viruses and such but were always checked through anti-virus software designated by the National Institute of Technology.

Furthermore, site access data was analysed to see how often students were visiting the site, at what times, and from what locations, to see how useful specific pages and contents were to the students, which in combination with regular surveys, were able to further cater the contents to the students' needs for learning.

Results

Student feedback was seen to be generally positive, especially with first year students, as seen in Table 1 below. Second year students who had first experienced the website had showed a slight decrease in their excitement of the website from the previous year, with increasing demands for customization that is not always possible with teaching workloads. Surprisingly, higher grade students (fifth and sixth graders) who were also exposed to the MALL website showed the lowest levels of satisfaction in terms of finding it very useful.

Grade (Students)	1st year (168)	2nd year (153)	5th year (39)	6th year (30)
Very Useful	82%	72%	57%	60%
Useful	18%	23%	33%	21%

Table 1: Student feedback on site usefulness by class

The reasons for the results are seen in Table 2 below, in which free comments by the students on the midterm surveys were detailed. Like the percentages of satisfaction seen above, most comments were also seen to be along the same lines. Lower grades had more positive feedback, and higher grades had more straightforward complaints. It is important however to take into consideration that the higher grades although were also introduced to the MALL website for the first time like the first-year students, their experiences at National Institutes of Technology are much more plentiful, and have also previous experiences in other LMS, like Moodle and Blackboard, in some of their other specialized engineering courses over the years. This previous exposure may skew their perceptions of an ideal LMS blended learning experience, whereas first-year students who came straight out of junior high schools are likely to be exposed to these technological incorporations for the first time in their education.

- The website makes it easy to get information that otherwise we'd need to go see you in your office and ask for in person (1st year)
- Having everything from class available on a website that is smartphone friendly is something I wish all other classes had (1st year)
- I'm glad last year's pages are still available even though we aren't taking that course anymore (2nd year)
- More regular updates would be nice (2nd year)
- I understand that its useful, but taking time to check it outside of class is annoying (5th year)
- The website is hard to navigate, especially since the course titles and content are so similar for both advanced classes (6th year)

Table 2: Detailed comments from students based on written opinions from test feedback surveys

Discussion

The first and most concerning point brought up by the results was the surprising lack of confidence and satisfaction by higher level students with the free MALL website. The initial suspicion was due to comparisons to previous LMS based teachings in their other courses, which was confirmed by interviewing a few students that volunteered to partake in one-on-one discussions about the free MALL site.

Botero et al (2018) have just recently published a study on the usage and more importantly acceptance of MALL environments in regard to attitudes towards its use. Student perceptions are obviously key, but the perceptions that were initially assumed to be similar to first-time users of the EFL MALL site were not the case, due to more experienced students having greater expectations based on their previous encounters with LMS and blended learning.

To put simply, what can be seen as a trivial, beneficial tool to lower grade students is not seen to positively by their seniors, due to the seriousness of their studies and concerns with grades. A previous study by Lander (2015) also reinforces this concern with their research concluding that successful incorporation of blended learning environments are able to and are somewhat expected by students to improve their grades through online practice testing. In other words, the senior students who are most concerned with their job hunting, university entrance exams, and marks average upon graduation are sadly more concerned about the numbers achieved at the end of the course rather than the content of what is taught or how it is achieved.

The higher graded students need confirmation from the get go, or as soon as possible, that using this material will be a plus for them and be reflected likewise in their marks, otherwise they will only see the site as an obstruction to what they can find and learn themselves (Hinkelman & Gruba, 2012). It is due to these demands that further links with other sites and services, like Quizlet or other testing services are intended to be appropriately incorporated to further the positive aspects that can show benefits to the senior students while still maintaining a fun, albeit trivial perception by juniors, which is still understandable.

Potentially the most crucial, and still in discussion with the students involved in the study are appropriate forms of feedback to the students, regardless of grade or level. As previously mentioned, if there is no clear sign of benefit to the senior students, they do not feel the need to access supplementary material, whether it is freely available online, with easy to navigate environments or not, also shown by Ginns & Ellis (2007). It came as an initial shock to the developing team that what was assumed to be user friendly and beneficial to all users, could have such a polarizing result. This also displays the importance of catering the content to the needs of the students using the technology – free or not. Further improvements and updates are being planned with revisions being implemented as soon as the fall of this academic school year.

Conclusions

As mentioned by Radin (2017), implementing MALL is a lot more complex than expected, with various factors needing to be considered before successful implementation. Does the system selected suit the needs better than other options? What is the plan for the learning environment, and how will it be created and implemented? And perhaps most importantly – what kind of support is provided or available in case anything may happen? These are often overlooked.

Although most of the students that were observed in this study had previous experience with LMS-based blended learning and other ICT initiatives in their English and other classes, it was found that investments in higher-cost intervention methods were found to have been better accepted by senior students. Yet in the cases of younger students, it was preferred for the simplicity of the free technology due and their familiarity of access to use on their own mobile devices (phone or tablet).

However, there is still room for improvements with their use, especially in concerns for privacy and safety. By using free media, it is often completely open to the entire Internet, with most technologies offering a paid option for login IDs, which defeat the ideal of staying free to use. The risk of students' personal information being used for marketing purposes is an understandable concern for school administrators, as well as parents and guardians of the students themselves. This is one concern that the college administrators are quite adamant about keeping an eye on for clear reasons.

In the case of National Institutes of Technology, licenses of Office365 are available for students and staff, but their incorporation is still not made fully available due to previous issues at various institutions. By using this, the cost for instructors to use this service is technically free, and becomes valid option, albeit proper instruction for their use has yet to be designated and confirmed. With further budget cuts projected, it is key to keep cost to a minimum, and preferably free without risking privacy. Also, considering that the school and its technical staff in the case of this free MALL implementation gave no advice or support, further improvements to these issues must be carefully planned, for risk of personal information getting into the wrong hands, or misuse by third parties unbeknownst to the students or school administration themselves.

With the increasing familiarity of students to ICT integration in classrooms, and decreases in funding for educational implementations, the use of free websites and online service to improve classes will only become more common. Open media is only growing in space and content and is also a valid option as opposed to previously published materials (Miyazoe & Anderson, 2009), which creates a wider future of learning. Probably the most important factor in keeping these efforts up to date and truly effective is the need to create a community in which educators from around the world can collaborate and discuss their intervention methods and share experiences of what works best in various situations, not just an EFL classroom in Japan.

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MAKING THE VIRTUAL SPEECH JUDGE 2.0: VOICE AUDIO WAVE AND FACIAL EXPRESSION ANALYZING SOFTWARE

T.D. Cooper* [a], Akira Tsukada, Miki Takashima [b], Nobuyuki Gomi, and Akira Shimauchi [c]

[a] NIT Toyama Imizu, Dept. of General Education, Imizu, Japan
[b] NIT Toyama Imizu, Dept. of Electronics and Computer Engineering, Imizu, Japan
[c] NIT Fukui, Dept. of Mechanical Engineering, Fukui, Japan
*cooper.td@nc-toyama.ac.jp

Abstract

Non-verbal communication is an essential part of understanding the speakers "total message". Most researchers place non-verbal communication (NVC) cues, as making up about half of the total message. NVC consists of kinesics, paralanguage, proxemics and haptics. Current technology used by voice assistants eg. Google Voice, Apple's Siri and Amazon's Alexa have become very good at recognizing words used in verbal communication through their speech recognition (SR) engines. But these SR engines are not effective at analyzing the quality of NVC. Our system, the Virtual Speech Judge (VSJ) 2.0 addresses this gap, and gives students the opportunity to improve their performance on speeches, presentations and interviews.

Through a combination of the Kinect camera and audio-wave analyzing software we can target two components of NVC: richness of facial expression and paralanguage, namely individual sounds, rhythm, intonation and stress. When analyzing facial expression, speakers were filmed using two cameras: a digital video camera, and the Kinect 3D motion sensor. The digital video files of 10 speakers were assessed by 5 Japanese "judges" and 1 English native-speaking judge at 10-second intervals using a 5-point scale. Then these results are compared to the data taken by the Kinect camera. When analyzing paralanguage, we replace the Kinect data with audio-wave analysis software. 43 speakers were given several sentences to read, which were then compared to a native-speaker. Audio files were assessed using a 5-point scale.

The development of this system, along with the collection of more data, gives speakers the opportunity to have their NVC cues evaluated, offering the chance to improve their overall total message, resulting in better speeches, presentations and interviews.

Keywords: *Non-verbal communication, gestural analysis, facial expression, audio-wave analysis, total communication*

Introduction

When learning a second language, such as English, things like spelling, vocabulary, and grammar can be taught and learned with no direct correlation to the class-size. However, this is not so when training students to perform well for the advanced tasks of giving a speech, making a presentation or taking an interview. These require more one-to-one facilitation in order to improve a student's communicative competence. Our system, the virtual speech judge (VSJ) focuses on improving non-native speakers (NNS) "total communication" (TC). We define TC as the combination of both verbal (VC) and non-verbal communication (NVC).

Currently, the VSJ pinpoints and gives feedback to NNS with regards to two areas of NVC: quality of facial expression and pronunciation. In a previous study, we showed the correlation between the VSJ and human speech judges when evaluating a speech given by NNS. In that experiment we highlighted the specific facial movement indexes that generally resulted in a high evaluation by a human judge, namely the movement distance & speed of the nasal tip, and movement of the eyebrows. In this paper we will address our current experiments by dividing the methods, results and discussion into two parts.

Methods (Facial Expression)

The VSJ uses the Kinect v2, a motion-sensing camera, created by Microsoft. The Kinect combines features typically found in a two-dimensional web-camera, with an RGB sensor which provides depth data. It has the ability to track 1347 facial feature points, as shown in figure 1:

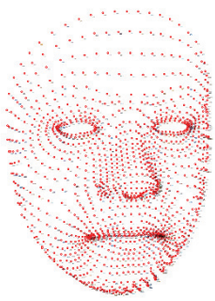
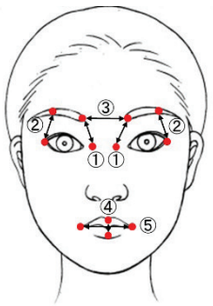


Figure 1: 3D mask created by the Kinect v2

Nine NNS were asked to talk for approximately two minutes. These videos were evaluated at ten-second

intervals on a 1-5 Likert scale (1=poor, 3=satisfactory, 5=highly effective) for the quality or richness of facial expression. Unlike our previous experiments, the subjects were asked to talk freely about any subject. The human evaluators consisted of one EFL teacher [a national-level speech and presentation coach] and five NNS research students. The subjects were randomly selected, and had varying levels of English ability. All videos were evaluated with no sound, with focus on only the facial movement.

While the human judges focused on the overall performance, the Kinect pinpointed on the five areas shown in Figure 2:



① Avg. between inner eyebrow and nasal tip
② Avg. between eyebrow middle and eyelids
③ Right and left eyebrow
④ Upper lip and lower lip
⑤ Corners of mouth

Figure 2: Facial feature points

Our goal was to find a correlation between objective facial movement data with the subjective evaluation of a human judge. Given this data, speakers can get receive precise feedback.

Results and Discussion (Facial Expression)

Compared with previous experiments (r = 0.86), the correlation between the human judges' subjective-evaluation index (SEV) and the Kinect's produced-evaluation index (PEV) was not high, as shown in Figure 3:

	①	②	③	④	⑤
A. total movement	0.35	**0.42**	0.25	**0.47**	**0.43**
B. domain	0.34	**0.42**	0.26	0.39	**0.51**
C. max. distance	0.11	0.26	0.05	**0.53**	**0.60**
D. peak distance	0.36	**0.46**	0.28	0.38	**0.55**

Figure 3: Correlation coefficient (r) for evaluation index and subjective evaluation value

However, a look at Figure 4 shows one of the reasons:

	Teacher	Std A	Std B	Std C	Std D	Std E
Teacher	1.00					
Std A	0.35	1.00				
Std B	**0.49**	**0.42**	1.00			
Std C	0.37	**0.41**	**0.67**	1.00		
Std D	0.17	**0.40**	**0.48**	**0.54**	1.00	
Std E	0.20	0.39	0.37	**0.40**	**0.41**	1.00

Figure 4: Correlation between teacher and student judges' scores

There was a wide difference between the scores of the EFL teacher and those of the NNS research students.

Methods (Pronunciation)

Audio analysis for the VSJ was done using "Wavesurfer", which is sound analysis software developed by the Royal Swedish Technical University. It analyzes audio wav files and indicates temporal changes in fundamental frequency. Forty-three students (International Business Department 1st year Kosen) were given 11 sentences to read into a USB headset. Their sentences were recorded in wav format using the software "Streaming Audio Recorder". The sentences were created from a list of vocabulary they previously learned in their pronunciation class. While 11 sentences were chosen, only the first sentence was analyzed. The following sentence was used:

For the New Year, the student bought cards for his father, tickets to a rock concert for his mother, and some chocolate for his family.

The human judge evaluated the speakers" pronunciation of the sentence on a modified 1-5 Likert scale. Pronunciation was divided into "individual sounds (8)", "word/sentence stress (6)", and "rhythm/intonation (6)." These classifications were weighted (multiplied by the corresponding number), for example the individual sound was scored from 1-5, then multiplied by the assigned weighting, resulting in a total score of 100.

The resulting wav files were compared to the reference and analyzed using the one-class MT method, calculating the distance in in the y-axis using the formula shown in Figure 4:

$$\left.\begin{aligned}\beta &= \frac{L}{r}\\ \eta &= \frac{r}{V_N}\end{aligned}\right\} \quad \eta_1 = \frac{r\beta^2}{V_N}$$

Figure 4: Formula used for MT method

As the value of η_1 increases the closer the quality is to the reference.

Results and Discussion (Pronunciation)

Figure 5 shows the correlation between the human judge's score and that of the wave analysis. As you can see, there is a gap in the scoring correlation.

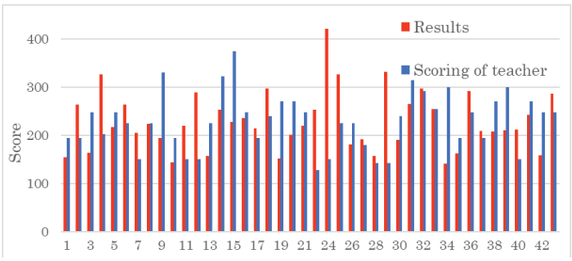


Figure 5: Scoring correlation

A more detailed look at the wav files, showed one of the main reasons for this gap was the difference in timing between the native speaker and NNS. Students read words slower and less fluently than the native speaker, as shown in the raw data in Figure 6:

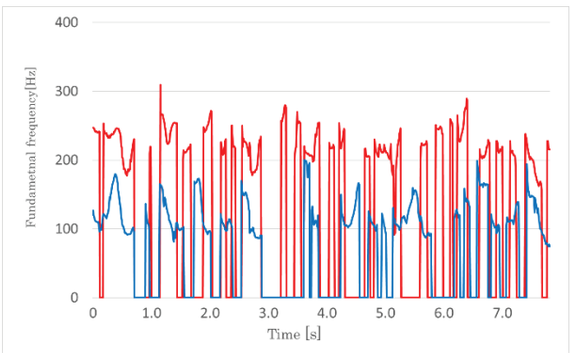


Figure 6: Raw data of wave analysis

Our system was aimed at evaluating pronunciation, (rhythm, stress and intonation), and not fluency. Therefore, the resulting raw data proved to be difficult to assess with the MT Method. To assist in our analysis, the audio wav file was edited to remove the silence or parts where y=0, as you can see in Figure 7:

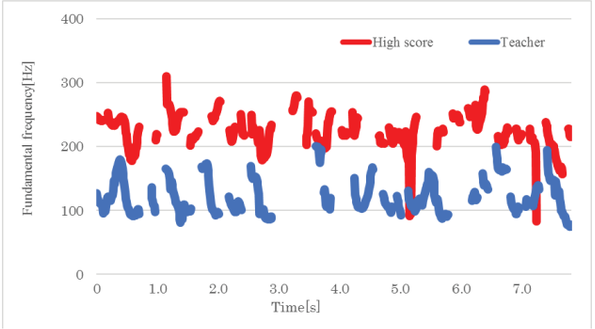


Figure 7: Sample of edited audio wav files

The data shows the approximate time/word where the student needs to improve.

Conclusions

NVC makes up about half the message when communicating. While Google, Amazon and Apple have given us great voice assistants, the job of that software is to recognize speech and not pick up on NVC clues. Therefore, these tools can help, but only with half the message; they can't assist in learning TC.

Currently, the VSJ is helping improve the TC for the selected research participants, but this requires a person with an IT background to explain the data. There needs to be an improvement in the user interface (UI) so students from all academic backgrounds can visualize where they need to improve.

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Acknowledgements

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VIRTUAL REALITY SIMULATION AS HUMAN BODY LEARNING TOOL

W.K. Poon*, K. Leung, J.W.M. Chan and B.Y.C. Lau**

Department of Applied Science, Hong Kong Institute of Vocational Education (Kwai Chung), Hong Kong
*poonwaikwong@yahoo.com
**bellelau@vtc.edu.hk

Abstract

Human anatomy and physiology used to be a very difficult module to teach on students especially those without biological science learning at their secondary school curriculum. Furthermore, students are getting less official access or more restriction to pictures, illustration or photo lately. If combining the most latest advanced visualization technology, virtual reality as learning tools with reconstruction of our clinical Magnetic resonance imaging (MRI) and computed tomography (CT) scan images; it would be a very attractive and valuable learning tools to student who does not have much biological background but now like working with a virtual cadaver with orientation. For those who did have deeper knowledge, such tools would facilitate them for better understanding in a three dimensional image and how body physiology works seamlessly in our body instead of using real cadaver which is not practical in our health care studies teaching environment.

In the past this process could be very complicated because the DICOM data shown on a computer monitor would not be an accurate 3D representation for the lack of orientation. Thanks to the advanced technology, students are now able to quickly visualize the patient inner anatomical structures in virtual reality and have it available for different people on different platforms. This also allows lecturers to explain the clinical conditions with the students much effectively and efficiently.

We have conducted a preliminary trial for six Institute of Vocation Education Lecturers, we all were impressed and satisfied with the preliminary trial result. We would like to apply such on teaching our real students in coming future and further explore its effectiveness in related modules and compare their academic performances. We are expecting that the use of latest vitural reality and simulation technology on teaching and allowance of personal self hand on control and hope it would increase their interest in learning related subjects and with good performance outcomes.

Keywords: *Virtual Reality, Human Body, Anatomy, Physiology, Pathophysiology*

Introduction

BodyMap Pro is the human anatomy learning tool combing with the most advanced visualization technology, virtual reality. Through reconstructing human bodies based on Magnetic resonance imaging (MRI) and computed tomography (CT) scan, BodyMap Pro provides the comprehensive medically accurate anatomical systems in the following twelve categories: integumentary system, skeleton system, muscular system, nervous system, circulatory system, digestive system, endocrine system, reproductive system, urinary system, respiratory system, lymphatic system and connective tissue.

Virtual reality (VR) is an interactive computer-generated experience taking place within a simulated environment, that incorporates mainly auditory and visual, but also other types of sensory feedback like haptic. This immersive environment can be similar to the real world or it can be fantastical, creating an experience that is not possible in ordinary physical reality. Augmented reality systems may also be considered a form of VR that layers virtual information over a live camera feed into a headset or through a smartphone or tablet device giving the user the ability to view three-dimensional images.

1. Education and training.

Basic Anatomy and Physiology along with health care Nursing or Clinical procedures are often difficult for our VTC students to master, yet obviously nobody wants to be a foolish or contemptible nerd.

The study of human anatomy has also emerged as a popular application of augmented and virtual reality technologies. New tools promise to enable students to "peel" away skin and muscle and observe the placement and functioning of bones and internal organs. We're intrigued by the augmented reality.

2. Pathophysiology Understanding

It shouldn't be a surprise that complex surgeries are planned in excruciating detail with virtual reality technology with wearing special goggles.

"Kids playing video games have had this technology for 10 years. It's amazing we only now get it in the operating room." He further suggests that patients and their families find it easier to understand his surgical plans when they can virtually experience them.

3. Telementoring

Imagine you're a lecturer in the midst of a complex procedure that's pushing the student limits of their training and experience. It would a scary thought if on real patient especially if anything unexpected happens during the procedure. Now, using augmented reality technology developed; mentor can virtually join the procedure while it's underway; using special google to superimpose a real-time projection of the mentor's screen and sight from across the hall or around the world even.

4. Student experience

Studies outcomes with full understanding are paramount. Augmented and virtual reality technologies almost certainly have a role to play here. It's great to explore the benefits of virtual reality amongst students and appears that "escaping" to imaginary worlds for recreation could significantly reduce student's boredom and studies depression.

5. Augmented reality enhanced health care

Healthcare, by its nature, is extremely information intensive. The challenge, however, is helping students or participants get the right information at the right time and place so they can deliver effective care and full understanding on delivered knowledge.

6. Preparation of their Future

The goggles are triggered by a QR code and can pull in electronic health record information ranging from nurses' notes to lab results. "I believe wearable computing will replace tablet-based computing for many clinicians who need their hands free and instant access to information.

The European Space Agency (ESA) is thinking even bigger. They're testing an augmented reality system to help astronauts who may be called on in emergencies to diagnosis medical conditions and perform basic surgeries. "Although medical expertise will be available among the crew to some extent, astronauts cannot be trained and expected to maintain skills on all the medical procedures that might be needed," says Arnaud Runge, a biomedical engineer overseeing the project for ESA.

The Computer Assisted Medical Diagnosis and Surgery System (CAMDASS) will use ultrasound technology to overlay information and images into a head-mounted display. It's designed to function even when out of communication with earth-based flight controllers, an advantage for deep space voyages. Does is sounded too far away from our reality here?

BodyMap Pro breakthrough success element was turning our 2 dimensional Digital Imaging and Communications in Medicine (DICOM) image data into three dimensional presentation with visual reality and spacial orientation so that both students and lecturers are able to quickly visualize the human body inner anatomical structures and physiological relationship during lecture; and elaborate those pathophysiological conditions and changes in a much effectively and efficient way.

BodyMap Pro was proven to be working well with lecturers' trial class with 100% satisfaction and perfect experience on its practical setting. It enhanced our clinical experiences and proper knowledge without actual hand on real contact. The hide feature allowed participants to further explore deeper anatomical structure and further along with physiological elaboration and reasoning by lecturer like having a dissection simulation class.

BodyMap Pro is the most comprehensive human anatomy tool, where students are able to learn from our virtual cadaver to understand the human body. This allows for a better understanding of the human anatomy that may have been confusing in the past. In clinical field, our proprietary cloud rendering service is to supply medical centers an effortless turnkey solution to generate each patient's medically accurate avatar based on their DICOM for diagnosis and surgery simulation.

In the past this process could be very complicated because the DICOM data shown on a computer monitor would not be an accurate 3D representation for the lack of orientation. Thanks to the advanced technology, students are now able to quickly visualize the patient inner anatomical structures in virtual reality and have it available for different people on different platforms. This also allows lecturers to explain the clinical conditions with the students much effectively and efficiently.

Results and Discussion

We have conducted a preliminary trial for six Institute of Vocation Education Lecturers, we all were impressed and satisfied with the preliminary trial result.

Conclusions

We would like to apply such on teaching our real students in coming future and further explore its effectiveness in related modules and compare their academic performances. We are expecting that the use of latest vitural reality and simulation technology on teaching and allowance of personal self hand on control and hope it would increase their interest in learning related subjects and with good performance outcomes.

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A PILOT STUDY OF MEASURING THE EFFECTIVENESS OF BLENDED LEARNING

Kelvin. Loo[a*], Christin. Hu[b], K. M. Choi[c], T. K. Chang[d]

[a] Republic Polytechnic/School of Engineering, Lecturer, Singapore
[b] Republic Polytechnic/School of Engineering, Lecturer, Singapore
[c] Republic Polytechnic/School of Engineering, Lecturer, Singapore
[d] Republic Polytechnic/School of Engineering, Programme Chair, Singapore

[*]kelvin_loo@rp.edu.sg

Abstract

This study examined four factors of students' perceptions towards a blended learning environment of a module. Two surveys measuring e-learning experience and study process were administered to seventy-four second-year engineering students at a polytechnic in Singapore. Final module grades were examined for correlation analysis. It was found that students generally agreed that this module provided a good on-line environment for learning as well as sufficient on-line resources to enable students to learn effectively. Their online interactions with the lecturer and peers have aided them to delve further into their learning. Furthermore, all four factors, blended learning approach of the module and deep approach to learning were significantly correlated with each other. The findings of this study can provide valuable insights for the development of similar modules in a blended learning environment.

Keywords: *e-learning, online learning, blended learning, life-long learning, information and communication technologies*

Introduction

In Singapore, the Ministry of Manpower launched a Continuing Education and Training (CET) masterplan, which aimed to prepare the Singapore workforce for the future and to ensure a competitive and career resilient workforce (Tan, 2014). At the same time, "Singapore envisaged to be a Smart Nation, where people lived meaningful and fulfilled lives, enabled seamlessly by technology, offering exciting opportunities for all." (Lee, 2014) As such, together with the rapid development of information and communication technology (ICT), e-learning has been envisioned as a staple learning system that underpins the future CET framework (Tan, 2014).

Benefits of e-learning

There were several benefits of e-learning and thus explained the wide acceptance in education, especially for institution of higher learning and in the realm of adult learning. The predominant benefit is the flexibility of learning in terms of time and place (Lee & Lee, 2008; Lee, Yoon, & Lee, 2009; Mahdizadeh, Biemans, & Mulder, 2008; Sun, Tsai, Finger, Chen, & Yeh, 2008). Learners have the freedom and the discretion to learn wherever they were, at any time of the day. As learning materials are normally available online or given in digital format, learners do not need to be in school premises to access learning content (Lee & Lee, 2008; Liaw et al., 2007; Liaw, 2008; Ozkan & Koseler, 2009; Sun et al., 2008). This helps to save travelling time, giving the learners opportunity to learn more. E-learning could be conducted in two modes: synchronous and asynchronous. In synchronous mode, the lecturer with learners or learners with learners need to participate in the learning process at the same time through the internet space. This helps to alleviate space limitation. As long as the learners have internet access, they can learn wherever they are. After the synchronous session, if learners have any learning issue, they could make use of an asynchronous platform to seek help from their lecturer or peers. Asynchronous platform could take several forms, such as email, chat group, social media or discussion forum. In the asynchronous mode, the use of e-learning allows learners to learn at their own pace. This, therefore, increased learning satisfaction and reduced stress (Arkorful & Abaidoo, 2015; Liaw, 2008; Mahdizadeh et al., 2008; Sun et al., 2008). Learners, who are introvert or shy in expressing themselves, often, have difficulty interacting and communicating in class. E-learning could enhance group discussion and collaboration, where it creates a platform liberating interaction between lecturer with learners or learners with learners, without seeing the person physically. This helps to eliminate barriers, give learners the freedom to express their thoughts and ask questions without much limitation. E-learning allows learners to choose from the variety of learning materials that best suit their learning needs (Arkorful & Abaidoo, 2015). For example, some learners may focus on certain sections of the course materials, while others are prepared to review the entire course. Therefore, this way of customizing content for learners' need could enhance educational values (Engelbrecht, 2003). Lastly, from the lecturers' perspective, e-learning could be a cost-effective way to offer opportunities to maximise the number of learners without the need for additional infrastructure resources (Arkorful & Abaidoo, 2015). Furthermore, this could help to compensate for lack of academic staff, including

instructors, lab technician, etc. Through e-learning, learners are encouraged to depend on themselves as lecturers were no longer the solitary source of knowledge, instead, they became advisors and guides (Alsalem, 2004).

Pitfalls of e-learning

In spite of the benefits, researchers argued that e-learning still has its weaknesses. As compared to an environment where learners were surrounded by lecturer and peers, during the course of e-learning, learners, most of the time, might be alone trying to make sense from the given learning material. Thus, they might suffer from isolation or remoteness going through the e-learning content (Al-Qahtani & Higgins, 2013; Arkorful & Abaidoo, 2015). Furthermore, this could cause issues of clarification and interpretation as learners may not have anyone to talk to at that instant when they had learning issues. Another situation could be that the lesson designer might assume the learners to have a certain level of understanding about a particular concept. However, there might have a gap where the learners' understanding was different from what the lesson designer has assumed. Typically, this situation does happen even in normal face-to-face classroom teaching. However, it can be mitigated on the spot in class because once the lecturer sensed that there was any misconception through their interaction with the learners or from their behavior in class, the lecturer could rectify instantly by addressing the learning issues. On the other hand, in the e-learning environment, the lecturer has limited control over the situation. Lastly, although e-learning can help to avert the situation of learners having interaction or communication issue, this might pose a negative effect on learners' socializing skills because, for full e-learning courses, they were often not required to meet face-to-face and had to complete all learning assignments through computers and internet. This would result in learners acquiring excellent academic knowledge but they might not possess the needed skills to deliver their acquired knowledge to others.

Blended Learning

Since pure e-learning and traditional face-to-face learning hold some weaknesses and strengths, mixing the strengths of both learning environments could enhance students' learning experience. (Azizan, 2010). This new environment is commonly called blended, hybrid or mixed learning. This new strategy capitalizes on the positive aspects of e-learning and to mitigate the negative aspects of face-to-face learning. As such, blended learning has gained its popularity over the years because lecturers believed that varied delivery methods can increase students' satisfaction from the learning experience as well as their learning outcomes (Lim & Morris, 2009).

There are numerous research articles on evaluating various aspects of blended learning. One of the most important aspects would be to look into the coherence of e-learning with face-to-face learning as "the overall goal of a blended learning experience is to provide a mix of both on-line and face-to-face experiences which support each other in achieving desired learning outcomes" (Ginns & Elllis, 2007, p. 55). Thus, this study intends to extend the work from previous research done by Ginns and Elllis. Ginns and Ellis administered an instrument to a group of undergraduate degree students in an Australian university. This study aims to extend the use of this instrument to a younger cohort of students in a Singapore educational institution. As such, the guiding research questions are as follows:

- What are the factors of student's perception towards effective blended learning environment?
- How these factors are correlate to student's approach to learning and their academic grades?

The Participants

Seventy-four Year 2 students from a polytechnic in Singapore, who were enrolled in a module, Green Building Technology and Design, were invited to participate in the survey during the twelfth week of Academic Year 2017 Semester 2. They were briefed about the purpose of the study and how the study will be conducted. Students were informed that their participation will be kept anonymous and that they can refuse or discontinue participation at any time without penalty. After cleaning the data, sixty students' responses were valid and fourteen students' responses were incomplete.

Instruments

This study adopts a quantitative methodology where students, filled out two paper-based survey questionnaires, namely, a 31-item E-learning Experience Questionnaire, and a 20-item Study Process Questionnaire-Revised (R-SPQ-2F). The e-learning experience questionnaire was adapted from Ginns and Ellis (2007). To suit local context, word like "teacher" was substituted to "lecturer". Some questions were re-phrased to suit the way blended learning is conducted for the module under research. For example, the original question was, "The relationships between the on-line resources and the whole unit of study was clarified on the unit's website" and it was changed to, "The relationships between the on-line activities and the whole module motivated me to learn more deeply". One question was removed, as it was not applicable to the module under research. The study process questionnaire was adopted from Biggs, Kember, and Leung (2001). The original version of this questionnaire (Study Process Questionnaire SPQ) was developed in 1987 and it has been widely used by education researchers assessing approaches to learning. Choy, O'Grady and Rotgans (2011) validated the SPQ with 1,608 Republic Polytechnic (RP) students and results shown that the construct validity and reliability was deemed adequate. Biggs and his team revised the questionnaire in 2001 to a two-factor version. The new version has fewer items and is found to be suitable for use by teachers in

evaluating the learning approaches of their students. For both questionnaires, students responded by indicating their level of agreement with each question on a 5-point scale with a higher score reflecting greater agreement.

Procedures

This study takes a semi-exploratory approach to the data collected, as the e-learning experience questionnaire was not validated in Singapore while the study process questionnaire was partially validated. The goal of the analysis should be guided as far as possible by prior research while being flexible enough to allow possibilities for future research to emerge. The analysis was based on the data collected from the two questionnaires. Correlations between factors, the R-SPQ-2F, the overall satisfaction with blended learning module and students' final module grade were examined.

Exploratory factor analysis was carried out to assess the dimensionality of students' responses on the thirty-one items of the e-learning experience questionnaire. The analysis involved principal component analysis as the factor extraction method with equamax rotation to extract four factors. Items with loadings less than 0.4 were eliminated. The items and factor loadings are shown in Table 1. The Keiser-Meyer-Olkin value of sampling adequacy was .754, which exceeded the recommended value of 0.6 and Bartlett's Test of Sphericity showed statistical significance. The analysis revealed that the four factors have eigenvalues greater than 1 and explaining 31.2%, 7.8%, 6.8% and 5.7% of the variance respectively, with a total of 51.4%.

Results and Discussions

The pattern matrix in Table 1 showed the grouping of the items based on the loadings. There were some differences in the groupings of the items as compared to the research done by Ginns and Ellis. Nonetheless, based on the description of the items, it was appropriate to use the same label descriptions as the prior research. The factors were labelled as Good e-Teaching, Good e-Resources, Appropriate Workload, and Students' Interaction. With these grouping, the measure of reliability was examined for all four factors and the results are shown in Table 2. Generally, Cronbach's Alpha of more than 0.7 is deemed acceptable and more than 0.8 is considered good.

Next step is to analyse the students' responses to the four factors that were identified earlier. Table 3 showed the descriptive statistics on the issues of online teaching. The module under research has two on-line environments that the students used. First, there is an on-line platform where students used to access learning material for their daily lesson. The other on-line environment was more specific to the module itself. It is a free voice and text chat app, where students used the app to discuss learning issues among their classmates or with their lecturer. As the results have shown, majority of the students agreed that the lecturers made good use of the on-line environment to facilitate their learning by providing prompt guidance. Table 4 showed the descriptive statistics on the issue of online resources.

Table 1
Pattern Matrix

	Good e-Teaching	Good e-Resources	Appropriate Workload	Students' Interaction
EL5	.709			
EL30	.707			
EL26	.639			
EL19	.627			
EL6	.615			
EL7	.560			
EL2	.515			
EL24	.471			
EL12	.452			
EL15	.434			
EL27		.642		
EL1		.627		
EL17		.620		
EL10		.618		
EL28		.599		
EL8		.579		
EL18		.487		
EL29		.441		
EL3			.678	
EL21			.650	
EL25			.627	
EL9			.447	
EL13			.436	
EL14				.669
EL11				.638
EL23				.581
EL20				.545
EL22				.454
EL4				.436

Extraction Method: Principal Component Analysis.
Rotation Method: Equamax with Kaiser Normalization.
Rotation converged in 9 iterations.

Table 2
Reliability Statistics

Factors	No. of Items	Cronbach's Alpha
Good e-Teaching	10	.843
Good e-Resources	8	.799
Appropriate Workload	6	.702
Students' Interaction	5	.700

Most of the module resources were provided through an on-line platform. Based on the results, majority of the students agreed that the online resources allow them to learn effectively and motivated them to learn more deeply. Table 5 showed the descriptive statistics on the issue of workload. The results showed that students have mixed views on the amount of workload given to them. This may be due to the diverse academic abilities in the cohort. Academically stronger students may find that the assignment given was appropriate while academically weaker students may find it challenging to complete the assignment. Table 6 showed the descriptive statistics on the issue of students' interaction. As the results have shown, majority of the students agreed that lecturers' interaction with them have encouraged them to learn more and that other

Table 3
Descriptive Statistics for Good e-Teaching

Item No.	Mean	Std. Dev.	Likert scale Response (%)		
			Disagree	Neutral	Agree
2	3.82	.854	5	32	63
5	3.85	.954	12	18	70
6	3.75	.950	12	25	63
7	3.53	.947	15	33	52
12	3.52	.833	8	45	47
15	3.45	.928	17	35	48
19	3.65	.917	10	35	55
24	3.8	.798	5	28	67
26	3.52	.748	7	43	50
30	3.55	1.227	20	27	53

Table 4
Descriptive Statistics for Good e-Resources

Item No.	Mean	Std. Dev.	Likert scale Response (%)		
			Disagree	Neutral	Agree
1	3.02	1.000	28	37	35
8	3.27	1.039	21	37	42
10	3.73	.954	10	32	58
17	3.50	.911	13	33	54
18	3.65	.988	13	27	60
27	3.38	1.027	21	27	62
28	3.93	.778	3	23	74
29	3.57	.890	10	40	50

Table 5
Descriptive Statistics for Appropriate Workload

Item No.	Mean	Std. Dev.	Likert scale Response (%)		
			Disagree	Neutral	Agree
4	3.48	1.017	17	30	53
11	2.95	1.080	32	40	28
14	3.45	1.032	17	35	48
20	3.38	.976	16	37	47
22	2.92	.809	25	60	15
23	3.47	.892	13	35	52

Table 6
Descriptive Statistics for Students' Interaction

Item No.	Mean	Std. Dev.	Likert scale Response (%)		
			Disagree	Neutral	Agree
3	2.83	.905	25	57	18
9	3.53	.982	13	32	45
13	3.55	.723	7	38	55
21	3.48	1.033	20	27	53
25	3.43	.871	13	37	50

students' online posting has encouraged them to delve further in their learning.

Finally, this study investigates the correlation of the four factors with the overall perception of the blended learning approach, the approaches to learning and students' final grades for the course. Table 7 summarises the result. The four factors were significantly correlated to each other, which implies that students' having a positive perception on one factor will have a similar positive perception on the other three factors. Furthermore, these four factors were shown to be significantly correlated to students' overall perception to the blended learning approach of the module (EL31). This implies that there were reliable association between indicators of the online teaching components, online resource components, students' interaction and workload and the indicator of the quality of the whole blended learning course. In the correlation analysis between grades and the rest of the construct, the results showed that there is a significant positive correlation between indicators of on-line teaching components and deep approach to learning. In addition, there is a negative significant correlation between grades and surface approach to learning. These imply that students' having positive perception to on-line teaching generally will have intrinsic motivation to learn more in-depth about the module as well as scoring well for the final grades and not merely carrying out the tasks. Lastly, all the four factors and overall perception of the blended learning approach of the module were significantly correlated to deep approach to study. At the same time, it is intriguing to note that these four factors and overall perception of the blended learning approach in the module were not significantly correlated to surface approach to study. The results imply that students' perception to learning in such a blended learning approach has allowed them to have internal motivation or curiosity to learn more in the module.

Limitations and recommendations

There are a few limitations in this study. Firstly, the small sample size in this study might have affected the groupings of the items into the four factors, as there were some differences as compared to the research done by Ginns and Ellis. Secondly, although the reliability scores for three factors were in the acceptable range, a

Table 7
Correlations Matrix

	Teaching	Resource	Interaction	Workload	Overall Perception	Grade	Deep	Surface
Teaching	1							
Resource	.561**	1						
Interaction	.482**	.543**	1					
Workload	.472**	.452**	.349**	1				
Overall Perception	.327*	.549**	.389**	.306*	1			
Grade	.307*	.122	.070	.139	.133	1		
Deep	.489**	.472**	.425**	.365**	.291*	.373**	1	
Surface	-.071	.161	.082	-.260*	-.014	-.284*	.053	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

further refinement on the wordings and phrases might help to improve the reliability scores. Lastly, the study was limited only to students from a particular diploma who were taking the module under research, thus, it cannot be generalized and results may differ in other fields of engineering. As such, the present study raises some issues for future research. Firstly, it may be worthwhile to investigate further the reason to improve the reliability of the two factors, namely, Appropriate Workload and Students' Interaction. This may help to improve the reliability results. Secondly, it would be useful to replicate and extend these findings to different student populations and domains. This could help to further strengthen and generalize the theory that was presented in this study. Lastly, it may be beneficial to explore cluster analysis where it identifies subgroups of students who varied systematically according to their perceptions of the e-learning environment, their approaches to study, and overall grade.

Conclusion

This study determined the four factors on students' perception towards blended learning environment in the module, Green Building Technology and Design. Students generally agreed that the module had a good on-line environment for learning, provided good on-line resources for the students to learn effectively, and their interactions with the lecturer and their peers have encouraged them to delve further in their learning. Furthermore, results showed that all four factors were significantly correlated with each other as well as with the blended learning approach of the module and deep approach to learning. Specifically, on-line teaching components had a positive significant correlation with grades, which suggested that students with good perception to on-line teaching would also score well for their final grades. Although the findings in this study cannot be generalized and a lot of work still needs to be done, they can be used to provide valuable insight for the development of similar study in future.

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Appendix

No.	Item
EL1	To do well in on-line quizzes all you really need is a good memory.
EL2	My lecturer used the on-line environment when appropriate to keep students informed about their learning progress.
EL3	I received too much feedback on-line from my lecturer.
EL4	My lecturer's responses on-line motivated me to learn more deeply.
EL5	My lecturer helped to guide on-line discussions between students.
EL6	My lecturer used the on-line environment to regularly update students about relevant unit of study information.
EL7	Reading on-line team's comments clarified some of my own ideas.
EL8	The on-line learning materials in LEO 2.0 are extremely good at explaining things.
EL9	My lecturer's interaction with me on-line encouraged me to get the most out of my learning.
EL10	On-line quizzes helped me to learn effectively.
EL11	The workload for the on-line component of this module is too heavy.
EL12	My lecturer's on-line responses motivated me to do more on-line learning than I would have done otherwise.
EL13	Information needed to understand the purpose and contents of the module was integrated in one place on-line.
EL14	I generally had enough time to understand the things I had to learn on-line.
EL15	I did not receive enough helpful on-line feedback from my lecturer.
EL16	I interacted with classmates' on-line postings even if they were not assessed.
EL17	The on-line activities are designed to get the best out of students.
EL18	Other students' on-line postings helped me understand my ideas from a new perspective.
EL19	I am clear about the requirements of using on-line discussions.
EL20	The on-line learning materials in LEO 2.0 are designed to really try to make topics interesting to students.
EL21	Other students' on-line postings encouraged me to investigate further sources of knowledge.
EL22	The sheer volume of work for the on-line component of this module means it cannot all be thoroughly comprehended.
EL23	The on-line learning materials in LEO 2.0 helped me to learn during the face-to-face situations in this module.
EL24	It was clear if on-line resources were related to assessment.
EL25	The on-line activities helped me to reflect and understand the face-to-face activities in this module.
EL26	The on-line learning materials in LEO 2.0 supported some key assessment items in this module.
EL27	The relationships between the on-line activities and the whole module motivated me to learn more deeply.
EL28	My lecturer helped to focus on-line discussions between students.
EL29	Information needed for assignments was integrated in one place on-line.
EL30	I was able to learn more during classroom session as compared to during e-learning session.
EL31	Overall, I was satisfied with the quality of the on-line activities for this module.

IMPROVEMENT OF STUDY PERFORMANCE BY APPLYING FLIPPED CLASSROOM CONCEPT IN ENGINEERING MODULES

K.C. Ying*[a]

[a] Department of Construction, Lecturer, Vocational Training Council, Hong Kong

*kc_ying@vtc.edu.hk

Abstract

Tertiary students face difficulties in using technical modules because they rarely utilise these materials in high school. Given that they are new to this concept, including the related theories and methods of calculation, these students occasionally perform poorly in their studies, particularly in the technical modules of engineering courses. Evidently, students from engineering schools constantly encounter learning problems because of the many technical modules that they use in their respective programmes. The concepts, theories and calculations involved in various technical modules are new to tertiary students.

Civil engineering is one of the most popular but difficult programmes in Hong Kong. The increase in the number of infrastructure projects in this territory has resulted in an increasing number of high school students preferring to pursue an undergraduate degree in Civil Engineering. However, they often face difficulties whilst pursuing their tertiary study.

Video tutorial as a concept of flipped classroom is recommended in tertiary education, particularly for engineering modules. This tutorial provides a 7-day/24-hour and repeat resources to assist tertiary students upgrade and enhance their skills, particularly in technical modules. This research conducts a pilot study of a technical module titled 'Temporary Work Design' from the High Diploma of Civil Engineering programme. Moreover, a three-year rolling study is performed. Results indicate an improvement in the academic outcomes of students who studied under the aforementioned technical module.

A 10% increase in the average mark and passing rate was observed from academic years 2015–2016 to 2017–2018. Moreover, the number of students who obtained a grade of 'A' increased. The overall result of the engineering module was enhanced by using video tutorials based on the flipped classroom concept. The mean of the result, passing rate and number of students who obtained an 'A' were generally enhanced as well. Conclusions and recommendations were likewise provided in this study.

Keywords: *flipped classroom, technical module, video tutorial, engineering, Hong Kong*

Introduction

Tertiary students often encounter difficulties in using technical modules because these materials are new in the tertiary education. The syllabus of tertiary modules is completely different from those used in high school. For example, high school students who study mathematics (e.g. algebra, differentiation, integration, trigonometry, probability and logical analysis) learnt only the foundation theories and basic concepts. However, they need to apply the related concepts and theories into the technical modules in engineering. Additionally, students should apply the basic mathematics concepts into the technical analysis of engineering problems.

Civil engineering is one of the most difficult amongst various School of Engineering programmes. Particularly, civil engineering involves broad and detailed analyses. Fluid, soil and structural mechanics are basic modules in civil engineering that require substantial understanding and analyses of mathematical concepts. Students will definitely experience academic difficulties if their knowledge and skills in mathematics are limited. Consequently, their academic performance will be affected, particularly in terms of low academic results.

The current study proposes the concept of a flipped classroom. Wikipedia (2018) defined flipped classroom as 'students watch online lectures, collaborate in online discussions, or carry out research at home whilst engaging in concepts in the classroom with the guidance of a mentor'. This concept has been applied in teach technical modules in civil engineering. The researcher introduced video tutorial to civil engineering students in the 'Temporary Work Design' module. Firstly, video clips on the methods of solving tutorial problems had been uploaded in the Moodle system for the tutorial class of students of the High Diploma of Civil Engineering programme. They were required to 'pre-study' for the tutorial questions and 're-study' at any time. Thereafter, the researcher discussed with the students during the tutorial class, asked if they understood the discussion and

encouraged them to present the difficulties that they encountered in the tutorial questions.

A three-year rolling pilot study has been introduced to investigate the effectiveness of the method in teaching technical modules to the students of the High Diploma of Civil Engineering programme. The study started in 2015 and the academic results of the Temporary Work Design module were recorded from 2015 to 2017 for analysis. An overall 10% improvement in the academic performance had been recorded using the concept of flipped classroom.

Literature review

Palmiter and Elkerton (1993) determined that a trainee often demonstrates improved results during training when using video instruction. The researchers conducted a survey that involved 59 engineering students with mean ages of 24.9 years old in their US study. They determined that the students who used video tutorials as demonstration can reply to questions faster and more accurate than those who used reading materials as demonstration. When using video tutorials, the students did not have to spend time to interpret the steps from the reading materials. Moreover, the students did not need to do referential mapping of verbal concepts in the text to objects and actions in the interface.

Leng et al. (2007) investigated the effectiveness of using video tutorials to teach medical students. These researchers determined that video tutorial classes assist students who lack clinical experience to gain knowledge on the actual process of surgery. Additionally, video tutorial classes provide definite visuals to students compared with books or texts. Furthermore, these researchers mentioned that videos facilitate good memory retention. That is, students can remember actions and procedures related to the surgery.

Lloyd and Robertson (2012) presented learning outcomes by using video tutorials in the US, in which their investigation involved undergraduate students of psychology. These researchers determined that video tutorials are an effective and efficient tool for enhancing student learning, particularly mathematics concepts.

He et al. (2012) investigated how video tutorials assist in addressing learning difficulties in chemistry. These researchers introduced video tutorials to undergraduate Chemistry students and determined that online video tutorials are a valuable, flexible and cost-effective tool to improve the learning process of students and address their difficulty in this particular subject.

Meij and Meij (2015) discussed the effectiveness of video- versus paper-based tutorials. They determined that video tutorials provide better results in terms of retention task performance for junior students, whereas paper-based tutorials cannot match those of the former. Additionally, these researchers conducted a questionnaire survey involving a group of 30 students with a mean age of 13.2 years. Their result showed that the task performance of the students is good.

In summary, researchers concluded that the trainees (i.e. tertiary students) prefer to attend video tutorials possibly because of the following reasons. (1) The new generation loves to use new media (e.g. YouTube, Internet forum, WhatsApp, Instagram and Facebook) to communicate and learn. (2) Video tutorials are 7 day/24 hour-platforms, thereby enabling students to learn and review videos anytime. (3) Video tutorials eliminate location barriers, thereby enabling students to continue studying even if they are absent from the actual class. (4) The quality and quantity of the tutorial class can be maintained. (5) A tutor is not required (although the performance of a tutor in various tutorial classes may be retained).

A video tutorial is only a one-way method for students to 'pre-study' and 're-study'. Hence, this method is a component of the flipped classroom concept.

Flipped classroom

Lage et al. (2000) defined flipped classroom learnings as concepts that 'require human interaction' and 'automated through technology' (see Figure 1):

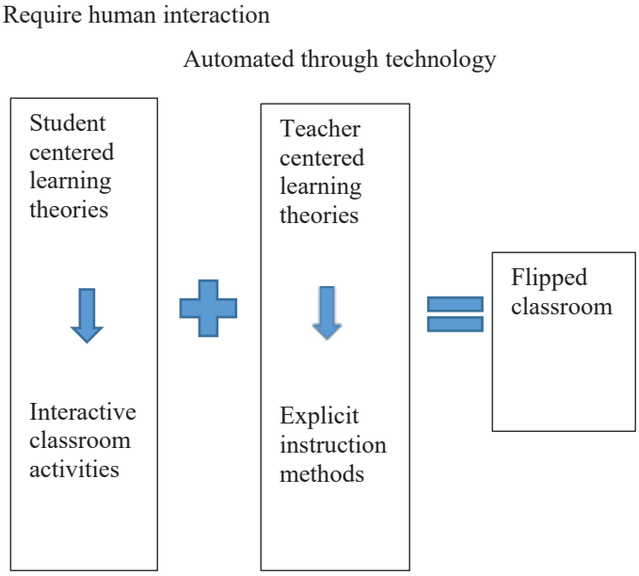

Figure 1: Concept of Flipped classroom

Bishop and Verleger (2013) indicated that the concept of flipped classroom represents a unique combination of learning theories that were previously considered ineffective. The flipped classroom concept is an active, problem-based learning method. The researchers stated that learning performance can be improved by using flipped classroom because students prefer face-to-face learnings, such as video lectures.

Roehl et al. (2013) summarised that flipped classroom is easy to use and readily accessible. This concept allows an expanded range of learning activities during class time and provides opportunities for teacher–student interaction, mentoring, peer-to-peer collaboration and cross-disciplinary engagements. Such type of learning is good for millennial students (born between 1982 and 2002) because they are 'digital natives'. That is, they have been exposed to information technology from an extremely young age.

The researchers further suggested that the flipped classroom model could be easily adapted in different disciplines, such as textile, apparel and interior designs and nutrition and construction studies. Additionally, the researchers performed their investigation in various courses (e.g. chemistry, psychology and medical education).

In this work, the researcher conducted a pilot study to investigate the effectiveness of video tutorial for students in engineering study to improve their learning performance.

Methodology

A three-year rolling survey has been conducted starting from 2015. The Temporary Work Design module for civil engineering has been utilised for analysis. The academic year (AY) 2015–2016 is a control year. That is, no video tutorials have been provided to the students. For AYs 2016–2017 and 2017–2018, the researcher introduced video tutorials to the second year students of the High Diploma in Civil Engineering programme. Their academic performance had been recorded and analysed.

Regarding the distribution of video tutorials, the researcher uploaded video clips (see Figure 2) on how to resolve the problems in 'Moodle' (an internal communication system between students and lecturers provided by Vocational Training Council). The students were required to 'pre-study' before the tutorial class. Thereafter, they were encouraged to ask questions regarding the tutorial questions after their 'pre-study'. The students assessed the videos after the class for their 're-study'. The video clips were available within the entire semester. Hence, the students can 'pre-study' and 're-study' in 7-day/24-hour learning mode. The tutor further discussed the tutorial questions and provided in-depth ideas during the class. The academic results of the three consecutive years had been recorded for analysis. The SPSS version 24 software was used for analysis.

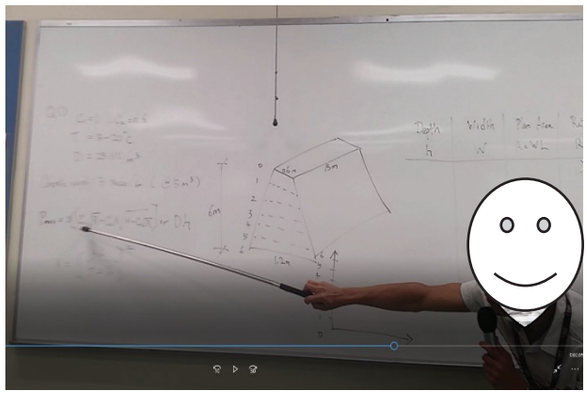

Figure 2: Video clip which uploaded into the Moodle system

Findings and analysis

	Pass rate	% of A grade	Mean Statistic	Std. Deviation Statistic	Variance Statistic
AY 15/16	79.5%	0.9%	50	15.798	249.584
AY 16/17	85.9%	1.8%	53	13.001	169.032
AY 17/18	87.3%	8.5%	55	14.782	218.511

Table 1: The followings are the results from SPSS version 24:

Table 1 shows the summary of the academic result. The passing rate of the students steadily increased by 10% from 79.5% in AY 2015–2016 to 87.3% in AY 2017–2018. The students had a high passing rate when using this engineering module. A significant improvement (i.e. 10%) was obtained after introducing video tutorials to second and third year students.

An increasing number of students obtained a grade of 'A' (75 marks and above) in their total mark. The percentage of grade A recipients substantially increased from 0.9% in AY 2015–2016 to 1.8% in AY 2016–2017 and to 8.5% in AY 2017–2018. The video tutorials were determined to be beneficial for students to 'pre-study' and 're-study' under this engineering module.

The mean of the academic results were increased when comparing the control mark in AY 2015–2016. A total of 10% improvement was recorded in the final mark compared with the result between AYs 2015–2016 and

2017–2018. The mean mark in AY 2015–2016 was 50 and slightly increased to 55 in AY 2017–2018.

The standard deviation and variance in AY 2017–2018 was narrow and concentrated to the mean value compared with those in AY 2015–2016. The results of the students were consistent.

Student feedback was positive and they were often welcome to the video tutorial setting. They appreciated the availability of video tutorial provided in the Moodle system because of the easy way to 'pre-study' and 're-study' on their own

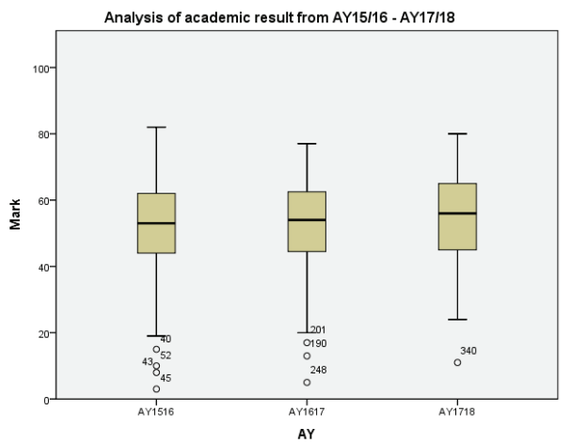

Figure 3: Summary of Academic result from AY15/16 – AY17/18

Figure 3 provides the boxplot graph. The outliers of AYs 2015–2016, 2016–2017 and 2017–2018 are 4, 3 and 1, respectively. The majority of the data were reliable. Moreover, the majority of data (lower quarter) was above the passing mark of 40. The mean mark slightly increased from AY15/16 to AY17/18.

Conclusion and recommendation

A flipped classroom is a remarkable and variable concept in learning. The concept is beneficial for millennial students because they are considered 'digital natives'. That is, they have been exposed to information technology from an extremely young age. Additionally, this concept was determined to be beneficial in various disciplines.

The students of the Higher Diploma in Civil Engineering programme were selected for the evaluation of the effectiveness of applying the flipped classroom concept in engineering modules. A three-year rolling study was conducted and the academic results were collected for the analysis.

The flipped classroom concept is an effective idea to improve the learning performance of engineering students. An engineering module (Temporary Work Design) of the High Diploma in Civil Engineering programme was used as a pilot study. The mean of the result, passing rate and number of students who obtained an 'A' increased generally.

The average mark and passing rate increased by 10% from AY 2015/2016 to 2017/2018. The number of students who obtained an 'A' likewise increased. The overall result of the engineering module improved by using the video tutorial from the flipped classroom concept.

Further study was determined to be good to millennial students. The majority of the High Diploma students are in this age group. Therefore, the researcher recommends that the flipped classroom concept is feasible for approval in the engineering discipline. Moreover, investigating the 5Ws (i.e. What, Who, Where, When and hoW) must be the direction of further study.

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Sub Theme 3

Multidisciplinary Collaborations



"WE CAN ALWAYS PRODUCE IF WE ONLY CAN SELL…" – NEED OF SALES EDUCATION FOR ENGINEERS

L.E. Kairisto-Mertanen[*,a]
[a] Turku University of Applied Sciences, Engineering and Business, Turku, Finland

*liisa.kairisto-mertanen@turkuamk.fi

Abstract

The core of engineering education lies very much on teaching our students knowledge, skills and attitudes related to conceiving, designing, implementing and operating technological solutions. Engineering students are expected to possess good skills in mathematics, physics and other disciplines belonging to the group of scientific knowledge. However engineering is a very versatile profession. There are many different kinds of work profiles where engineers are needed. It could be beneficial for all stakeholders if the scope of engineering could be broadened and the fact accepted that engineers are needed in many different professions.

Creating innovations requested in businesses all over the world calls for an innovative mind-set in our future engineers. Successful innovations need to be commercialized and this requires understanding of business principles. What is needed is proactive understanding about future possibilities and about customer's reactions to these possibilities. All this belongs to the hearth of a discipline called selling as even the most excellent products are not any more powerful enough to sell themselves without understanding of customer journey.

This paper examines sales in engineering and presents the results of an inquiry about the needs for selling skills among heavy engineering industry. The interviewed companies are situated in south-west Finland and mostly export oriented. At the end of the paper there are some recommendations for engineering educators concerning sales education.

Keywords: *Engineering, Sales, Sales engineering, Competences, Multidisciplinary education*

Introduction

The sales profession has not traditionally been considered as a career the engineering students are aiming for during their studies. However many graduated engineers have found interesting positions in the field of sales. A commonly known fact is that usually the income level in sales positions is higher than in pure engineering design jobs which are more often considered belonging to the traditional core of engineering.

Selling skills are needed when bringing both new and old products to be reached by the customer. They are desperately needed after launching an innovation coming from research and development and trying to bridge the haunting "death valley" where the innovations sometimes fall.

A big deal of sales in business to business context is done by engineers who work in that profession and many times without hardly any educational background in sales. It is also known that the need for sales engineers is increasing in Europe and this could be the situation all over the world as well. The World economic forum report (2017) researched new and emerging job categories and functions that the respondents expect to become critically important to their industry by the year 2020. In the report two job types stand out due to the frequency and consistency with which they were mentioned across practically all industries and geographies: The first are data analysts and the second are specialized sales representatives. It can be foreseen that practically every industry will need to become skilled in commercializing and explaining their offerings to business or government clients and consumers.

The Academic association for sales engineering (AASE) defines sales engineers as follows: "Sales engineers sell technical products and services to companies. They consult the professional customer and suggest technically and economically feasible solutions with an added value for both the customer and their own company. They combine technical knowledge with commercial skills. They are best trained to understand the requirements of the industry." (AASE web-site.)

The sales profession as a whole is undergoing big changes due to digitalization and other possibilities offered by the changes in the working environment. In the internet era the salesperson is not any more the only source of information to the customer. Research claims that a big part of typical purchasing decisions have been completed before contacting the selling firm or the salesperson. Adamson, Dixon and Toman (2012) say that nearly 60 percent of a typical purchasing decision has been completed before contacting the selling firm or the salesperson. Hallikainen & Laukkanen (2016) found in their research that 27 % of B2B customers had used digital services by which they mean websites, social media, mobile apps etc. during the customers' last purchase experience with a company. As many as 18,5 %

of the respondents made the purchase decision online and 15 % of these B2B customers also completed the purchase online. The conclusion here is that although the sales profession is undergoing big changes, the demand for salespeople and especially sales engineers is existing and even growing.

Aim of the paper and methods used

The aim of this paper is to examine the role of sales in engineering. It first handles the recent literature on the future of business to business sales context putting a special emphasis on complicated and demanding selling situations as it is more likely that sales engineers are to be found there.

The paper also presents the results of interviews conducted among heavy technologies industry companies in South-West Finland. The aim of the interviews was to paint a picture of the present state and art of sales among those companies and use the information for developing material and training needed to improve selling skills of engineers employed in them.

The research was conducted in form of deep interviews where the discussion proceeded according to a list of questions which were freely handled during the conversations. After the interviews all the discussions were transcribed and analyzed. The discussions lasted for 45 min to 1,5 hours and there was space left for the discussion to find a new direction when needed. The people interviewed belonged to the top management of the companies acting in the field of technologies industry in South-West Finland.

The evolving sales discipline

Since 1990's customer value has been something business has been thriving to create to their customers. Big companies have understood that rather than selling mere products they must shift their focus on facilitating the emergence of value for their customers. (Eggert & al. 2018.) The function of sales is assisting and helping the customer during the customer's journey, which is the process of gathering information, making a decision and implementing the solution. During this journey the customer engages with the company in several touchpoints. (Alhonen & all. 2018.)

Alongside with the change in understanding also the definition of sales has been changing. Dixon and Tanner (2013) provide a revised definition for selling and state that it is "*the phenomenon of human-driven interaction between and within individuals/organizations in order to bring about economic exchange within a value-creation context*." According to this definition selling is about interaction and about value creation, the task of salespeople is to help the customers to challenge their existing ways of thinking and provide them possibilities to improve their decision-making process.

The change in sales science is likely to continue at an accelerating speed in the coming years. The changes concern not only sales but also purchasing. This is mostly due to the possibilities technology is offering to the profession and the exponentially increasing demands from customers. Even today the buyers have wide access to many important facts related to their buying situation. They can check the offerings of several vendors and inspect other customers' experiences. In general due to the accessibility and visibility of information their buying power has increased. (Wiersema 2013; Matthews & Schenk, 2018.)

Matthews and Schenk (2018) predict that in the future sales professions will require people who are comfortable working with technology. Analysing data to reach insight about the customers beyond what can be experienced or seen by eyes and ears will become an important skill. They go on by saying that the future of sales will shift from art to science. According to my understanding engineering, due to its applied nature, might be a better word when describing the next phase of sales. This gives space especially for sales engineers.

To whatever direction the development goes and regardless of the share between technical skills and emotional intelligence demanded in the future sales professions, it is likely, that the value of human connection will bring benefit to the interaction when creating and maintaining relationships and networks. (Matthews & Schenk, 2018.) On the other hand when artificial intelligence and other digital solutions will replace human beings in routine like tasks, it becomes more important to concentrate on developing skills that the machines are not (yet) capable of doing. Interaction, teamwork, independent and critical thinking as well as making judgements are such skills.

On the concept of value

Research agrees that value should be placed at the core of buyer – producer relationship. The value literature has evolved from a focus on resource exchange and value in exchange to an emphasis on resource integration and value in use.

According to the value in exchange concept the value is embedded in gods and services provided to the customer. Customer value is defined as "the customer's perceived trade-off between benefits ("what you get") and sacrifices ("what you give") in marketplace relationships" (Eggert & al. 2018; Ulaga and Eggert 2006; Woodruff 1997).

The value in use concept considers the buyer as the ultimate creator of value and argues that value cannot be delivered to the customer but according to Vargo & Lusch (2011) is "*determined by the customer on the basis of value in use"*. The role of the producer remains to act as the value facilitator. So value is not seen as something given to the buyer in the exchange process but instead something which is being created together by both parties in the interaction process. (Grönroos & Voima 2013; Vargo & Lusch 2011.) Finding and preparing opportunities for value co-creation together with the customer and acting as a facilitator in them is the salespeople's' job. The value perceived by the customer is thus dependent on the supplier's capabilities but on also on the customer and on other stakeholders present in the network. (Eggert 2018.)

According to Vargo and Lusch (2011) there is only one market: the actor to actor market where the actors are generically engaged in service-for-service processes. Resource integration and application are the bases for this service provision.

Focusing on customer journey

We are living at the age of the customer. Improving customer experience, e.g. what the customer experiences when being in contact with the company, by understanding their demands towards the seller, lies at the focus of the sales function. (Alhonen & all. 2018.) This means that successful companies are concentrating on understanding the customer journey and how they can produce value at every encounter with the customer. Adding value by deeply understanding customers' business, the unique situation of the customer and the goals and desires of the customer is the main task of any salesperson. (Matthews & Schenk 2018; Alhonen & all. 2018.)

It has been shown that buyers set high demands towards the possible suppliers especially at the early stages of the decision process. From sellers they expect expertise and understanding of customer needs and problems which leads to an ability to demonstrate, create and facilitate value of the product at every point of contact. (Kock & all, 2017).

When focusing on value in use sales discussions are evolving to dialogs where salespeople listen to customers and get a deep understanding about their situation and needs so that they can target at facilitating in the process where the customer needs are being clarified. Value creation is the customer's creation of value-in-use during usage, where value is socially constructed through experiences. Sometimes value is literally created, sometimes is just emerges during the process, e.g. interaction. (Grönroos and Voima 2013) When the customer journey proceeds and is approaching the decision-making stage, the criteria set by the customer evolve to a well-established selection criteria including such criteria as price/cost, differentiation from the competitor related to added value, functioning, quality etc.

It is to be noted that the customer journey can end due to an unsuccessful customer experience before the decision stage. Adaptability is required from salespeople to meet the individual characteristics and needs of each buyer during the journey. Especially in case of complex, important or strategic products and services intensive human interaction is needed. The research by Koch & all (2017) and Korpela & all. (2018) show that although buyers use the digital possibilities during their journey they also want a face-to-face meeting at a rather early stage of their journey.

Selling as interaction

Salespeople belong to the group of knowledge workers and their task is to act as value facilitators in the unique situations during the customer journey, meeting the customer at several touchpoints and helping the customer to create value. (Dixon and Tanner 2012.) Some of the touchpoints include face-to-face interaction but some occur via internet or other media where the salesperson is accessible and what is available also for the customer.

According to Grönroos and Voima (2013) interactions are "*situations in which the interacting parties are involved in each other's practices*." Interaction can take place physically, virtually or as a mental contact. The interacting parties take actions that influence the other party's process. During the sales interaction the salesperson creates opportunities to engage with its customers' experiences and practices. These interactions influence in the outcome and in the experiencing of customer value. As the value-in-use is created through resource interaction, it is actually shifted to a joint sphere, between the salesperson and the customer, where it becomes the responsibility of them both. Value emerges in the use situations and both the seller and the customer share the co-created value (Eggert & al 2018; Grönroos & Ravald 2011.)

In a dialogical sales interaction where the salesperson and the buyer both are active and meet at a coordinated, interactive process the salesperson has a possibility of immediately influencing the buyer's value creation process. Both salesperson and buyer engage in a joint value creation process where they co-create value. This co-creation of value can take place during interaction only. (Grönroos & Ravald, 2011.)

Engineering companies and evolving sales

This research reveals that sales is emerging among companies within technologies industry in South-West Finland as an issue which should be paid serious attention to. The same fact seems to concern companies all over Finland. Finally we have reached a situation where salespeople and sales work seems to be valued among the companies.

Many of the comments reveal that the top management understands the value of good salespeople: "*Salespeople are the most important people in the company*". One of the interviewees, an entrepreneur in heavy fabrication industry continues: "*we will not need any engineers if they cannot sell our products*". Or another comment coming from a contract manufacturer: "*In a service company we are exactly what we manage to sell and make.*" Sales engineers are considered to be the profession "*guaranteeing that we will survive*" (as a company).

There seems to be a unanimous agreement that sales is not very highly honoured among engineers or the big audience in general. The traditional engineering expertise is what engineers themselves seem to honour. "*If you work in sales as an engineer, you maybe don't dare to reveal that in the family gatherings…*".

Sales is considered as a challenging profession especially in the case of exports and when it is necessary to travel and engage with people from different language groups and cultures. Salespeople must constantly step out of their comfort zone. Travelling and giving the most of yourself are not always easy or comfortable engagements.

When working with international sales there are also language requirements, which do make the work more demanding.

Salespeople carry big responsibility: "*the whole remaining chain depends on whether you (salesperson) manage to sell or not*". Sales determines whether the production can continue and guarantee full employment to the people in the company. Salespeople are also expected to carry their responsibility and be accessible even during their vacation: "*you have to answer the phone and you should never have bad days, at least you are supposed not to show them."* However getting a deal and succeeding in sales is very rewarding: "*…to myself succeeding, getting a new customer, new deal is very satisfying."*

Salespeople are also well paid. Sometimes they can be the people with the biggest income in the company: "*I have experienced a situation where the country director starts asking about the people who earn more than him in the company. And it turns out that they are the best salespeople…"*.

When working with technical products it is important that the salespeople have a solid background in knowing about the technology: "*It is not about purely selling but there has to be a deep technological understanding at the background also"*. And the amount of knowledge needed concerning technology seems to be increasing. A sales person needs to have basic knowledge about commercial law, business understanding and knowledge about cost effectiveness. A salesperson must have an ability to fix up situations and organize the puzzle as well with the customer as within the company. Deep understanding about the capabilities of the sellers' company is also essential as the promises made must also be kept and fulfilled.

However, many of the interviewees emphasize the importance of personality and good interpersonal and communication skills. Also adaptability and good command of the situation are mentioned: "*salespeople solve the problems together with the customers*", *"they have to be able to communicate the added value"*. Communicating and facilitating added value to the customer and with the customer, is one of the most important engagements in sales work.

Improving the customer journey

Being customer centric is emphasized in the answers given by the interviewees. Taking the customer's perspective and trying to understand customer needs is seen as essential in sales work: "*also our designers have to understand how to produce added value to the customers*". This means that it is also seen important that not only the salespeople in the company are sales oriented. The concept of "*everybody sells*" seem to be the leading principle in the companies which were interviewed. *"Everybody sells. Absolutely everybody. Be it the expert, administration, salespeople, or executive director. Absolutely everybody sells."* It is important to handle all touchpoints with the customer well and to their satisfaction. The chief executive officer is often the most important sales person in the company. *"It is the role of the CEO to act in the front building and opening relationships by looking at the world in the surroundings of the company making the path together with the sales force and even going in front of them."* This seems to be characteristic for all the companies interviewed, they are involved in B2B business where the financial value of each deal is big.

A specially mentioned common requirement is that all the engineers must have selling skills. *"The message is that all engineers need selling skills. Out of our 100 employees, 50 visit the customer surface for a shorter or for a longer period of time."* The requirement seems to be that basic engineering education should include at least some studies in business understanding and sales: "*let's educate our engineers to understand also these commercial and business issues*".

A successful customer journey seems to require characteristics like being punctual and responsive. Sales people need to be self-directed and independent; they must have a strong desire to reach results. "*A good salespeople builds a better future for the customer and makes the customer feel that s/he is succeeding."* When meeting the customer sales people also have to be adaptive. "*Anticipating the answers when there is no question yet. You will learn that and it will come almost automatically*." Being able to produce added value at every encounter with the customer is important. "*Every time you meet the customer you must have added value to bring to the customer."* The question is also about leading the customer to a direction which is beneficial for the customer but at the same time also for the seller.

Trust is an important concept during the customer journey. "*If you are dealing with 10 to 20 million business there is no change to win deals if there is no trust."* When there is trust it is easy for the customer to contact the seller during the journey in whatever matter. And this can lead to new possibilities for the seller to recognize customer needs. Open communication is needed when building trust.

Interaction in engineering sales

Interaction is stated to be at the centre of business to business sales work. All the respondents bring it up and there seems to be a general agreement that sales in general and interaction as part of it has evolved to a more demanding direction. A typical engineering company in business to business context in Finland operates also in international markets which increases the requirements concerning the content of interaction. Interaction is needed when digging for new customers but also when working with existing customers and deepening the relationship.

Good interactions skills require that the salesperson is in balance with him/herself. Good interaction skills are needed when exploring the real needs of the customer and when facilitating need recognition together with the customer. Being good with people is part of that, as one of the respondents puts it: "*If you are not good with people it is quite difficult to succeed in the field. You do not succeed being cranky*."

The emergence of technology in sales work is understood. However social media and digitalization seem not to be much used in the sales work in the

companies of the interviewees. Especially the older sales people might not be aware of how to apply social media in their work. *"Knowing how to use the social media. We are lacking behind."* Also the management sometimes is not eager to update themselves about the latest possibilities offered by technology. Education is needed to fill the existing cap.

Understanding about how sales work is changing due to the possibilities technology offers seems not to be very deep. It is pointed out that work done by people is expensive and that in the future it will to some extent be replaced by technology. How this is affecting sales work, is not very clear in the interviewed companies. *"Digitalization has influenced and it will influence our whole existence. Video negotiations, transparency in the whole chain will increase. The final user will see, right from the beginning, how the product is being made."*

Results and Discussion

The role of sales as an important fuction also in engineering companies seems to be understood. This has not always been the case as earlier it was a widely accepted belief that there is something wrong with a product if strong promotion is needed. No sales function was considered important as "*good products will always sell themselves".* Now the understanding seems to be that all employees must adopt a customer centric approach in their work.

The results show that the role of sales producing value to the customers is well understood among the companies. However the answers reflect that in many companies the value is still understood as embedded in the product or service. Having this perspective the salesperson is seen as the creator of value whose job is to understand, communicate and deliver value to the customer.

When moving to the "value in use" ideology the companies should rethink the process how value emerges. According to that approach value cannot be delivered to the customer. Salesperson and customer are together in a process where the salesperson is facilitating the value creation process of the customer. Adopting this kind of deeper understanding about the processes of the customer might require some training of the sales force. This would call for resources invested in training but on the other hand the results could turn out to supercede the money and time invested.

"Everybody sells" seems to be the leading principle in the companies. All the employees must understand the value of the customer and their own role in facilitating the customer journey. Paying attention to this is likely to improve the performance of the companies in relation to customer satisfaction and this way lead to improved financial results as well.

Learning something about selling should form part of every engineer's education as engineers are the ones who act as salespeople in the domestic as well as in the international market. This is the case specially in the field of technologies industry. In South-West Finland succeeding in this industry is essentially important as the biggest part of exports is gained through the products of this field of industry.

When planning the curricula, the engineering educators should keep in mind that sales job is a possible alternative to the engineering students as well.

Conclusions

The aim of this paper was to examine sales in engineering and present the results of an inquiry about the needs for selling skills among heavy and export oriented engineering industry in South-West Finland.

The results show that sales is valued and seen important in this industry. Comments like *"we can always produce if we only can sell"* or *"salespeople are the most important people in our company"* reflect that the importance of sales is understood as essential for the success of the enterprises. There is a clearly indicated need to include at least some sales related studies in the curriculums of our future engineers. As well, there seems to be space for a special sales engineers' profession. Sales engineers are specially educated to have both technological knowledge, commercial background needed and selling skills to handle the complex sales situations. In addition to the up-todate knowledge and skills it is important that these engineers have a real sales spirit, a right attitude to succeed in the demanding encounters with customers.

When thinking about the actual selling skills, interaction is seen as forming the core of sales work. Listening to the customer to understand his/her situation and having good knowledge about salesperson's own company and product form the base for successfull saleswork. Acting as a value creator is understood belonging to the core of sales work. Putting empahsis on educating the salespeople to become value facilitators instead of being value creators could help the companies to deepen their relationships with their customers.

New technologies, and especially different digital solutions and social media providing solutions to meet the customer on line during his/her journey before actually getting in physical connection, are not used to their full extent. There seems to be several unused possibilities to help the salespeople in their work. Education should be directed to the companies so that they would start using the possibilities awailable.

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ENABLING DEVELOPMENT OF INNOVATION COMPETENCES BY MULTIDISCIPLINARY LEARNING ENVIRONMENTS

M. Keinänen[*,a], L. Kairisto-Mertanen[a] and T. Konst[a]

[a]Turku University of Applied Sciences, Turku, Finland

*Meiju.Keinanen@turkuamk.fi

Abstract

All sectors of the economy emphasise the importance of innovations. Businesses and organizations are continuously looking for innovative employees. Consequently, how to educate innovative graduates is a crucial question for educators. The aim of this paper is to discuss how to develop students' innovation competences by applying a multidisciplinary learning environment. In this paper we first describe a learning approach called innovation pedagogy, which aims to educate innovative graduates. In order to participate in innovative activities in working life, it requires that graduates must have not only the study field specific competences but also the innovation competences. This paper also presents the results of the research done on defining innovation competences, which are a prerequisite for innovative knowledge. Based on the research results innovation competences can be presented in form of five dimension: critical thinking, creativity, initiative, teamwork and networking. Each of these dimensions is measured via items which together form the final score of a person. After describing innovation pedagogy and defining innovation competences, we present one example of how to build an innovative multidisciplinary environment in higher education where both approaches are present. The presented example gives ideas how to develop students' innovation competences through social learning in a diverse surrounding. However, the implementation of a multidisciplinary approach and training students' innovation competences has many challenges and it can meet strong opposition especially by the faculty members but also by the students. In our paper, we discuss how we handled the implementation and present our view on the results to which it has led to.

Keywords: *Innovation pedagogy, competence, learning outcome, multidisciplinary learning*

Introduction

Innovations are a topic handled all over in modern society. When aiming to create added value the companies are increasingly basing their earnings logic on innovations. There are several definitions on innovation and the topic itself is constantly evolving. Today we understand something different by innovation than some five years ago. In ISPIM 2018 Innovation conference the innovation was defined simply as something novel and valuable. Verganti (2016) makes a notion that today we are more facing the problem of defining a meaningful direction when considering innovation rather than being worried about the amount of ideas when looking for solutions to problems which are difficult to solve in the field of a single discipline. It is known that new solutions based on innovations are best born at the boundaries of different knowledge domains. (Kairisto-Mertanen & Mertanen, 2007; Kairisto-Mertanen et al., 2010; 2011; Konst 2017.)

World is changing at a speed never seen before. The companies and other working life organizations are facing the need to adapt themselves to the changing customer requirements, to the changing ways of conducting work and to the changing conditions in the whole environment. All this calls for capability to change old ways of doing things. The universities are supposed to educate the future labour force. They should be at the top of the development and capable of meeting new requirements. However, at universities, we still tend to educate students with traditional methods meant originally for a stable world, emphasizing the learning of explicit knowledge.

The aim of this paper is to discuss how to develop student's innovation competences by applying multidisciplinary learning environments. We also give one concreate example of innovative learning method where innovation competences have been set as learning outcomes for firs year engineer students. The paper does not only focuses to present the method and connect it to the development of student's innovation competences, but also to reflect our experiences as educators concerning implementing a new and innovative learning method in the faculty.

Innovation pedagogy as strategic approach to learning

Methods better suited for a constantly changing world focus on activating students in learning and include unofficial and exceptional situations. It is a crucial step for any nation to be able to educate future generations so that they are equipped with the tools and understanding needed in the present and future world. It is also a crucial step for any university to be able to adapt their studies to these needs and continue to develop new approaches to meet them. (Kairisto-Mertanen, 2017.)

Innovation pedagogy is the new learning approach with an aim to educate graduates who in addition to the study field specific competences also gain competences called innovation competences, which help them to be active in different innovation processes and ultimately create innovations (Kairisto-Mertanen et al., 2012; Kettunen et al., 2013). The innovation competences include the 21st century skills defined by OECD but they have been defined so that also the innovation aspect has been taken into account.

It is important to understand what we mean by innovation as it can be defined in many ways. According to Rogers (2003) it is an idea, practice or object that is considered new. In innovation pedagogy, we use the definition of Finland's national innovation strategy (Innovation Strategy 2008), where an innovation is understood as a competitive advantage based on knowledge. According to this definition, innovation can also be understood as a process that can be already existing but new in the circumstances where it is being applied (Lehto et al., 2011; Kairisto-Mertanen et al., 2010).

To make sure that the defined aims will be met we have defined several cornerstones, which should be present in the learning environment. Some of these cornerstones such as multidisciplinary education or RDI activations embedded in learning, require a strategic decision made by the university but some of them, such as activating learning and teaching methods or versatile and development-oriented assessment, can be made at the faculty level or even at the individual teacher level. The different cornerstones are presented in figure 1.

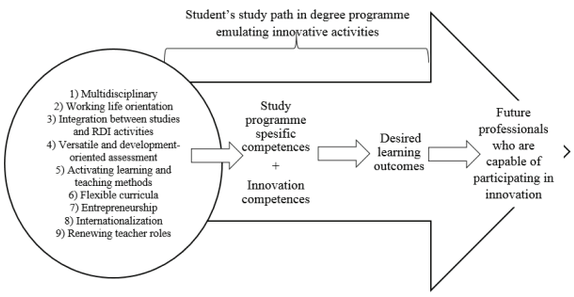

Figure 1. The outcomes, competences and cornerstones of innovation pedagogy (Keinänen & Kairisto-Mertanen, 2018; Kairisto-Mertanen 2017.)

The cornerstones are essential requirements for the everyday application of innovation pedagogy. They are designed to guarantee that the desired learning outcomes will be produced during the learning process as they are enabled in the learning environments.

There are altogether nine cornerstones which are: *multidisciplinarity, working life orientation, integration between studies and RDI activities, versatile and development-oriented assessment, activating learning and teaching methods, flexible curricula, entrepreneurship, internationalization, and renewing teacher roles*.

The innovation process calls for different types of knowledge to be available and to be used. This requires that the learning environments also are multidisciplinary. Working life orientation and integration between studies and RDI activities are needed to ensure that learning takes place in authentic learning environments where real-life situations are brought to be handled in the learning situations in format of assignments and projects stemming from the working life. This way it becomes possible to emphasize that the task of education is also to develop, renew and question the models of operation in working life. People with different talents and competences interact in the learning environment which in addition to a physical space is also a virtual and social space.

The learning and teaching methods have been shown to be the most important cornerstone regarding the development of student's innovation competences (Keinänen & Kairisto-Mertanen, 2018). Their aim is to activate the students in actively constructing knowledge and meaning from the situations they meet. One of the key elements is also the flexibility of the curriculum, which enables students to take various alternative learning paths. It means that the curriculum can be adapted during the study years to meet the needs and motivation of each individual learner. Adopting entrepreneurial attitude is needed in working life regardless of the tasks or study field. It includes also the ability to manage innovations and have the courage to seize the opportunity in the situations encountered. The world is becoming increasingly global and new graduates are facing the situation of a multicultural working environment instantly when entering working life. This requires that the students develop both their language skills and cultural understanding needed when entering working life and encountering the global working environment. Teachers and faculty members in general are the key people to make the innovation pedagogy approach work so they have to be ready and willing to constantly reflect and question their ways of conducting teaching.

Innovation competences as objects for learning

In innovation pedagogy, innovation competences are the targeted learning outcomes. Learning outcomes are statements used to describe what a learner is expected to know, understand and do at the end of a period of learning. These statements describe what is achieved and assessed at the end of the course. Guidelines for learning

outcomes highlight that they should be clearly observable and measurable (Buss, 2008; Harden, 2002). Competence is a holistic concept, which describes a person's ability to manage in a specific context (Mulder, 2012). According to Marin-Garcia, Pérez-Peñalver and Watts (2013), competences, capacities and skills can be considered the three categories of complexity in contextualized know-how. A competence is formed by a set of capacities and these, in turn, are formed by several skills, all of which are required for a more complex professional performance.

The work of defining innovation competences and creating a tool to assess them has been done in several EU funded projects in a network of universities (e.g., Keinänen, Ursin & Nissinen, 2018). The results presented here are a result of a project called FINCODA (Framework For Innovation Competencies Development And Assessment), which was finished at the end of year 2017. The project partners included a significant number of universities and innovation-intensive companies from five countries, which were working together to develop a tool to measure innovation competences (Butter & van Beest, 2017; Marin-Garcia et al., 2016; Perez-Penalver et al., 2018).

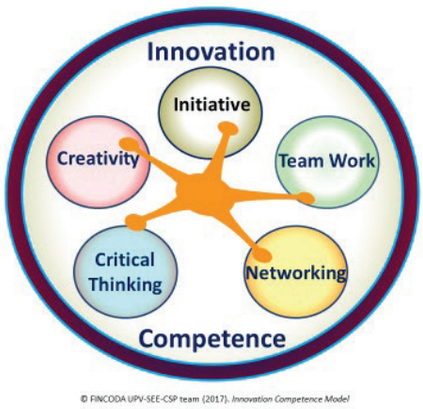

Figure 2. The FINCODA model of innovation competence © Fincoda UPV-SEE-CSP team 2017 (Marin-Garcia et al., 2016; Perez-Penalver et al., 2018)

The FINCODA Model of Innovation Competence, presented in Figure 2, is based on five equally important dimensions: Creativity, Critical Thinking, Initiative, Teamwork and Networking. Definitions of the five dimensions are:

- Creativity: ability to think beyond existing ideas, rules, patterns or relationships. To generate or adapt meaningful alternatives, ideas, products, methods or services regardless of possible practicality and future added value.
- Critical thinking: ability to analyse and evaluate advantages and disadvantages and estimate the risks involved for a purpose.
- Initiative: ability to influence/make decisions that foster positive changes. To influence creative people and those who have to implement the ideas.
- Teamwork: ability to work effectively with others in a group.
- Networking: ability to involve external/outside stakeholders outside the team. (Marin-Garcia et al., 2016; Perez-Penalver et al., 2018.)

If we want that students will learn innovation competences already during their studies, we must also embed these competence objectives in curriculum and take them into account in course designing. Consequently, we can develop learning environments, which mirror and simulate innovation processes.

Several studies also support these objectives. For example, Kivunja (2014) states that the key to teaching creativity and innovation skills lies in designing quality learning environments in which learners can solve real-life problems, and be inquisitive and open-minded. Instead, Vila et al. (2012) show that working together on solutions to new problems supports the acquisition of innovation capabilities in higher education students. Moreover, Keinänen and Butter (2018) and Keinänen and Oksanen (2017) have found that specific pedagogical practices in university-company cooperation develop students' learning of innovation competences. Furthermore, it has been shown that an innovative curriculum improves students' innovative performance (Hu et al., 2016).

Embedding a multidisciplinary approach and innovation competences in engineering education

The learning method described in this paper is called project hatchery. It is one of the methods developed at Turku University of Applied Sciences to be used with first year students when introducing them to the new way of learning according to innovation pedagogy and its cornerstones. During the project hatchery study unit new students start developing their innovation competences, such as creativity, critical thinking, initiative, teamwork and networking competences, and acquire a new way of learning and engaging themselves.

Project hatchery is based on real-life assignments, peer counseling and working in cross disciplinary groups. There have been many implementations during the past 10 years through which we have gained experience of delivering it to first year students and this way engaging altogether 500 students in this novel way of working. It is a 5 credit study unit and lasts for one semester. The working groups, consisting of 12-15 students, are formed to include as many different students from different study programs as possible. Each of the groups has a second year student tutor responsible for helping the students to proceed with their work when starting with this totally novel approach of learning.

The assignments for the hatcheries are versatile, some of them include tasks given by external stakeholders like companies and other organizations, some of them are topics stemming from internal research and development projects in the university. This study unit offered to all first-year students is also the first experience with the intensive activating teaching and learning methods

applied in the faculty. Interacting in team work with students having totally different approach and networking with the world are basics of the learning environment.

The main objective of this study unit is to make students understand that in addition to their own study field competences their future employers will require that they during their studies have developed and adopted more general competences as well the innovation competences. Innovation competences are expected in all fields in businesses and organizations.

This study unit introduces a new way of learning and working when new students start their studies and by activating the students also encourage them to take responsibility of their learning. In the hatcheries the students are expected to start creating new ideas as they work with people who might have different agendas and ways of thinking. (Kairisto-Mertanen, 2017). They are expected to learn how to define the goals of work and ways how to reach the goals. One of the student tutor's tasks is to lower the anxiety among project hatchery students when they face the challenge of not knowing exactly what they expected to do. The students are also expected to learn how to continue after something which could not be described as a success. During their first study semester they are allowed to make mistakes but they are expected to learn from them.

The work in the project hatchery groups starts by helping the students to identify themselves as members of the team. It continues by helping the team to assign roles to each team member. The group has to select the project leader, the secretary and assign other roles to the rest of the team members. The project hatchery group is also expected to elaborate on the assignment and find their own angle from which they want to approach the task. When doing this they start developing a capability to take responsibility for whatever they are doing. We also want them to develop an intrinsic approach and motivation to their work.

Studies in project hatchery are designed to contain weekly hours of contact work but also independent work which, as well as the working methods, the groups are free to choose. The study unit also contains a few compulsory tasks allocated to each group involved. Every group has to: 1) draw a project plan for their work, 2) design and prepare a poster reflecting what they are doing, 3) make a presentation and present their work in a creative way, and finally 4) write a final report on their activities and results. Moreover, every student has individual learning tasks, where s/he has to reflect own learning, experiences, goals and motivation.

Because ultimately the learning goals of the project hatchery are not connected with learning of the study field specific competences which are different for most participating students but to learn innovation competences which are equal regardless of the study field, it is very important to define and discuss the goals together with the participating students. Once they are set together it is equally important to reflect reached results constantly in order to make learning visible.

The project hatchery as an innovative learning environment supports students not only in helping them create and meet goals on the development of their innovation competences, but also helping them to find their preferred role in the continuously changing innovation teams present in today's highly volatile organizations. Innovation requires not only creatives, but also critics, initiators, co-operators and networkers.

Challenges and possibilities in multidisciplinary learning environments

Although the project hatchery is a functional pedagogical practice nowadays, it has required lot of long-term and persistent development work. In this section we shortly reflect our experiences and observations related to changing pedagogical practices towards innovative learning. We also highlight some main elements, which are needed to make a change, and point out some key findings, which have changed in faculty during the development period.

There are many challenges when introducing a new way of learning in the faculty. According to our experience it is especially challenging when students from many different study programs are put together for the first time. However, since project hatcheries started, a clear difference could be observed in the atmosphere of the faculty. Students from different study programs started to hang around and work together when they were not forced to doing so. In addition, based on feedback, interviews and discussions with students, it seems that project hatchery concept has a significant role increasing communality of students in the faculty. Perhaps, a shared and common learning experience with new fellow-students in discomfort zone is a key factor enhancing a sense of solidarity

On the other hand, it is not just the students who have not been accustomed to studying together but also the faculty members who might be suspicious about the importance of different domains than their own. Developing trust seems to be a crucial question. Trust is needed when putting students working together across study programs but it is also needed between faculty members from different disciplines. The teaching profession has traditionally been very independent. After shutting the classroom door each teacher has had the freedom of delivering the content in his/her preferred way and even choosing the content to be delivered. Often the own content is considered to include the most important information to be learnt by the students. To accept that there a many different contents equally important requires understanding and trust on the colleague's professional competence.

Building trust calls for getting to know each other. The role of the management is to organize occasions where faculty members can meet and get to know each other. Trust is not likely to develop without personal contacts and this is why many discussions are needed and space for them organized. It also possible to organize work supervision, which provides the chance to stand apart from one's work and to reflect on what is being done, the context and the impact that this has on ourselves as professional people. Work supervision aims at

learning through interaction. It is a relationship which is ethical and confidential and where both parties have rights and responsibilities. Work supervision is also a forum for reflection and learning from our experiences. It can lead to professional growth. (Beddoe, 2010.)

In project hatcheries, using work supervision was implemented a few years ago. Counselling sessions are not only used with teachers but also with student tutors. Its implementation has led to remarkable results. Counselling sessions have increased trust, communality and cooperation between teachers and students. For many teachers sessions have been an empowering experience and increased well-being at work. With this model, student tutors have also learnt a new reflecting and conversational method to develop their professional competences which later might be utilized in their future occupations or workplaces.

Conclusions

Higher education institutions have a crucial role in training innovative professionals for their future occupations. This requires that students have developed innovation competences and acquired needed experience already during their studies. To succeed in this requires new kind of learning environments. The aim of this article was to present one example of pedagogical pratice of innovative learning environment in engineering education.

Innovation development requires risk taking, novel methods and ways to act and think, enthusiastic people, and supportive environments (Assink, 2006). The same elements should be required in education as well. Flexibility and learning to learn are the main success factors in future work according to OECD. Education must prepare students to meet the world where they continuously need to adapt to new ways of working, technologies and business models. However, success in working life is not the only aim for education. Successful education provides also happier individuals and functional societies, improves economic and sustainable development, and adds well-being and equality. This is both a challenge and opportunity for education; we can react, adapt, and have an active influence on the desired future. Competences provided by education are an important tool in shaping the future. The world keeps on changing, but we can have impact on that what kind of world we will have.

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ENHANCING THE REGIONAL INNOVATION SYSTEM: MULTI-DISCIPLINARY EDUCATION & RESEARCH COLLABORATION NEEDED BY BUSINESSES

Takeharu KIYOSHI, PhD
Department of International Business,
National Institute of Technology, Toyama College, JAPAN

take11@nc-toyama.ac.jp

Abstract

The objective of this paper is to show how technological collaboration among industry, academia, and government can be enhanced in order to achieve better actual success in the business world. I suggest a model, based on my research into advanced case examples from a Danish Industrial PhD Program (I-PhD). Even in rural areas, efforts to enhance regional economic development have been made by seeking "Technology development ~ Commercialization, Business establishment, and then Industrialization" through cooperative activities between companies and academia. Currently, these results are not seen in conventional technological collaborations of industry, academia, and government, although the numbers of collaborative research cases and patent applications have increased. In order to overcome this situation, there is a need for a new collaborative approach that can produce better results from the viewpoint of social implementation.

Keywords: Multi-disciplinary education and research design, Industry exposure, Innovation, Technology Collaboration

1. Introduction

As a means of endogenous economic development, regional output from a functioning regional innovation system is desirable and important for growth. A regional innovation system is one where regional industry-academia-government technological collaboration creates a process of "Technology development ~ Commercialization, Business establishment, and then Industrialization," which function autonomously. The good news is that the numbers of collaborative research and patent applications have increased recently from the viewpoint of social implementation (e.g., Kiyoshi 2013a). However, we have not seen results that build toward the autonomous functioning of "Technology development ~ Commercialization, Business establishment, and then Industrialization." To overcome this situation, I believe there is a way to collaborate that can produce better results. The aim of this paper is to show how we can utilize cooperative educational collaboration across industry and academia to promote effective technological results. I believe that it is necessary to support industry-academia-government technological collaboration in the form of a kind of social network of cooperation across industry and academia, namely, "Collaboration, Co-creation → Fostering trust."

My research identifies a mechanism related to the mobilization of industry, academia, and government technological collaboration, specifically for small and medium size firms in rural areas. The research, as a practice case study, also aims to identify how we can revitalize regional industries through the "creation of a mechanism that drives innovation" within a regional system so that "high value-added co-creation" can be achieved. Today, various local communities are impacted by the effects of globalization. Thus, creating a globally competitive regional innovation system is an urgent task for local areas. This task is seen as extremely significant. To achieve such a competitive advantage in the region: new technologies need to be developed; various industry-academia-government collaborations need to occur; local public policies need to be established; and firm business and social performance need to be managed; among other efforts. To this end, institutional and human capital have to be accumulated that can utilize regional resources through organic development. Therefore, the field of economic sociology, I believe this research has academic significance for system research in regional economic sociology.

2. Background: Regional activities and research

In Japan, by issuing various policies, the revitalization of technological collaboration of industry-academia-government has been promoted mainly by the Ministry of Education, Culture, Science and Technology through its Policy Industry Collaboration and Regional Support Division and its University Technology Transfer Promotion Office.

I believe that the aim of these policies has been the creation of a unique regional innovation system through the creation of intellectual clusters. However, except in some excellent individual cases, the formal structure of these clusters has been emphasized ahead of collaboration as the aim. In many cases, there is not substantial cooperation leading to "Technology

development ~ Commercialization, Business establishment, and then Industrialization," which should be the aim.

The theoretical background underlying such policy development is derived from the regional competitive advantage in Porter's (1990) strategic theory and his widely known "Diamond model." Subsequently, in the regional system referenced by Saxenian (1994), the existence of a social network where competition and cooperation coexist was highlighted. In social exchanges in a community, informal information, mutual learning, and transfer of tacit knowledge are naturally shared, building the transition to a knowledge-based society.

Cook et al.'s study (1997) is a well-known reference to a regional innovation system. This regional innovation system refers to technology transfer and commercialization from universities. The cooperative interaction of credit and trust is a social process and creates feedback for the innovation process as knowledge development. In addition, there is Etsukowitz's Triple Helix (2008), which models industry-academia technological collaboration. On the other hand, Florida developed the regional theory where innovation is an area of learning caused by knowledge creation.

3. Methodology

Here, I refer to human capital and assume that the key to regional economic growth is strong contribution from highly educated and highly productive human resources. The relatively new concept of "creative capital" is comprised of scientists, and artists, among others, who "create some meaningful new form." The existence and attraction of these creators are important for regional economic growth (Florida, 2005). This research focuses on the realm of "cooperative realization" among small and medium sized firms and academia. To achieve the aim of my research, I investigated overseas cases that had achieved distinctive innovations. In truth, this task itself is not completely novel, as there are cases that have been conducted on the strategic utilization of coordinator talent and the university research administrator (URA). However, it seems there is a need for an approach from a completely different viewpoint that considers the current situation, namely, there is an inherent problem such as the existence of no real cooperation, as mentioned above.

In other words, I hypothesize that we need to "foster social capital for better collaboration" in our knowledge-based society rather than pursue the traditional idea of seeking an ideal match among the related parties. Thus, I believe the Danish Industrial PhD Program can provide support for this hypothesis. I-PhD is a doctorate degree acquisition program produced by an industry-academia-government project-based collaboration in Denmark. It is a practical doctoral degree in line with the industry perspective and actual corporate projects and includes a mechanism of industry-academia-government collaboration involving the creation of actual innovation.

4. Current Technological Collaboration Process

1: Even though it is collaborative research, industry-academia-government technological collaborative activities are mainstreamed in the transfer of science and technology, going from development at the university and moving to the private sector (of course, there are cases where research starts with technology brought in from the company side); however, it is commonly one-way traffic. 2: The promotion of technology collaboration is a partnership with companies, aiming at "Technology development ~ Commercialization, Business establishment, and then Industrialization." The basis of the partnership is the logic of the market economy with each partner in a different position. 3: In the case of the technology itself, it is difficult to adapt qualitative and qualitative data into a linear, rational promotion method based on evidence of the causation by induction.

Here, I look to improve on the cooperative process. However, this is difficult to achieve in technological collaboration between industry and academia.

5. Use Case

5.1 The Industrial PhD Program

The I-PhD is a doctorate program where the degree is attained through industry-academia-government collaboration. Over three years, in a project environment, the participating human resources (students) are developed as they conduct fundamental and applied research from viewpoints based on industrial needs under the public assistance from the government. As a result, the accumulation of human capital is achieved together with contributions to the community through the business of the companies involved; this then becomes profitable activity. In fact, the outcome is a regional embedded innovation system that creates economic value for local communities.

In Denmark, under the Ministry of Science, Innovation and Higher Education, which is the jurisdiction agency concerned, the program is implemented through Innovation Fund Denmark (InnovationsFonden), which invests in new knowledge and technology creating growth and employment in Denmark and through a direct organization, the Danish Agency for Science, Technology and Innovation (DASTI). Although it is a program that provides doctoral education, from the perspective of the organizations concerned, it has an extremely strong orientation towards industrial development.

The program system was first introduced in 1971 at the Technical University of Denmark and at the Academy of Technical Science as a "two-year program" for the education of an "industrial researcher." The doctoral degree was added in 1988 and, in 2002, under the jurisdiction of the Ministry of Higher Education, the field of academic education expanded dramatically. The I-PhD program is regulated by Danish educational laws and other regulations and must be in compliance with ordinary PhD degree rules. Therefore, when a degree is awarded, it is an ordinary doctoral degree, but at the

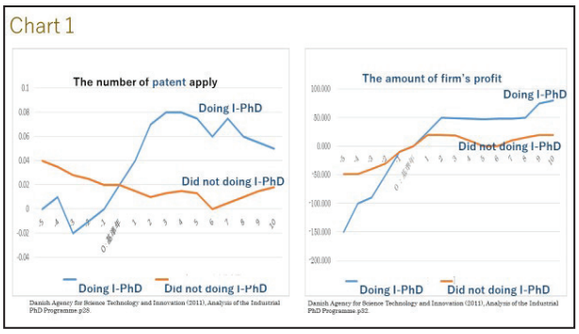
same time, Innovation Fonden issues a certificate for the I-PhD. The I-PhD proceeds in the form established by DASTI, which applies for the enterprise projects. At the time of the application, candidates are selected as employees to continue in the future; three people, including the doctoral candidates and professors, work together, and the project schema is planned.

Once a project is accepted, the doctoral students become full-time employees of the companies, while at the same time, they remain as doctoral students of the universities where they collaborate. Their jobs at the companies are as registered doctoral students at the university where, for three years, they conduct research that focuses on the industrial side.

5.2 Utility of a Multi-Disciplinary Education

The utility of the I-PhD program is as shown in Chart1. The number of patents applied for and the amount of each firm's profit rose under I-PhD program participation.

Chart 1



6. Results and Discussion

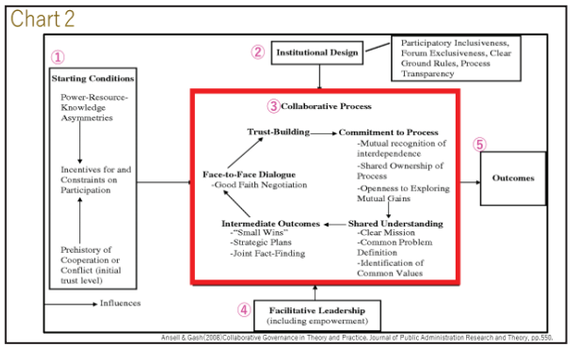
6.1 Collaborative Governance in Theory and Practice

From these survey, it became clear that I-PhD is a strong cooperative model, especially for small and medium sized firms that can take advantage of the characteristics of the program. For comparison, I followed a previous academic theory developed by Ansell and Gash (2008), which I used as a theoretical framework to verify that the actual human interaction in the I-PhD program was effective [Chart 2]. The theory shows the utility of educational collaboration.

Looking at the five dimensions in Chart 2, "①Starting Condition," "②Institutional Design," "③Collaborative Process," " ④ Facilitative Leadership," and " ⑤ Outcomes," it can be said that the collaborative activities act to foster mutual, positive relationships. In promoting the project, they establish a "commitment to the collaborative process" by confirming mutual dependence and motivation for pursuit of mutual benefit. Moreover, during the collaboration, they clarify the mission and tasks to create a "common understanding," which is important to accomplish. The collaboration generates "intermediate results" by accumulating small accomplishments throughout the process such as finding new facts and formulating future plans. By faithfully negotiating "face to face dialog," they establish "trust building," which leads to positive "⑤Outcomes." Even in the cooperative process of this case, by formalizing the process of human resource development through dialog, it can be said that small results are visualized and trust developed.

From collaboration with industry in this case, there is a new discovery, which is "④ Facilitative Leadership" that is outside the "③Collaborative Process." As a matter of fact, it is important to ask the industry members to actively commit to the project.

Chart 2



6.2 Academic Theory of Dialog in Collaboration

If we consider the autonomous functioning of the actual work flow through collaboration, we can express it as "Sharing→ Co-creation → Fostering trust." Thus, it can be said as well that this is a line of effort for the realization of the positive relationship between industry and academia, building a nondeterministic theoretical structure as collaboration secures freedom and is independent of causality. This can be explained by the logic of the "SECI" model (Nonaka, Takeuchi (1995)). The model shows "Socialization," "Externalization," "Combination," and "Internalization" creating new knowledge.

When building mutual relationships, first, "Socialization" is formed through empathy where future experiences are shared. This is the creation of further tacit knowledge through the sharing of tacit knowledge. It can be said that this is the process of sharing through the empathy of knowledge. This is the awareness and understanding of mutual human resource development (education).

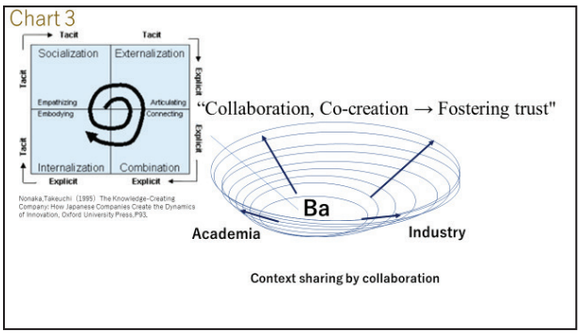
In the actual collaboration of industry and academia, the following occurs: 1) Select and confirm collaborating consultants and establish regular meetings; 2) Confirm the significance of human resource development for industry and academia; 3) Confirm the collaborative problems and clarify the path to the solutions, which represents collaboration with sharing and empathy, as described above.

The next step is to "Externalize" the tacit knowledge that is shared through the construction of a program design to make tacit knowledge explicit knowledge. After externalization, the parties deepen their mutual understanding and clarify the concepts through dialog. Furthermore, it becomes necessary to formalize the knowledge so it becomes more substantial. This act is deemed as the "Combination," which is the collaborative work that identifies the details of the

human resource development program. Here, the question is: What should the curriculum be that embodies the training goal? Moreover, what talent should an appropriate supervising teacher have and who is responsible for this? Further, how are industry members involved? The answers will lead to the creative realization of human resource development. In addition, these processes are driven by dialog. Through such processes, it can be said that the relationship between industry and academia is realized through collaboration ("Collaboration, Co-creation → Fostering trust"). Taking time into consideration, this relationship is fostered through the interactions of dialog and practice, which is repeated through past, present, and future collaboration.

The collaboration of industry and academia needs to be supported in the form of a kind of social network that occurs, where "Sharing, Co-creation → Fostering trust" is likely to take place; a lack of these characteristics makes the realization of the collaborative process difficult in industry-academia collaboration. A flow line returning between the science community (academic research/universities, etc.) and real society (industrial society/enterprises, etc.) is necessary to achieve a regional innovation system of industry-academia-government collaboration where the framework of "Technology development ~ Product development, Business establishment and then Industrialization" functions autonomously. This flow aims at knowledge creation through collaborative activities starting with the recognition of problems in industrial society at the early stage of industry-academia-government collaboration moving to the creation of concrete results in the final stage (social implementation, etc.).

Therefore, in summary, industry-academia-government technological collaboration needs to be supported in the form of a kind of social network in order to realize substantial collaboration for "Technology development ~ Commercialization, Business establishment and then Industrialization," which should be aimed at "Collaboration, Co-creation → Fostering trust" [Chart 3].

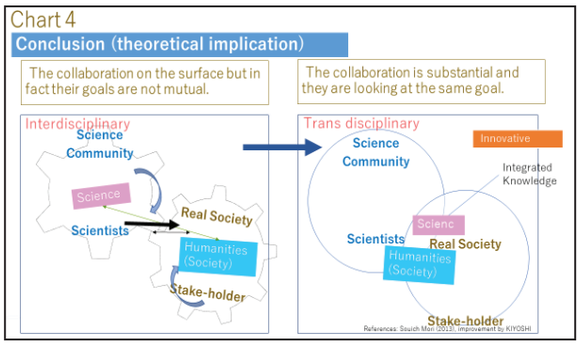


7. Conclusion

In conclusion, the I-PhD program can be regarded as a so-called trans-disciplinary educational activity and also "Super-interdisciplinary," which means creating new results from different viewpoints and ideas through collaboration with multiple academic fields (beyond one single specific field) [Chart 4].

In industry-academia technological collaboration, the research is often framed against the backdrop of specific academic fields. However, "Super-interdisciplinary education" as a prerequisite for collaborative research, as well as "Super-interdisciplinary" in its original meaning, as described, can demonstrate the collaborative activities that mediate education to build mutual relationships.

Such industry-academia educational collaboration can lead to the creation of a social network by utilizing and promoting existing alliances such as "university consortiums in the region" already established in many areas in Japan. I believe this type of effort can lead to the realization of a regional innovation system, a system of industry, academia, and technological collaboration, which utilizes "Sharing, Co-creation → Fostering trust" as the basis of a successful regional system.



Acknowledgments

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DESIGN OF A MULTI-DISCIPLINARY FRAMEWORK FOR IMPROVING GENERIC SKILLS AND PRACTICAL EDUCATION IN A DEPOPULATED MOUNTAINOUS AREA

Y. Omori*[,a], T. Ohata[b], K. Tanaka[a], Y. Sato[b], S. Muroga[c], K. Tsuzuki[d], Y. Ichikawa[a] and Y. Mizuguchi[a]

[a] Department of General Education, National Institute of Technology, Toyota College, Japan
[b] Department of Civil Engineering, National Institute of Technology, Toyota College, Japan
[c] Department of Electrical and Electric Engineering, National Institute of Technology, Toyota College, Japan
[d] Department of Information and Computer Engineering, National Institute of Technology, Toyota College, Japan

*yukiko.omori@toyota-ct.ac.jp

Abstract

Not only domain-specific knowledge but also versatile abilities are required for leading engineers of recent technologies. Especially, it is pointed out that community education with industry-academia collaboration is of benefit to developing talents who contribute to region and industry. At the same time, since many industrial developments have been achieved in relatively limited regions, the decline of rural areas is problematic in many countries. National Institute of Technology Toyota College (NITTC) has launched the "Dormitory + town = Dormitown" project to improve student's generic skills and to contribute to a revitalization of a local community. The project features a multi-disciplinary collaboration of NITTC faculty members in different research area: Economic geography, urban planning, concrete engineering, condensed-matter physics, English education, and material science. All activities in the project are carried out in a depopulated area in Toyota city where some regional innovation has been highly desired, for which the faculty members take advantage of their expertise, and the students are encouraged to plan and carry out volunteer activities. In this paper, we study how the project is effective to develop the students' skills. As a concrete example, we introduce one of the project events in this year, "Workshop of making miniature concrete ship" for younger children, and examine how students who organized the event acquired practical and generic skills through this project.

Keywords: *Multi-disciplinary collaboration, generic skills, practical education, community education, regional revitalization*

Introduction

In modern society where science and technology have been highly developed and segmentalized, possibilities of innovations are often found on boundaries between different fields. Therefore, it is desirable for young students to learn and experience various things which stimulate broad interests in a wide range of fields beyond their own major subjects. One may consider that such knowledge or experiences are readily available in the modern internet society. However, it is the case only when we already know what we want to know; the information technology is not very useful when we do not even know a "search word". Furthermore, real communications and collaborations with other people are indispensable to develop a multi-disciplinary perspective. Thus, it is desirable for colleges to perform cross-cutting educational programs.

However, in practice, it is difficult to assemble such a multi-disciplinary education program as a part of regular classes, mainly because of time limitation: In recent years, every research field is highly advanced and segmented, and thereby curriculums in all department are fully occupied (Sato, 2018). In fact, in National Institute of Technology Toyota College (NITTC), most of the faculty members are too busy with their regular duties to have cross-disciplinary collaboration and/or cooperation, which would be otherwise expected especially in the colleges of technology. The lack of cross-disciplinary activities also affects education; students tend to have rather narrow perspectives limited to their own major subjects (Muroga, 2017). To resolve such an issue, a new framework for multi-disciplinary education is highly desired.

To establish the multi-disciplinary new framework, we adopted the two educational strategies. The first one is the project-based learning (PBL) which has many advantages in the practical education. Especially, we focus on the fact that understanding progresses in stages as in the order of "learning", "using", and "teaching". The practical education is also effective for developing

generic skills, such as problem-solving skills and communication skills, required for leading engineers. In addition to the practical skills, PBL is expected to increase student's spontaneity.

The second factor is the community education. Most industries are concentrated in city areas, and the rural areas such as inter-mountainous area have been depopulated and declining. In accordance with globalization and depopulation of the society, various problems in the mountainous areas such as the decline in agriculture and forestry industry are extremely crucial. As a means of solving these problems, it is helpful to locate schools and social educational facilities as the core of the local community, which contributes to the promotion of the region and to reinforce the autonomous community. Through the activities serving to the revitalization of the local community, the students can spontaneously acquire the generic skills. Indeed, it has been pointed out that community education with an industry-academia partnership has a considerable potential to develop promising human resources.

Based on the above points, we launched the "Dormitown" project. It started from the town development plan "NITTC Dormitown" that students and one of the authors proposed in a contest in 2014. In this contest, we made a proposal to make use of human educations at "Dormitory" in student autonomy, which is one of the characteristics of NITTC, leading to the development of a "Town" in the inter-mountainous area. The project name "Dormitown" was named by students as a slogan connecting these above two elements (Tanaka, 2017). When we planed to implement this project in 2015 under the aid from the administration, we have included the third element of "Multi-disciplinary education" from the above idea. The Dormitown project is a framework of educational activities with multiple objects, where we support PBL activities in the inter-mountainous area conducted by students in the cooperation of teachers of different branches. In this paper, we describe the assembly and actual activities of this project and discuss its educational effect.

Materials and Methods

In the following, we summarize our purpose and implemental method of the Dormitown project.

1. PBL education under multidisciplinary collaboration. The project provides a framework for the implementation of workshops and summer schools for elementary school students organized by the students in different majors as multidisciplinary collaborative education. This is carried out as student-centered free activity outside lectures, curriculums, and club activities. This workshop aims at promoting understanding by teaching specialized contents to participating children and students in different majors and nurturing communication skills and leadership through the management of the event. Furthermore, students can touch various expert knowledge by participating in the operation of the workshops planned by students from different departments.

Table 1: The number of the faculty and students of the Dormitown project. The departments G, M, E, I, C and A are abbreviations for the department of General Education, Mechanical Engineering, Electrical and Electronic Engineering, Information and Computer Engineering, Civil Engineering, and Architecture, respectively.

	Faculty (core) 2015	Faculty (core) 2018	Faculty (support) 2018	Students (core) 2018
G	2	4	1	
M	0	0	0	2
E	1	0	1	7
I	0	1	1	6
C	1	2	2	7
A	0	0	0	8

Faculty members from different departments organize this framework. They provide their own expert knowledge to the students and educate students in other departments for workshops as necessary. The specialized areas of the current leading faculty members are as follows: economic geography, urban planning, concrete engineering, physics, English education, and superconducting engineering (see also Table 1). Depending on the content of the workshop, other faculties also participate and teach the students. The details of specific implementation are described in the following section.

2. PBL in Community education. All workshops of this project are held in the mountainous area. Continuous participation of students in the depopulated areas for the workshops stimulates the community and, in turn, naturally brings students' attention to the local problems. This enables us to help students to notice regional problems such as depopulation and difficulties in agriculture in such area and to try to find solutions for them. In this way, we also aim for students to acquire the ability to utilize their knowledge and techniques practically.

Toyota city is a suitable location for such community education, because prosperous industrial areas represented by celebrated Toyota Motor Corporation and depopulated inter-mountainous area coexist. In the Dormitown project, we chose Sasado town in Toyota city as the main activity place. This town is one of the mountain villages located about one hour from the center of Toyota city. In the past, a tourism industry of hot spring was flourishing there. However, due to the shrinking public works and the diversification of travel, the number of hotels in Sasado city has decreased from 8 in the 1990s to 3. This is accompanied by population decline and aging population, which makes it difficult to maintain the agriculture. It is necessary for educational research institutes to work together on such issues in their own regions.

Table 2: The list of some of the workshops and collaborative research carried out in the Dormitown project by June 2018. As for the abbreviations for department, see the caption of Table 1.

Workshop/Research	Year	Leading department	Contents
"Guardian of the Field"	2016	I	Development of notification device for vermin control (collaboration with Hirano Laboratory in NITTC)
"Creating an Air Plane"	2016	M	Making a small air plane of wood and paper and study of the mechanism of lift and flight direction
"Programing with the Microcomputer IchigoJam"	2016	I	Workshop on computer programing with microcomputer
"Building an Electromagnetic Train"	2017	E	Making a small electromagnetic train with coil and dry cell
"Making a Corrugated Chair"	2017	A	Strength design of structures by the making a corrugated chair (one of events in summer school)
"Get Creature in the Water!"	2017	C and E	Observation of aquatic organisms in rivers of Sasado Town
"Making a Miniature Concrete Ship"	2018	C	Making miniature concrete ship and buoyancy experiment

Results and Discussion

Table 1 shows the organizations of the faculty members and students of the Dormitown project by department. The number of support faculty is counted only for faculties who have actively participated in the Dormitown events and does not include faculties whom the students asked for professional advice to carry out the workshops. The numbers of students are also counted only for the core staff. Although participation in the project is not mandatory, at least for the students, personnel composition can cover most departments.

We pick up several examples from the workshops and collaborative research that the Dormitown project has done so far, and summarize them in Table 2. Except for the collaborative research with a laboratory like "Guardian of the Field" in Table 2, all workshops are driven by the faculty and students of a specific department. However, management of the workshops and explanation of the procedure of the work for children are also handled by students from all other departments. On that account, before the workshop, participating students take a lecture on the subject matter of the workshop from members of the leading department. Therefore, students in the leading department can deepen their expertise practically by organizing their workshop and teaching on children and students of other departments. On the other hand, students in other departments can learn new knowledge outside their major by taking a lecture from the project members and giving it to children.

In this paper, we describe this educational process in detail of the most recent workshop "Making a Miniature Concrete Ship" as an example. This workshop was organized by one of the students in the department of Civil Engineering, and he proposed to create a concrete ship under the guidance of a faculty specializing in concrete engineering in his department. They conducted experiments several times to determine the formulation

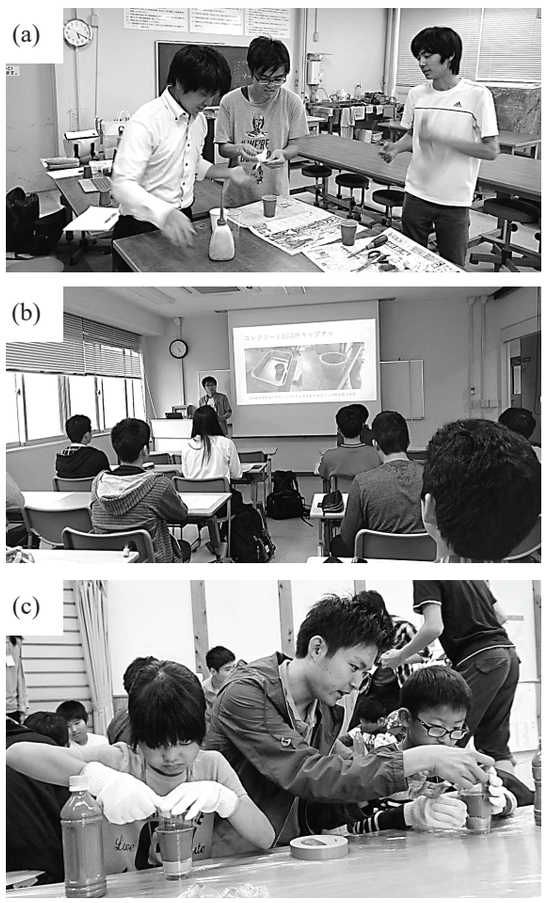

Figure 1: (a) Preparatory experiment by the faculty and students of the department of Civil Engineering. (b) Lecture on concrete working to students of other departments by the student of the leading department. After this lecture, experiment for the concrete ship was carried out in the laboratory. (c) Student doing instruction for children at the workshop.

of concrete and the shape of the ship (Fig.1(a)). At the same time, they made easy explanatory materials so that children could understand the principle of the concrete ship, with advice from the faculty of physics regarding buoyancy. After these preparations, they gave a lecture to other students going to participate in the workshop (Fig.1(b)). The students consist of one from the Mechanical Engineering, five from Electrical and Electronic Engineering, three of Information and Computer Engineering, nine of Civil Engineering, and one from Architecture. Based on the knowledge the learned there, they instructed the children to manufacture concrete and create a ship from it at the workshop.

In this way, students in multiple departments collaborate to plan and manage workshops for children, so that they can acquire 1) sharing of expert knowledge, 2) ledership, and 3) presentation and communication skills. At the same time, in this Dormitown project, the effect of regional revitalization by continuing the activity in Sasado town is also recognized, as reported by Sato (2017).

Conclusions

In this paper, we introduced the Dormitown project in NITTC, which has launched to improve student's multi-disciplinary knowledge and generic skills, and also to contribute to the revitalization of a local community. The project is organized by faculty members from different research areas. All activities in the project are carried out in Sasado Town, which is one of depopulated areas in Toyota city, to contribute to revitalization of the local community. In this project, student plan and manage workshops for children in collaboration with other departments, and share their specific knowledge. In this way, it is indicated that they acquire not only the new knowledge of other major but also leadership and communication skills. We expect that this framework of the project can be widely effective for nurturing talents who contribute to region and industry.

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DIGITAL INFORMATION FLUENCY FOR THE FUTURE WORKPLACE: A COLLABORATIVE, INTEGRATIVE DISCIPLINARY APPROACH

C. Pang[*,a], M. Goh[a], A. Liew [b] and H.H. Kheak [b]

[a] School of Business Management, Nanyang Polytechnic, Singapore
[b] Library, Nanyang Polytechnic, Singapore

*Chris_Pang@nyp.edu.sg

Abstract

The globalised knowledge economy and the rapid integration of information and communication technology (ICT) make it imperative for pre-professionals to acquire digital information skills (DIS) necessary for gaining employment. There is now a growing recognition that the modern workplace needs to move from DIS to digital information fluency (DIF) for enduring career success. DIF is defined as the trinity of critical thinking, net savviness and information source diversity. This study describes a case study, which is a strategic learning collaboration between Nanyang Polytechnic's business school and library to prepare pre-professionals for the digitalised workplace. As such, this study examined the pedagogical benefits of an integrated disciplinary approach for developing DIF. Digital information literacy instruction and learning activities were integrated into a core foundational business module. A gamified blended learning approach, with elearning modules and gamified classroom activities, was used. The year-long study found that the intervention group consistently outperformed the control group. There were improvements in scored information search strategy articulation and the number of authoritative sources cited increased significantly. Tutors and students reported increased engagement due to the experiential learning experience design and enhanced use of ICT. The DIF strategic collaboration also allowed the initial conceptualisation of a viable working model that helped outlined the co-teaching roles, co-designed learning activities, co-scheduling of teaching, areas of integration, and operational conditions for successful DIF development. This can be extended to and applied in other schools.

Keywords: *Digital information fluency, Digital literacy, Information literacy, Disciplinary integration, 21st Century Skills*

Introduction

The job markets' demand for 21st-century skills that include the ability to find, evaluate and problem-solve using digital information effectively, efficiently and ethically is deemed as essential for continued employment success (Van Laar et al., 2017). This set of skills can be collectively referred to as digital information literacy. Traditionally, digital information literacy leaned more towards the use of ICT to access and assess information as core skills (Bawden, 2008). This technology-use conception has started to change as it is no longer sufficient to be knowledgeable about using a software or online resource. In order for pre-professionals to succeed after graduating, there is a need to shift to digital information fluency (DIF), defined as the trinity of critical thinking, net savviness and information source diversity (Miller & Bartlett, 2012). The shift from literacy to fluency is indicative of the sweeping changes the future workplace is experiencing. More than ever, technical or digital skills, on its own, no longer guarantee job security, let alone promotions or better wages. The 21st-century workplace has expanded from a technology-use concept to a digital-competence concept.

Digital information skills are assumed by many educators as something that can be picked up as part of disciplinary content instruction. This assumed approach may not be ideal for developing true competence, as even if digital information skills are mastered, it is often done so in an isolated, compartmentalised manner. Building DIF requires a collaborative and integrative effort to better prepare pre-professionals to function in a technologically-rich workplace (Ahmad et al., 2013). Therefore, DIF is of interest to administrators, instructors as well as librarians. It is this partnership that confers the best possible advantage in achieving this desirable 21st-century skill as DIF requires the use of technology to teach beyond technology. DIF is as much about mastering the skills as it is about applying skills masterfully. In a more ambiguous environment, a learner must be able to apply a skill fluently in any personal or professional situation. A skill is also best learnt when applied in context rather than in a classroom leading to an examination.

This paper describes a case study, which is a strategic learning collaboration between a business school and an institutional library to prepare pre-professionals for the digitalised workplace. DIF has, of late, gained an even greater significance due to the rise of misleading and falsehoods (fake news) as it is perceived as being able to counteract such. Therefore, this study examined the pedagogical benefits of an integrated disciplinary approach for developing DIF. The research questions are meant to illuminate pedagogical practice:

1. What is a viable learning approach for developing digital information fluency for the 21st Century workplace?
2. What is the optimal collaborative approach that allows for cultivating digital information fluency?

Digital Information Fluency

DIF stems from two similar lines of reasoning. Stripling (2007) defined information fluency as the "ability to access, make sense of, and use information to build new understandings…because students must not only know the skills, but also apply the skills fluently in any personal or academic learning situation" (p. 25). Miller and Bartlett (2012) added to the skills-led discourse by expanding it to a tripartite concept of critical thinking, digital savviness and information source diversity. Both studies suggested that the trigger for DIF was the need to better prepare learners as workers for a digitally transformed world. DIF is also often referred to as an amalgamation of literacy skills, having assimilated digital literacy and information literacy. Lombard (2016) stressed the need for a cross-disciplinary collaborative approach involving faculty members, librarians, instruction designers, educational technologists and support staff to actualise DIF. Lombard (2016) further recommended each role's basic responsibilities. Table 1 presents the roles augmented with DIF principles.

Table 1 DIF-augmented Collaboration Roles

Component	Faculty	Library	Instructional Design
Identify	Ensure student topic feasibility	Create awareness of topic	Integrate & present course objectives & resources
Locate	Develop students' ability	Provide training & support	-
Evaluate	Develop students' ability	Discuss source quality criteria	-
Use	Integrate course objectives & resources	Demonstrate citation mechanics	Provide IT capabilities training & support

21st-Century Skills and Digital Information Fluency

The impetus for the growing recognition of DIF can be attributed directly to the adoption of 21st-century skills. Like 21st-century skills, DIF consists of a broad spectrum of skills meant to prepare a future-ready knowledge worker. Different frameworks address and include DIF differently, ranging from broad generalisations to specific operationalised skills. However, Van Laar et al. (2017) in completing a systematic review of 21st-century skills and digital skills, found that the focus tends to be on knowledge- or content-related skills and on technical use rather than skills required for the workforce. There were limited instances in the frameworks that articulated digital competence or information fluency. This implies that there may be a fundamental disconnect in how institutions, researchers and educators perceive 21st-century skills and its outcomes to develop future knowledge workers. The assessment strategies may also be too narrowly defined and overly focused on functional skills that emphasised knowledge regurgitation and repetitive practice rather than performance. Ferrari (2013) argued it was pointless to focus overly on functional skills as new technologies have made formal digital skills training somewhat redundant. Students can easily learn a software like Excel online on their own. Strømsø and Bråten (2014) also argued that undergraduates needed more training in sourcing, evaluating and applying digital information beyond information search and ICT usage. Siddiq et al. (2016) highlighted that despite the increased use of ICT in the classroom, teachers still characterised students' digital information skills as lacking. This suggests that DIF may be critical for meeting the working demands in the 21st-century. It also implies that 21st-century skills should incorporate and articulate DIF more expressively.

Method

The intervention study was conducted over an academic year, which involved business students aged 17 to 21 years at Nanyang Polytechnic in Singapore. There was a total of 942 learners in the intervention group and 880 learners in the control group. The control group was the preceding year's cohort where the intervention was not implemented yet. The learners were taking a foundational business research course and the assessment was to produce a 2,000-2,500 word group report. In the pre-conceptualising stage, the initial pilot trials explored several instructional formats including flipped classrooms, instructor-guided classroom instruction and supplementary elearning. The pedagogical approach also took into account the educational setting where applied learning and outcomes-based learning were dominant educational hallmarks. The resultant intervention chosen was a blended lesson plan comprising three elearning modules (Effective Search Skills, Cite Using Endnote/Mendeley, Copyright and Plagiarism), a 90 mins hands-on workshop (Information Search Strategies, 'Online Sleuth' Gamified Activities) tutorial and assessment activities (information search strategy, digital scholarship). A gamified approach was chosen as it fitted

well with the adopted experiential learning style. The intervention lasted 5 weeks and was presented to instructors and learners as a "Business Research Week@The Library". Content analysis was also used to assess the submitted reports. Several researchers have stated the conditions essential for developing DIF such as the extensive use of digitally formatted sources, digital search using specialised tools, knowledge of intellectual property rights, information evaluation strategies, and authentic application (Moore, 2002; Sharkey, 2006; Fogleman et al., 2013; Heine & O'Connor, 2014; Lombard, 2016). As such, the categories coded included the frequencies of source citations, number of authoritative sources used and digital scholarship (adeptness in the use of digital sources to produce insights, conclusions and recommendations). End of semester self-reported online user satisfaction surveys were also conducted.

Results and Discussion

The study sought to discover the optimal learning approach for developing DIF. The outcomes associated with DIF included the increased use of authoritative sources, increased number of digital sources referenced, digital scholarship demonstration and articulation of an effective information search strategy. It was found that the intervention group consistently outperformed the control group. The study was repeated over two semesters. There was a statistically significant difference between groups as determined by an one-way ANOVA ($F(1,363) = 3.853$, $p = .050$). A Tukey post hoc test revealed that the intervention group used more authoritative sources in their group reports (3.14 ± 1.5, $p = .050$) than the control group (2.81 ± 1.6, $p = .050$). Authoritative sources were defined as the use of peer-reviewed journal articles and the use of objective industry reports with detailed references produced by reputable consultancy firms. Whitepapers and case studies were excluded as these are often used by companies as marketing tools.

Table 2 DIF One-way ANOVA Descriptives

		N	Mean	Std. Dev	Std. Error
No. of Authoritative Sources	Control	182	2.81	1.638	.121
	Intervention	183	3.14	1.507	.111
	Total	365	2.98	1.580	.083
Total No. of Sources Cited	Control	182	9.29	3.869	.287
	Intervention	183	15.12	6.429	.475
	Total	365	12.21	6.052	.317
Digital Scholarship	Control	182	5.63	1.058	.078
	Intervention	183	6.47	1.171	.087
	Total	365	6.05	1.192	.062
Info. Search Strategy Articulation	Control	182	5.27	1.321	.098
	Intervention	183	6.15	1.416	.105
	Total	365	5.71	1.437	.075

The intervention group (15.12 ± 6.4, $p=.00$) also significantly outperformed the control group (9.29 ± 3.9) for the total number of digital sources cited. It was observed that the reliance on using news articles was higher in the control group. News articles were considered to be less authoritative as it was difficult to identify and separate opinions, bias and associated political agendas from objectively reported facts. Digital scholarship, scored from 1 to 10, was also significantly higher for the intervention group (6.47 ± 1.2, $p=.00$) than the control group (5.63 ± 1.1, $p=.00$). Learners in the intervention group demonstrated a stronger ability to use evidence to produce analytical insights, conclusions and recommendations. The rubric scored learners on the ability to synthesise analytical insights rather than describe and paraphrase, as well as the relevancy of conclusions drawn and recommendations proposed. The intervention group (6.15 ± 1.4, $p=.00$) was also better at articulating their information search strategies used than the control group (5.27 ± 1.3, $p=.00$). An effective search strategy articulation, scored 1 to 10, was deemed more effective if it clearly articulated the search keywords used, the diversity of sources considered and a method to filter sources for relevancy and currency. Learner satisfaction ratings from end of semester feedback exercises also improved by 6.2% year on year. Surprisingly, the learners rated the instructors higher showing an increase of 9.3%.

The findings concur with Çoklar et al. (2017) who found that increases in digital information literacy increased digital competencies especially for online information search strategies. The improvements in this study's intervention group could be attributed to the learning experience design as well as the novel experience of marketing the strategic collaboration as a special learning week. Hess (2015) emphasised the use of a motivational design in information literacy instruction as much of current practices seldom addressed learner motivation meaningfully. The experiential learning approach, learning event branding and the gamified elements were designed to impact learning motivation and achievement through engagement. The inclusion of these motivational elements resulted in increases in learning application as seen in the increases in number of digital sources cited and demonstrated digital scholarship. The learning design used in this study had instructional significance for developing DIF.

The study also sought to identify the optimal collaboration approach for faculty and librarians for developing DIF. The resultant learning approach used in this study could be described as a shared responsibility. Both faculty and librarians contributed their relevant expertise at three distinct stages over a working period of 12 weeks. At the planning and conceptualising stage, faculty instructors shared desired learning outcomes, learning content and lesson plans. Similarly, librarians shared existing training resources and recommended context-specific digital resources for writing a business report. A series of meetings between faculty and librarians then identified opportunities to enhance the learning activities that could better engage leaners. The efforts culminated in a co-developed lesson plan with

clear instructional outcomes that were aligned with assessment strategies.

At the implementation stage, a pilot was first completed before the full roll-out to tease out implementation issues and refine instructional delivery. The librarians conducted the workshop-style training sessions on-site at the library, heightening experiential learning. Previously, many learners would only have attended a library tour during orientation. The instructors added a gamified element which introduced a friendly yet competitive element during the workshops. The on-site training sessions were therefore, co-taught by librarians and instructors. Instructors pointed out how to maximise the use of library resources during and at the end of the training session. The core elearning modules were developed by the library and additional elearning were supplemented by the instructors in subsequent weeks. The librarians curated a list of business-relevant research resources which increased the chances of learners exploring and incorporating the use of such resources. At the post-workshop stage, the focus was developing fluency over the next four weeks. The topics covered in the elearning modules (Effective Search Skills, Cite Using Endnote/Mendeley, Copyright and Plagiarism) were discussed in greater depth in subsequent tutorial classes as groups wrote their business reports. Consultations were also integrated into the lesson plan every week over a month. Learners were encouraged to explore the library resources and apply them effectively. Learners were encouraged to approach librarians should they wished to revisit core concepts in using library resources effectively. Deep integration at all three stages were deemed essential and this reinforced Lombard's (2016) synergistic approach for developing DIF.

The strategic DIF collaboration's success could also be attributed to a conducive and open partnership that leveraged the strengths of faculty instructors and librarians. It was not without its share of challenges. The first being the increased instructional burden on the part of the librarians. Technostress was experienced by some faculty instructors. Instructors expressed concerns over whether learners could cope with the increased digital teaching content and their own discomfort with the enhanced use of online research tools. While instructor training was made available, it did not reduce anxiety. What worked was a buddy-system where a more technologically savvy instructor was present for the first round of classes.

Conclusions

This case study demonstrated that DIF can be an institutional reality when the synergistic practice of "collaboration with commitment" results in improved learning outcomes that better prepared pre-professionals for the 21st Century. The gamified blended learning approach where both instructors and librarians worked hand-in-hand to develop learning content and activities was also effective in cultivating DIF. This validates the work of DIF researchers that emphasised the importance of digital or ICT-enhanced integration as well as disciplinary integration so that skills are applied in context to build fluency. An element of challenge imbued in experiential activities is also integral in activating DIF. The DIF strategic collaboration also allowed the initial conceptualisation of a viable working model that helped outline the co-teaching roles, co-designed learning activities, co-scheduling of teaching, areas of integration, and operational conditions for successful DIF development. This will serve as an evolving model to guide future endeavours for institutions seeking to develop DIF in a vocational setting.

It is nigh impossible for one to be an expert in curriculum development and delivery, librarianship and computer technology. DIF requires all three aspects to succeed. Thus, the best way forward is to collaborate to leverage core expertise that resides in an educational institution. A pedagogical and pragmatic model is key to unlocking learners' digital scholarship that builds DIF. A possible future direction is to expand the strategic collaboration to include a broader range of disciplines. This is because a widely used framework will contribute to the growing importance to develop this highly desirable 21st-century skill.

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PRACTICE OF INTERNATIONAL MARITIME ENGLISH EDUCATION IN THE CLASSES

Jongdoc Park[*,a], Min-Hung Chou[b], Seiji Shimizu[c] and Osami Yanagisawa[d]

[a, c] Shipping Technology Department, National Institute of Technology, Oshima College, Japan

[b] Department of Marine Engineering, National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan

[d] Maritime Technology Department, National Institute of Technology, Yuge College, Japan

[*] park@oshima-k.ac.jp

Abstract

The maritime technology departments in the five National Institute of Technology (NIT) colleges in Japan namely Toyama, Toba, Hiroshima, Yuge and Oshima College have been working together to improve the ability of Japanese students and instructors to use the Maritime English without any troubles. The English study and training program has been performed at NYK (Nippon Yusen Kabushiki Kaisha) - TDG (Transnational Diversified Group) Maritime Academy (NTMA) in the Philippines as they say "NYK project" since 2015. We decided to join the project with Japanese students and instructors. Aside from the students' English training, we, Japanese instructors were given several chances to have lectures in front of Filipino students. This paper has been reviewed how the English training and teaching experience worked for Japanese instructors at NTMA. For the second step, one of the NIT colleges, Oshima College invited professional instructor from National Kaohsiung Marine University in Taiwan. We requested him to conduct the technical educational program and onboard ship training simulation in English based on STCW (Standards of Training, Certification and Watch keeping for seafarers). We conducted survey questionnaire from the Japanese students, and analyzed the students' thought about English and the invited foreign instructor depending on each year and course. The results reflect how we should prepare the course information and understandable topics as well as teaching skill by using the active learning style.

Keywords: *Maritime English, NTMA, STCW, NIT maritime colleges*

Introduction

Maritime officers are specialists handling ship navigation and maritime engineering. As for the international maritime officers, a deep knowledge of theory, operating skill and maintenance for the ship is a very important requirement for them. Aside from that, they should speak English for internal or external communication between ship to ship or ship to shore. Actually, in the practical situation, almost of all the seafarers are foreigners.

All Japanese teaching staffs focus on how to teach maritime English effectively. All trainings in maritime technology department like the Practice of Boat Handling, Experiments and Practice, Onboard Training are conducted in Japanese language, but actually they should speak English for internal communication on merchant ship in the future. There is no doubt to say that.

The maritime technology departments in the five NIT colleges in Japan have been working together to enhance motivation and ability of the students to be international maritime officers and ship managers at sea (2013). We decided to bring the Japanese students to NTMA in the Philippines for a short term English training. The purpose is to experience the importance of English by living with Filipino students of the same age who are strongly aiming to be a maritime seafarer. NTMA promotes the standards in maritime education based on a variety of teaching methods delivered by highly qualified faculty members. We, Japanese instructors were given several chances to



Photo 1: Lecturing view at NTMA

have lectures in front of Filipino students who are involved in maritime technology. It is very important for Japanese teachers who are non-native English speakers to practice to teach maritime technical subject in English. It must be connected with students' motivation for English studying. This paper has been reviewed how the English training and teaching experience worked for Japanese students and instructors at NTMA.

For the second step, one of the NIT colleges, Oshima College invited professional instructor from National Kaohsiung Marine University in Taiwan. We requested him to conduct the technical educational program and onboard ship training simulation in English based on STCW (Standards of Training, Certification and Watch keeping for seafarers). We collected the data from the questionnaire for the program, and analyzed the students' thought about English and the invited foreign instructor depending on each year and course. The results reflect how we should prepare the course information and understandable topics as well as teaching skill by using the active learning style.

We concluded that the international maritime English program in the Philippines and Japan was successful to enhance students' motivation to study English and teachers' professional English communication ability. Thus, the practice of international maritime English education in the classes should be affordable for teachers and students in maritime colleges in Japan.

Teaching in English on technical subjects at NTMA

NYK-TDG Maritime Academy (NTMA) in the Philippines promotes the standards in maritime education through a competency-based and maritime industry-driven curriculum that employs a variety of teaching methods delivered by highly qualified faculty members.

During the first half of the stay, the Japanese instructors including me had a chance to be a school inspector sitting in the classes, and Japanese student acted as a temporary participants. Photo 1 shows the lecturing view at NTMA which shows U-shape seat

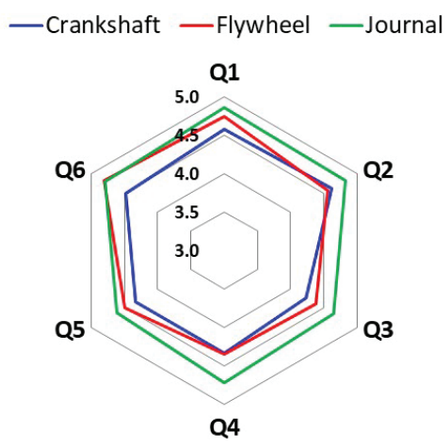

Figure 1: Average values to each question for the invited lecturer from NIT at NTMA

arrangement. This arrangement in the classroom is totally different from Japanese style.

A non-native English speaker NIT instructor performed lectures of maritime technical subject such as Marine Auxiliary Machinery engineering in English at regular classes. Also NIT instructor performed a presentation of Japanese culture and geography in English for all NTMA students. They listened intently to my discussion, and there was an exchange of ideas. They raised questions and participated in the class discussion.

At NTMA, the classes were conducted in various ways, such as students' discussion, presentation and exercise with instructor. Most of the classes, the instructors have their lectures using visual methods such as Powerpoint, Video, etc. to raise the students' understanding on the subject matter.

Questionnaire to the Filipino students on how they evaluate the invited lecturer from NIT

The question lists are as follows:

Q1. Is the lecturer's teaching well-organized?

Q2. Are you interested in the topics of the lecturer?

Q3. Have you understood the content of lecture?

Q4. Are you completely satisfied with the lecture?

Q5. Is the lecturer's English effective?

Q6. Is the lecturer's attitude (gesture, posture, and eye contact) effective?

For the feedback on the lecture at NTMA, we let the Filipino students choose one number from the list below for each question:

1. Very disagreeable
2. Disagreeable
3. Neither disagreeable nor agreeable
4. Agreeable
5. Very Agreeable.

igure 1 shows the average values for each question about it. A NIT instructor gave lectures three times for each of classes in Crankshaft, Flywheel, and Journal. They were all 3rd year students and 81 students in total. The class Journal got the highest score while the Flywheel got the middle score, and the Crankshaft got the lowest score. This means the NIT instructor (lecturer) have got used to teaching in English in the classes. The lowest score shows in the Q3 as shown in the figure. That is why the students do not completely understand the content of lecture. Lectures aren't just boring. They are ineffective too. Overall, they gave high values to the invited lecturer.

Figure 2 shows the average values for each question to the different way. For example, as for the Q1 (Is the lecturer's teaching well-organized?), the color of purple which indicates number 4 shares about 25% and the sky blue indicating number 5 shares about 75% of 81 students in total. As a result, it is a fairly high score and a good indicator that we did well in the lecture. The Filipino students generally gave high values on number 4 or 5 (means agree or very agree for questions) of 90% in total number. The several students agreed on giving a lower score for Question 2 to 4 (means slightly not interested in the topics of the lecture). There are only two colors in Q1

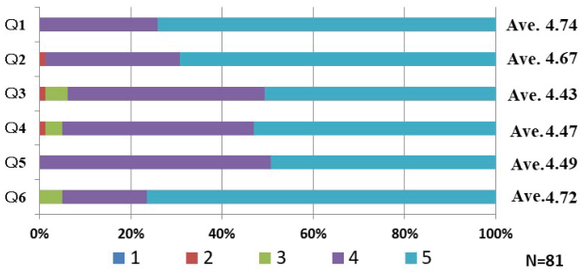

Figure 2: The results from all 3rd year students at NTMA

and Q5. This means that the students do agree or very agree with the effective lecture's organization and lecturer's English. We learned a lot from the results how we should prepare the interesting and understandable topics as well as teaching skill by using active learning.

In addition, Figure 3 shows what kinds of teaching methods are effective in the class. Students think the use of video is one of the most effective tools in teaching. They prefer a prepared visual presentation such as Slide, Video and Picture. The trend of preference of students on digital material or media is an indicator of people's fondness of social media. They also want some games or ice breaker to be incorporated in the lesson. That's why the quiz category ranked number 4. The demonstration is also chosen by the student because this activity involves people moving and doing something in actuality.

Teachers don't have to use the same teaching methods all the time. For the purpose of variation, the teacher has to use different teaching methods so that students won't get bored in the class. Followings are the students' comments about the invited lecturer from NIT.

NTMA student's comments for the NIT lecturer in the classes

- We would like to recommend that more sample quizzes and activities
- Icebreaking for the class needs for the long discussions
- More video or demonstration on each topic will be understandable
- It would be better adding some catching slides that will energize the students
- You could give some personal experiences on-board

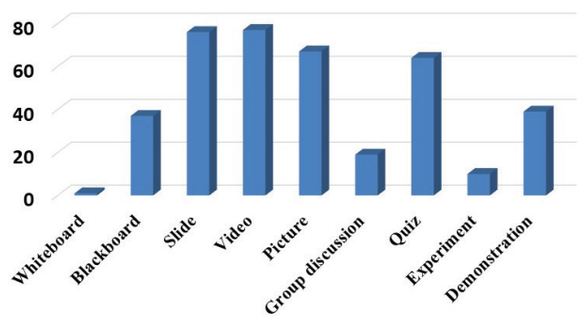

Figure 3: Effective teaching methods in the class at NTMA

- It will be more effective if more examples, videos and pictures will be used.
- Sometimes we must proceed to the engine room to demonstrate the actual process
- It would be better if you will make your voice louder
- We suggest more animation and more interesting examples like the superman example
- Before your talk, you need to find out the things what the students didn't know.
- You may also ask first what are the student's pre knowledge to know where to start the lecture
- Some pictures could not be seen and should speak more clearly
- There should be some ice breaking and fun discussion to have it lively like having group activities
- It would be much better if there are more examples and seat works
- We needed additional video presentation and more examples for calculations
- We would suggest that some difficult problems must be elaborated for the understanding to everyone
- Let the students answer the problems to see if they know how to solve it
- We could not understand clearly the statement of the lecture in English.
- Having a little joke in the class is good to keep the class good mood

Maritime English Seminar in Japan

For the second step, one of the NIT colleges, Oshima College invited professional instructor from National Kaohsiung Marine University in Taiwan (see Photo 2). We requested him to conduct the technical educational program and onboard ship training simulation in English. He was also a non-native English speaker like other Japanese teachers, so English was the only means of communication in the class. The students were able to identify the maritime technical professional words used in every subject, and to determine the meaning of the



Photo 2: Seminar view at Oshima College

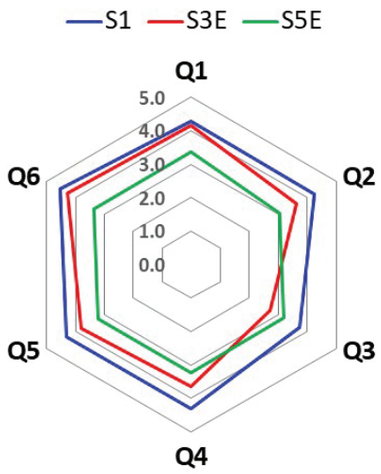

Figure 4: Average values to each question for the invited lecturer from Taiwan at Oshima College

maritime terminology and their functions in the classes. For speaking comprehension, students assigned to do a group activity where they have to make a plan on what to do. They could be able to speak in English and use some maritime terms correctly while doing the task.

Questionnaire for the invited lecturer from Taiwan in Japan

We conducted survey questionnaire in the Japanese classes on how Japanese students evaluate the Taiwanese lecturer. It is the same survey that we have done in the Philippines.

As shown in the Figure 4, you can see a hexagon chart. S stands for shipping technology department, and the number stands for year level of the students. E stands for course in the department which is the engineering course. Each of year level represents color blue, red, and green. Q1 to Q6 means questions 1-6. Inside of it is the score from 0 to 5. The S1 shown with blue color got the highest score from Q1 to Q6 in the chart. While the S3E shown with red color evaluated the second high score overall, but as you can see in Q3 (Have you understood the content of lecture?) they have got the lowest score among the other group. S3 students have not yet established the basic of professional subjects, so the content seems to be difficult for students to understand in English. The S5E shown with green color had a consistent low score from Q1 to Q2 and Q4 to Q6, but only in Q3 their score is a bit higher than red color. The results speak for the fact that the lower year level of Japanese students are interested in English lecture and they are very satisfied with the invited lecturer. However, as grade level become higher, their evaluation is getting worse.

Questionnaire about learning English for Japanese students

The question lists are as follows:

Q7. Do you feel the need to learn English?

Q8. Do you hesitate to speak English in public?

Q9. Do you think that your English ability in the class is more than "Average"?

Q10. Do you have opportunities to expose you to English?

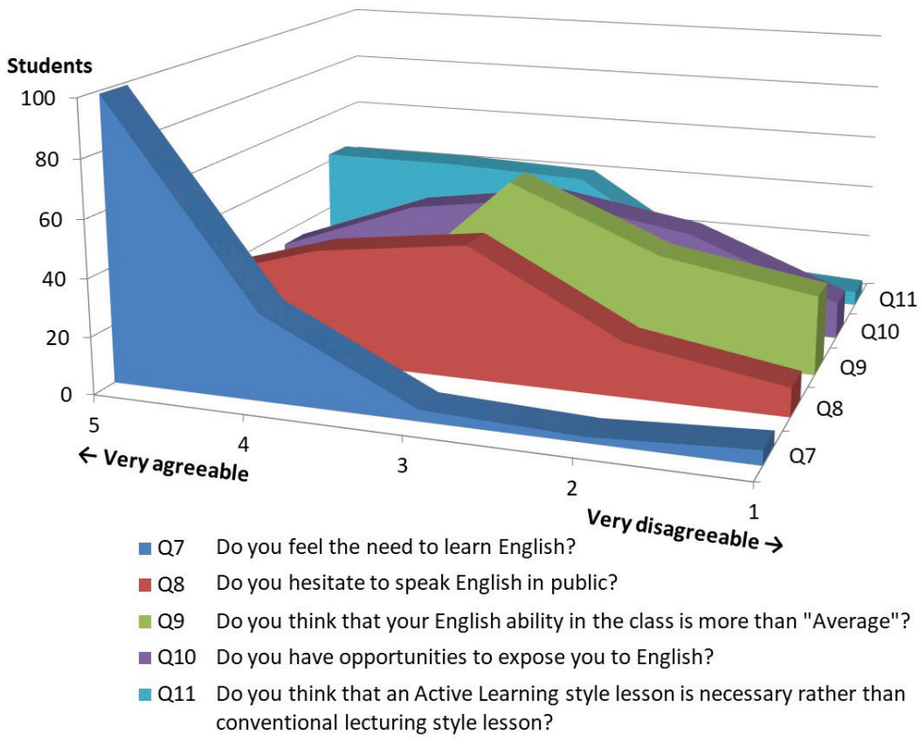

Figure 5: Questionnaire about English from Japanese students in the shipping technology department

Q11. Do you think that an Active Learning style lesson is necessary rather than conventional lecturing style lesson?

For the feedback on the lecture, the Japanese students chose one number from the list below for each question:

1. Very disagreeable
2. Disagreeable
3. Neither disagreeable nor agreeable
4. Agreeable
5. Very Agreeable.

Figure 5 shows the survey for Japanese students about learning English in the shipping technology department. It is shown in this graph how student responded to the survey. As you can see in Q7, the majority of the students strongly agreed that learning English is very important. Which means the Japanese students are very interested to learn English. In Q8, the opinion of the students are divided. Only few students are confident enough to admit that their English skills are good and that they would not hesitate to speak English in public. In Q9, students answer from maybe to "NO", means they don't think that their English ability in the class is more than average. Q9 leads Q10. In Q10, students' opinions are divided but the rating is almost equal from strongly disagree to strongly agree. In Q11 finally, students respond from maybe to "YES" means majority of the students believe that Active Learning style is necessary than conventional lecturing style, even though Active Learning style lesson is not a common way in Japan.

Self-evaluation vs year level of Japanese students about English

As you can see in the Figure 6, it shows the self-evaluation vs year level of Japanese students about English in the shipping technology. The Y-axis is represented by self-evaluation. You will see a score ranges 2.0 to 5.0. On the other hand, the X-axis is represented by the year level of the students from S1 to S5. The S4 is omitted because they had a shipboard training. The Q7 to Q11represent the question lists. Q7 obtained the highest score while Q9 got the lowest score. The students desire to learn English because of the following reasons: 1. Inspiration. They are in shipping technology and they will be using the English language when they become seafarers in the future. 2. Globalization. They might consider working in a foreign country so they really think English is important for them. Q11 ranked second from the highest. The active learning is necessary for their study since there is interaction between the student and the teacher. In this way, they can practice expressing their thoughts about a particular topic and also they can participate in the discussion. For Q10, the students have little opportunity to expose themselves to English. They have experience like by engaging in International Exchange Program and Internship for the upper level. The reason for obtaining a medium score is that the opportunity to go abroad is not enough. For Q7, the S1 students obtained the highest value as compared to other levels. Q9 has the similar trend in slope with Q7. This shows that the desire for the S1 is higher among the other levels. Everything that they learn in Junior High School is perhaps still fresh in their minds. So they are enthusiastic to learn more about English. However as they year progresses, the slope gradually goes down. Lack of enthusiasm. Their interest for learning English gradually fades away because their focus is now diverted to the professional subjects. Hopefully, if the upper level students can join the International Exchange Program and Internship, so they will have the desire again to learn English.

Conclusions

Through the International Maritime English Education in the classes, teachers could improve the management and teaching skills of professional subjects in English, and also students could learn the professional maritime English. For the students, it is expected that the passing rate of CoC and TOEIC score will improve as a result of English trainings. The instructor from Taiwan had gained Maritime English Education experience in

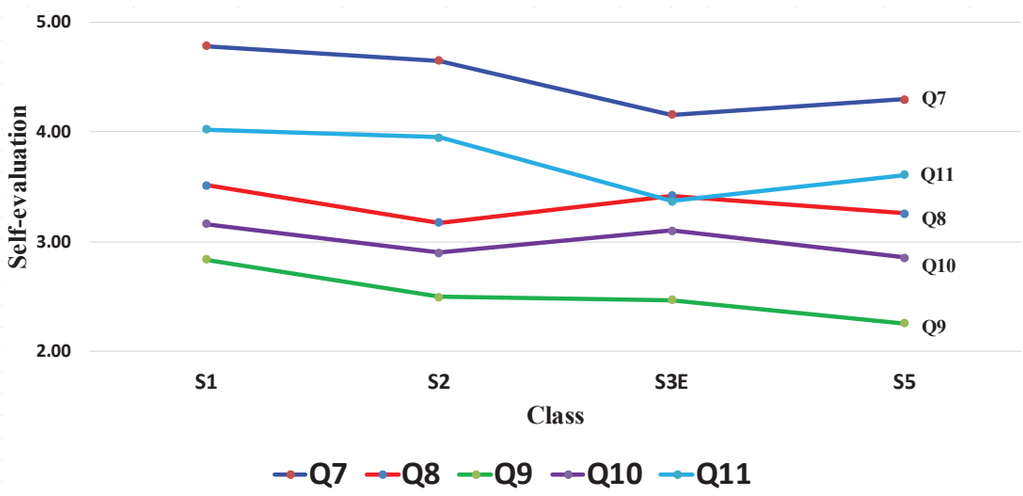

Figure 6: Self-evaluation vs year level of Japanese students about English in the shipping technology department

Japan where non-native English speakers are, so we were able to obtain the mutual effects. The questionnaire for the trainings were reported to prove their comprehension about Maritime English (2016, 2017).

However, the motivation to learn English passively cannot last a long time, and it disappears as time goes by. Only the learner's inner desire for improving is stimulated strongly, it could be the real sources of learning English. At the same time, the teachers should meditate the course information to fit students' needs. There's no doubt to say that.

Japanese people are not English native speakers and the medium of instruction in schools is not English. Exposure is important because it is one the effective ways of applying and using the English language. Learning is an active process and is activated by the learners. The learners are the center or the key players in the teaching-learning process. All the activities or learning experiences should be Active Learning style to assist in teaching such as applying charts or tables, using videos, web-sites or computer simulators, and collaborative learning or peer tutoring etc. Consequently, Japanese students will have the desire to learn English when they will be willing to join the International Exchange Activities and Internship programs that have been offered by each Japanese maritime college from now on.

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SIMILARITIES AND DIFFERENCES BETWEEN THE HIROSHIMA AND THE GUANAJUATO TUTORSHIP SYSTEMS

Yuko UESUGI*[a] and Gonzalo Enrique BERNAL RIVAS[b]

[a] National Institute of Technology, Kure College, Japan
[b] Universidad de Guanajuato, Mexico
*uesugi@kure-nct.ac.jp

Abstract

It's hard to find a co-presented paper between two professors of different nationalities at ISATE. Therefore, we consider that this text can be very enriching for anyone who read it. The purpose of this writing is to compare the Hiroshima and the Guanajuato tutorship systems in a broad spectrum, including the role of a tutor, the topics touched during a tutorship session, the students' channeling toward other departments, the number of students assigned to each tutor, the amount of time devoted to each group, the digital platform used to register the tutorship sessions and the impact that our role as a tutor has had on our students' human and academic performance. The focus of our research was qualitative, the research type was case study, the sample selection was theoretical, the data gathering was simple observation and the data processing and analysis was comparative. We are pleased to share the results that our contrast could reach at the end of our research. In the results section we show each one of the aspects that were analysed, discussed and compared. Every feature of the tutorship that we mentioned before was reviewed and the whole tutorship process in both contexts could be understood. The conclusions section was significant for our study since at the beginning we had assumed that the outcomes would show that our tutorship systems were very different to each other, but at the end we were shocked to find out how similar they can be, both, broadly in the entire tutorship process and particularly in the impact of our work as tutors on the students' development. Also, we could learn from what the other professor was doing to improve the tutorship system in our own University. We are very proud to recommend not only to get the chance to know tutorship systems in foreign countries, but also to co-create a presentation with someone from a totally different background, which will give you a fresh perspective on any issue. Discussion of similarities and differences will give you some unique educational insights from different cultural perspectives.

Keywords: *Tutorship, Japan, Mexico, Hiroshima, Guanajuato, cultural differences*

1. What are the Purposes of this Paper?

This paper is focusing on the comparison of the tutorship systems between Hiroshima and Guanajuato in a broad spectrum. The role of a tutor itself, for example, varies according to the educational stages. This paper especially focuses on cases in a high school and a college. During a tutorship session, the students' channeling toward other departments, the number of students assigned to each tutor, the amount of time devoted to each group, the digital platform used to register the tutorship sessions and the impact that our role as a tutor has had on our students' human and academic performance. Comparing the two different cross-cultural cases, the similarities and differences are to be clarified, which will suggest some unique educational insights from different cultural perspectives.

2. Real Case in Hiroshima, Japan

In Hiroshima, the tutors, class teachers, home room teachers, are responsible for home rooms and in charge of many different tasks for the general daily curriculum of education, while they teach their own specialized subjects.

In Japanese schools, there are so-called a home room which forms a greater part of students' lives, with home room teachers acting as a substitute parent in many ways. Students usually have the same home room teacher and fellow students during their entire life at a given school. Students are expected to take on tasks for their home room, including cleaning, day duty (note-taking and classroom organization), and the organization of competitive events between home room classes. Students also often eat lunch in their home room. Since teachers must usually travel to the students' home room, rather than students going to a classroom dedicated to a particular subject, the depth of lessons often suffers. Teachers must carry all materials needed for multiple classes, therefore the lessons usually end up taking on a lecture style with students simply taking notes in preparation for testing.

In high schools in Japan, they have a short homeroom time for 10 min every morning and after school every day. The morning homeroom means checking a daily schedule and students' health, while

the after school homeroom means giving information for the next day and cleaning. Two students are usually allocated on weekly duty: cleaning the blackboard after every class, writing daily journals to hand in to their homeroom teacher, checking homeroom cleaning, and getting information for their class if any.

They have two parent-meetings and individual talks a year. The PTA, Parent-Teacher Association, is organized and the PTA meetings are held several times a year. The parents who are appointed to the board have another executive meetings and even drinking party with the principal and the teachers in the evening. They tend to have a very intimate relationship and commit the school organization.



Picture 1: PTA meeting in NIT, Kure, in 2018

When a problem or trouble among students comes up such as bullying, the homeroom teacher immediately investigates the case and reports the case to the related parents and the teachers in higher ranks or responsibilities.

In college, the tutors' role is not as strong as the ones in high school comparatively. They have a parent-meeting and individual talk once a year. They don't have any morning or after school homeroom. Once a week they have a period of LHR, Long Home Room, where the homeroom teacher or the student affairs department in college can make some events for the class.

They have some points in common between high schools and colleges. In an emergency, the homeroom teacher has responsibility to take care of the students and report it afterward. They have to encourage the students to get a better grade in order not to drop out and give them advice. They guide the students in the choice of a career or further education in universities. They write recommendation forms if necessary. They have the closest roles to the students to consult with.

3. Real Case in Guanajuato, Mexico

In Guanajuato, an adviser is not the same as a tutor. Both of them are professors that also play the role of an adviser or of a tutor. An adviser provides students extra help to understand topics of the subject taught by that same professor, that couldn't be completely understood by the student or students. A tutor talks to students individually of in group about their academic performance to make sure those students who haven't been able to approve all of their subjects have a plan to become regular students. This text is devoted to describing the role of the professor as a tutor.

The University of Guanajuato has training at different levels, from high school, up to postdoctoral degree. Particularly in high school, there are no special spaces to provide students with a tutorship session. It takes place at a regular classroom, which has been previously reserved by the tutor.



Picture 2: Tutorship session with parents led by Gonzalo Bernal. Held at Salamanca high school, University of Guanajuato in 2016

During a group session, the students' on-line file is consulted and students are asked for their plan to pass the subjects that they have failed. If needed, students are sent to receive help from people different than the tutor. If students have doubts on specific topics, they are sent to get advice on those topics from the professor that teaches them a particular subject or with any other professor that teaches that subject. During a group session students help each other too, by telling each other which professor to choose and his /her schedule. The Salamanca school, for example, has an academic advice program that collects all the information about advisers, the subject they teach, their agenda and where to find them. Besides the advice given by professors, some students are advisers too. Adviser-students are brilliant at certain topics and have a natural gift to teach. During a tutorship group session, students frequently tell each other about other students who are outstanding at certain subjects. At the Salamanca high school, some of the adviser-students do their social service by teaching their partners the subject they're good at. This activity is called PANDEMIA (Students panel with the mission of advising).

During an individual session the tutor talks informally to students or to the students' parents. If the tutor finds out that students have a problem, not concerning a topic understanding, he/she sends them to the psycho-pedagogic department, where students get specialized advice to fix any personal or familiar issue that isn't allowing them to have a regular academic performance. Other services provided by this department is delivering information on learning and

studying techniques, as well as applying tests to help students choose their career. If the tutor realizes through the talk that students aren't eating enough, or notices that they have won or lost some weight, they are sent to the nutritionist, so they can get advice on a healthy diet, exercise, or even get phycological help too. Students have sports facilities and sport clubs at every school and campus. These services are free for the students. Also, students who can't afford enough food to eat can ask for a scholarship at the beginning of each semester.

The number of students assigned to each tutor at the high school level in Guanajuato is around 90, three groups of 30 students. Some schools of Guanajuato assign the same tutor for the whole 3-year high school program and some other assign a different tutor every year. The amount of time devoted to each group must be at least of an hour per week, this means it is common for a tutor to spend 3 hours per week talking to their students about their grades; their family and friends; and their feeding and exercise habits.

Also, there is a meeting with the students' parents per semester, in which the grades of every student are shown to his/her parents. Some other information is provided too, such as the calendar of regular exams and extraordinary exams (at Guanajuato university students have two extra opportunities to approve the subjects that they have failed), so they can make sure their sons and daughters are getting academic advice if it's needed. Specifically, at Salamanca high school, during the parents' meeting, the tutor delivers the schedule of academic advice program. It is important to mention that in Mexico, people who turn 18 years old are considered adults, so it isn't mandatory for students over that age to take their parent to the school meetings. Also, the grades of students over 18 can't be shown to their parents, unless students give their permission to do so. Independently of the students' age, parents can approach the tutor anytime to discuss about social or family issues that can be affecting the students' development, so the tutor can channel them, if they agree, to the psycho-pedagogic department or to the nutritionist.

At Guanajuato university, the presence of the tutor in college is not as strong as in high school, but it remains an important figure, specially to help students find strategies to approve the subjects that they have failed, such as looking for academic advice and being aware of the exams schedule. In both, college and high school, every session with a tutor is registered on a digital platform, which is called SIIA (Administrative Information Integral System). This platform was the first of its kind in Mexico and in the last years, universities from other states have launched their own tutorship platforms. All the information of every student (photography, name, address, telephone number, e-mail and academic record) is loaded there and is only available for the student and his/her tutor.

4. Comparison between two Cases

Hiroshima and Guanajuato universities have a very outstanding common trait, their interest in making sure students are having a proper academic and personal performance. Tutors from both institutions do big efforts to achieve this. This is something positive we have in common

An important opportunity area that we share is that the tutor must meet students in different spaces, which makes it hard for him/her to carry what he/she needs to accomplish a successful meeting with students. This is something negative we have in common.

A significant difference between both universities is that in Guanajuato high schools each group stays for the whole academic day in one classroom, while in college students move from one classroom to another depending on their schedule. In Mexico we are not familiar with the idea of a homeroom and it is usually forbidden to eat inside of the classrooms. Also, even if high school students spend a long time in one classroom, they are not made responsible for cleaning it. It would be a good idea to implement that. This is something Guanajuato can learn from Hiroshima.

5. Future Prospects and Conclusions

Tutorship programs around the world are very different and similar at the same time, but also perfectible. Comparing both programs allowed us to realize that, within a tutorship setting, there are certain activities that don't even exist elsewhere, like the tutorship digital platform used in Guanajuato or the home rooms in Hiroshima, and some others that are almost the same, such as the parents meetings.

We would very much recommend professors from different countries to present works in association about other educational features since it can be a very enriching experience for everyone. This could be the beginning of new international collaboration activities. For instance, it would be very interesting to coordinate an international agreement that could allow tutors from two or more universities to do short stays, in which they could observe the other country's tutorship program. This experience could have as its main advantage that professors could learn from what the other country is doing and propose it to be applied in his/her school or faculty.

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EDUCATIONAL EFFECTS OF THE VANGUARD ENGINEERING PROGRAM: DEVELOPING THE NEXT GENERATION OF GLOBAL LEADERS

S. Akazawa[*a], T. Iyama[b], N. Fukuda[c], Y. Ominato[c], O. Youda[d], K. Ichimura[c], I. Ishizaka[e], Y. Murakami[d], and S. Toyama[f]

[a]Department of Materials Engineering, [b]Department of Mechanical Engineering, [c]Division of General Education, [d]Department of Civil Engineering, [e]International Affairs Center, [f]Department of Electronic Control Engineering, NIT, Nagaoka College, Nagaoka, Japan

* s-akazaw@nagaoka-ct.ac.jp

Abstract

The Ministry of Education, Culture, Sports, Science, and Technology in Japan (MEXT) has highlighted the need for drawing up "regional revitalization strategies." In addition, MEXT has been demanding that every educational institution should collaborate with local companies and promote the cultivation of advanced human resources to solve today's complex and various challenges. The terms "regional revitalization" and "globalization" are, in other words, keywords in the development of human resources. Under these circumstances, MEXT has started a grant-in-aid for the "KOSEN 4.0 Initiative" project. Two project proposals from our college were accepted; one was the "Vanguard Engineer Fostering Program" to support and lead the development of regional industries internationally, and the other was the "NaDeC (Nagaoka Delta Cone) **Entrepreneurs Fostering Program," a regional revitalization project based on "Nagaoka Rejuvenation." Along with the two new educational programs and system design educational program, we also began work on a new human resources development program with the goal of nurturing next-generation leaders. The system design educational program has already embedded its roots deep in our college. The new program focuses on fostering the ability of students to solve problems, develop an entrepreneurial mindset, and to have a global mindset that is able to develop better communication, relationships, and understanding among colleagues and global partners. In this research, we introduce the "Next-Generation Engineers Fostering Course Programs" and "Vanguard Engineer Fostering Program." In addition, we discuss the educational effects of the aforementioned engineering program.**

Keywords: *Globalization, Global Leader, Innovation, KOSEN 4.0*

Introduction

The terms "regional revitalization" and "globalization" are keywords in the development of human resources in Japan. The Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT) has emphasized the requirement of "regional revitalization strategies." In addition, MEXT has been demanding that every educational institution, in collaboration with local companies, must promote the cultivation of advanced human resources to solve today's various complex challenges (MEXT, 2015). Under these circumstances, MEXT has started a grant-in-aid for the "KOSEN 4.0 Initiative" project (MEXT, 2017).

KOSEN4.0 is one of the competitive grants offered by the Japanese government, and targets all KOSENs in Japan. The fund is aimed at projects that promote the three directions of "human resource development leading the new industry," "contribution to the region," and "acceleration and promotion of internationalization." Therefore, based on these policies, we must renovate our educational system.

Our college proposed two innovative projects that were both accepted, namely, "Vanguard Engineer Fostering Program" to support and lead international development of regional industries, and the "NaDeC (Nagaoka Delta Cone) Entrepreneurs Fostering Program," a regional revitalization project based on "Nagaoka Rejuvenation." In this regard, we began working on a new human resources development program with the aim to nurture next-generation leaders.

In the present research, we introduce "Next-Generation Engineers Fostering Course Programs" and "Vanguard Engineer Fostering Program." Additionally, we discuss the educational effects of the educational program.

Outline of Next-Generation Engineers Fostering Course Programs

The Next-Generation Engineers Fostering Course Programs were created for fostering innovative human resources who can respond to the internationalization and impact of the social economy in Japan. The programs are based on the professional education of various departments, and consist of "System design educational

program" (Toyama, 2015), "Vanguard Engineer Fostering Program" and "NaDeC Entrepreneurs Fostering Program" (Fig. 1). The new program is focused on fostering the students' abilities to solve problems, develop an entrepreneurial mindset, and have a global mindset that is capable of developing better communications, relationships, and understanding among colleagues and global partners.

The three course programs consist of a "basic course" that will be available for 4th- and 5th-year regular students, and an "expert course" that will be available for 1st- and 2nd-year advanced course students. However, first-year students can also opt for some of these courses.

Each course program is composed of subjects that are common to all departments. Thus, all students can take the courses, regardless of the department.

In addition, course students can learn various educational methods from faculty members beyond their departments.

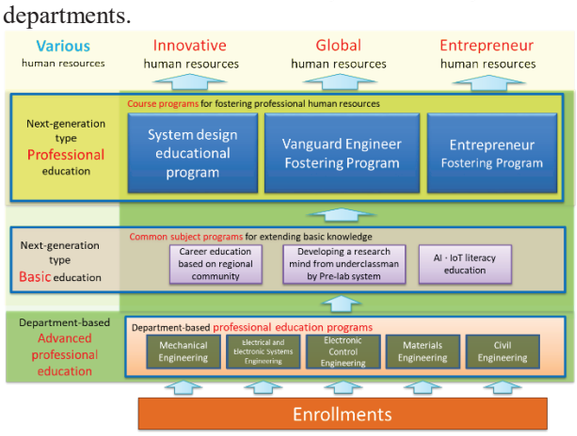

Figure 1. Next-Generation Engineers Fostering Course Programs.

Vanguard Engineer Fostering Program

In recent years, the globalization of the market and the subsequent multi-nationalization of companies has progressed rapidly; hence, it is necessary to encourage human resources that can play an active role internationally. In this course, opportunities to develop communication skills, a challenging spirit, and intercultural understanding considered necessary for global human resources are provided by Global Project-Based Learning (Global PBL), with Nagaoka or various foreign countries as the location for learning.

Having a wide range of experiences and connections, both domestic and international, as well as deepening the understanding of the local culture of Nagaoka, regional cultures, or cultures of other countries will be great assets in the future. In this college, one can expand their social circle to include people from all over the world, and aspire to become engineers who can play an active role on a global scale.

Some new subjects in this course were included; one of them is a "Global PBLI," in which mixed teams are created with local companies, Nagaoka Delta Cone (NaDeC) (Fig. 2), as well as foreign partner universities and international students, to work towards resolving various issues. "Global PBLII" is almost the same as PBLI, except the learning takes place overseas. Furthermore, "global debate" subjects for acquiring the debate skills necessary for discussion have also been arranged. The course encourages students to become engineers with leadership skills who have the ability to think appropriately for the international community and can also proactively expand the superiority of local culture and industries overseas.



Figure 2. Nagaoka Delta Cone plan.

Global PBLI

The new subject is a program to address solving regional issues at our college along with students of international partnership colleges.

As an example, we introduce the activity done with Far Eastern State Transport University (FESTU, Russia). This program aims at training IT human resources in the Nagaoka area as well as improving robotics education at FESTU. The students from both our college and FESTU created a self-propelled robotic AI system to learn about an automatic delivery system that attracted worldwide attention. Additionally, they discussed technical issues in the automatic delivery system during the activity (Fig. 3, 4). The subject was demonstrated as being useful for nurturing their practical programming and program solving skills in English.



Figure 3. The atmosphere of PBL activities.

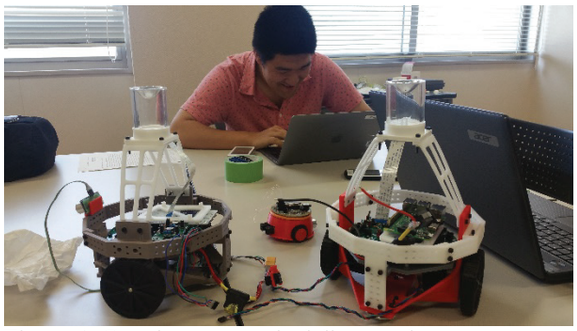
Figure 4. Creating automatic delivery robots.

Global PBLII

This subject differs from Global PBLI in that it is conducted overseas. We introduce the program with Guanajuato and Salamanca KOSEN in Mexico (Akazawa, 2017).

In March 2017, we conducted Global PBLII in Mexico, along with students of the KOSEN course in the University of Guanajuato and Salamanca in Mexico. We worked on solving local problems (e.g., the problem of graffiti, effective use of rainwater) in English. After these activities, we created a questionnaire for both the students and faculties. As a result, it became apparent that the project was highly appreciated by them, and all attendees and participants of the program were highly motivated. It has been obvious that this program was extremely effective in encouraging a global mindset and problem-solving skills of students (Fig. 5, 6).


Figure 5. The atmosphere of PBL activities.


Figure 6. A visual aids presentation.

Global debate

"Global debate" collaborates with NaDeC students to nurture their ability to debate in English.

First, the students learn the basics of debate using e-learning. Then, they discuss familiar subjects with each other, after which they attempt to debate against social problems. Finally, the students debate in English with NaDeC students, including students of the Nagaoka University of Technology.

All faculty members can watch the English debate stage. It is revealed that the educational effect is quite high for students (Fig. 7).


Figure 7. A debate convention with NaDeC students.

Development of overseas partnerships

As part of spreading international exchange activities, new overseas academic agreements have been formed. We visited the Metropolia University of Applied Sciences and the Turku University of Applied Sciences (Turku AMK) in Finland in March, 2018. Our KOSEN concluded a Memorandum of Understanding (MOU) with Turku AMK, and the student exchange program has started since May this year (Fig. 8). Furthermore, we are promoting the preparation of a double degree program with Turku AMK.


Figure 8. Ceremony for signing the MoU.

As other activities of the projects, we improved the learning commons, produced a brochure summarizing international activities, and prepared for participation in the CDIO (Conceiving-Designing-Implementing-Operating) initiative, which involved the development of an innovative educational framework for producing next-generation engineers.

Furthermore, to increase the global skills of faculty members, providing them with overseas work experience as well as encouraging them to participate in international conferences are being attempted. Through these activities, we are fostering "vanguard engineers," and promoting the internationalization of our College.

Conclusions

We developed novel educational programs for fostering vanguard engineers who are capable of debating with foreign students in the English language, as well as improved the learning commons. In addition, we concluded a new MOU with a foreign university, having been attempting to increase the global skills of faculty members. Through these activities, we facilitated a novel human resource educational system called the "Vanguard Engineer Fostering Program."

Acknowledgements

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DOES SEEING MEAN LEARNING WHEN USING TECHNOLOGY-ASSISTED AIDS? A PILOT STUDY TO UNCOVER LEARNERS' VISUALIZATION PATTERNS AND COGNITIVE PROCESSES WITH EYE-TRACKING AND INTERVIEW PROTOCOL TO INVESTIGATE MULTIPLE REPRESENTATIONS IN CHEMISTRY

P.N. Lau[*,a], S.J.R Hansen[b] and J.B. Black [c]

[a] Temasek Polytechnic/School of Applied Science/Singapore; MA (Cognitive Studies in Education), Teachers College/Columbia University/USA
[b] Columbia University/Department of Chemistry/USA
[c] Teachers College, Columbia University/Human Development/USA

*pohnguk@tp.edu.sg

Abstract

Eye tracking methodology is well-established in market research, UI/UX design and would possibly see greater adoption in AR and VR design. In contrast, eye tracking in education research is relatively nascent. An obvious application is to explore how multimedia instructional design impacts eye movements and learning. STEM subjects, with its emphasis on multi-modal learning, is well-suited for eye tracking studies.

This small pilot study explored if watching an animation movie incorporating multi-media design (MMD) elements such as narration or visual cues, enhanced multi-modal representation competency. The reaction involving silver nitrate and copper was presented on a silent video showing macro-level changes (experimental or E) and another animated video at the molecular level (M). Five learners with Chemistry background from a PhD granting institute from Northeastern USA were eye tracked in the initial view of both videos, on the Tobii Pro T60 with a sampling frequency of 60 Hz. Participants also drew molecular sketches, imagining the behavior of molecules and ions. An interview protocol was used to gather verbal comments in the retrospective gaze plot replay on the M clip. Changes in molecular sketches were made retrospectively. The first-cut descriptive statistics on the M clip indicated that time to first fixation, fixation duration and frequency were enhanced with narration and visual cues. Participants' verbal comments also corroborated these eye metrics, and revealed the underlying cognitive processes. Water molecule was a salient feature in the animation and was a critical conceptual bridge between both clips. However, no participants described how water molecules caused color change, and only one participant added water molecules in the after-replay sketch. Thus, noticing or acknowledging conceptually critical features might not lead to desired ability in multi-modal articulation.

Although this pilot study precluded deeper statistical analysis, it demonstrated the application of eye tracking to validate instructional design. Invisible cognitive processes could be uncovered with an interview protocol. Data analytics could be used to analyze the massive amount of data from eye tracking work, and shape classroom delivery to better emphasize conceptual linkage between different representations.

Keywords: *Eye tracking, multimedia design, chemistry, animation, STEM visualization, multi-modal representation*

Introduction

Chemistry is a subject that demands competent integration of chemical knowledge across multiple domains. The triplet nature first introduced by Johnstone (1982) in his seminal article suggested that there are three distinct domains translating into the "macroscopic", "representational" and the "submicroscopic" realms. The macroscopic level represents directly perceptible chemical phenomena collected through experimental observations. At the other end of the spectrum is the imperceptible domain depicting the subatomic particles. This level provides the all-important explanation of how molecular changes drive macroscopic phenomena. To complicate the learning experience, learners also need to master the representation symbols of the subject, such as chemical equations and formulae. Subject mastery requires the integration across all three levels.

Therefore, technology-assisted instruction could be used in Chemistry instruction to help learners integrate invisible atomic phenomena with the macroscopic world. A critical question of interest to Chemistry educators is what learners attend to when they view learning aids like animations. Are they looking at and processing the important on-screen features intended to facilitate the learning of specific learning content? While eye-tracking method has its early roots in reading research (Just & Carpenter, 1980), the technology has today attracted

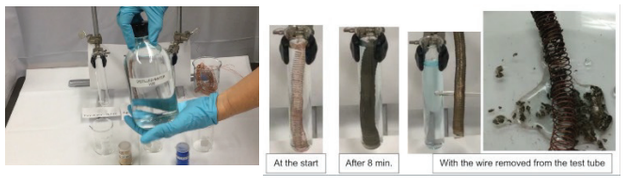
largely gaming and commercial applications (Chrobot, 2013). Eye tracking used in tandem with interview protocol has gained momentum in education research, to understand how learners devote cognitive and visual resources while viewing computer-mediated materials. In the area of chemical education research, researchers presented a review of application practices in a symposium at the American Chemical Society (Havanki & VandenPlas, 2014).

Eye tracking also allows the empirical validation of multi-media design (MMD) principles. Mayer (2008) proposed 10 principles of effective MMD to optimize the technology learning experience. These design principles recognize the limited working capacity of our cognitive processing systems. Of the 10 principles, signalling and temporal contiguity are tested in this small pilot study using eye-tracking and interview techniques. Signalling is to annotate critical on-screen features to direct viewers' attention. Timing a spoken narration in close proximity with the target feature is known as temporal contiguity.

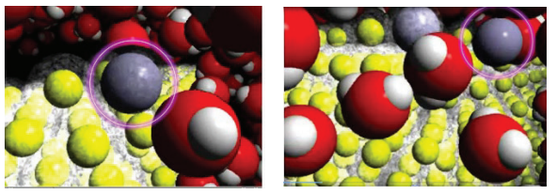
Materials and Methods

Study materials: Three animation materials were used, each depicting a reduction-oxidation (redox) between aqueous silver nitrate and copper. One silent video clip showed the reaction occurring at the macroscopic or experimental level (**E** clip). The second non-narrated clip presented several mis-representations of events occurring at the molecular level, which was not used for the current study. The third animation of interest was clip **M**, a fully narrated animation of the same silver-copper redox reaction at the molecular level. The original animation was based on the Vischem visualization clip (http://www.visichem.thelearningfederation.edu.au/topic13.html). The project team sought permission to modify the original clip for this study. The modified **M** clip included signalling cues (circles) to annotate critical on-screen features and timed audio narration to describe the interaction between the molecular entities. Screen shots of both the **E** and **M** clips are shown in Figure 1.

Equipment: Eye movements were recorded on the Tobii T60 with a sampling frequency of 60 Hz. This meant that the software sampled 60 gaze points per second. The Tobii Studio program (version 3.2.3) was used to generate the eye movement metrics such as total fixation duration (TFD) and number of fixations for the AOIs described in the last section. A fixation was defined as a pause in eye movements of 60 milliseconds or longer, a default value recommended by the manufacturer (Tobii Technology AB, 2015). The stimuli were presented on a computer monitor screen of size 42.5 cm with a resolution level of 1280 pixels wide and 1024 tall. At the beginning of each eye movement recording, the equipment was calibrated. All first views (**E** and **M**) and subsequent cued retrospective verbal recall (**M** only) were eye tracked.



(a) Clip **E**



(b) Clip **M**

Figure 1. Study materials, (a) experimental, **E** (b) molecular, **M**.

Eye movement data: The eye metrics measured are time to first fixation (TFF), total fixation duration (TFD) and fixation counts of the AOIs. Table 1 summarized the definitions and computation method of each eye data.

Table 1. Definitions and computation method of eye metrics.

Eye metric	Time to first fixation (TFF)	Total Fixation Duration (TFD)	No. of fixations
Definition	Time taken to first fixate on the intended object	Percent time spent fixating on the AOIs within the segment	Number of fixation on AOI (> 60ms)
Computation method	Difference in time to first fixation the moment the AOI screen appeared and the time to first fixation on the AOI itself (Tobii Pro, 2013)	Fixation duration of AOI ÷ Frame duration	By software

Areas of interest (AOIs): In order to obtain eye movement statistics, the target on-screen features on **M** must be identified. In this study, six AOIs were identified for the analysis of eye movement metrics on the **M** clip.

These AOIs not only convey the critical chemical phenomena (the electron exchange interaction between silver and copper, the clustering of water molecules), the scenes in these AOIs also highlighted the saliency of the MMD features, namely signalling and temporal contiguity. Since **M** is a movie, the position of the AOI differed frame-by-frame.

Thus, the AOI was mapped on a per-frame basis, excluding segments of pauses. This was done by tracing the path of the target object, from the moment it appeared on-screen, to the moment it disappeared. Care was exercised to ensure no overlapping of the frame to prevent double-counting of the eye movement data. Table 2 summarized the properties of each AOI.

Table 2. Summary of the AOIs.

AOI	Molecular species	On-screen events	Prior narration	Time (sec)	MMD principle	Mean segment duration (SD), sec
1	16-s Ag (non-circled)	Entry into scene and motion towards copper lattice	At start of clip	16	Signalling **X** Temporal contiguity **X**	1.80 (0.20)
2	31-s Ag (circled)	Motion towards copper lattice	At 19 s	31	Signalling ✓ Temporal contiguity **X**	4.84 (0.17)
3	56-s Ag (non-circled)	Previously settled onto lattice	No	56 - 65	Signalling **X** Temporal contiguity **X**	2.24 (0.17)
4	56-s Ag (circled)	Entry into scene	At 36 s		Signalling ✓ Temporal contiguity **X**	
5	56-s H_2O-Cu (non-circled)	• Extraction of copper atom by water molecules • Movement of water-copper system	At 36 s		Signalling **X** Temporal contiguity **X**	2.56 (0.22)
6	73-s H_2O-Cu system (circled)	• Extraction of copper atom by water molecules • Movement of water-copper system	At 65 s	73	Signalling ✓ Temporal contiguity ✓	3.52 (0.18)

Chemical symbols Silver: Ag, Water: H_2O, Copper: Cu. MMD annotation observed : ✓, violated: **X**

Participants: Five undergraduate students from a large PhD granting institute from Northeastern USA volunteered for this study; the data was collected between February to April 2015. All of them had taken general chemistry courses in the last 12 months. IRB approval was obtained and participants were compensated for their time.

Procedure: A mix of eye tracking and interview was deployed, since eye tracking can only tell where participants were looking, not why they were looking. The interview was guided by a protocol developed by the second author. Some parts of the responses were audio recorded, while other questions required written responses on paper.

After calibrating the eye tracker, participants watched clip **E** first, eye tracked. They were asked to describe what they thought **E** showed, its purpose and wrote down on paper its important features. One important artefact produced at this stage was the molecular sketch; where participants were prompted to draw events they imagined happening at the molecular world. They were also asked to relate features in their sketch which were in congruence or otherwise, with **E**. Participants were not shown their gaze plots which traced the movements of their fixations.

Participants then watched clip **M** and were eye tracked. They were prompted to think of how the events in **M** were congruent or incongruent with experimental

evidence from clip **E**. Next, the eye movements were reviewed by the participants. During the gaze plot replay, participants were prompted to describe why they looked at those features with "red dots" (that is, fixation points), audio-recorded. After the gaze plot replay, participants were given their earlier molecular sketches to make changes. Reasons for adding new features or not adding them were audio-recorded. Figure 2 summarized the flow of the study.

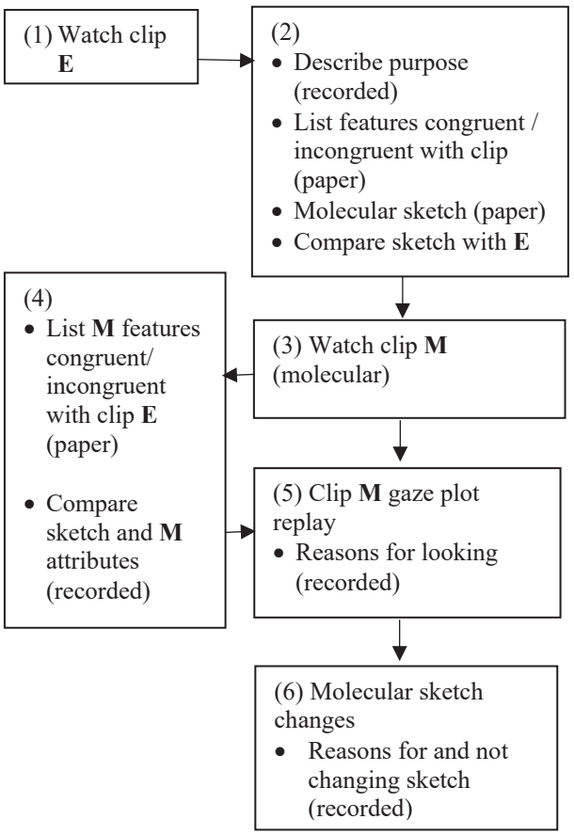


Figure 2. Overview of procedures.

Results and Discussion

Figures 3, 4 and 5 showed a trend in that AOIs in clip **M** that were annotated, using a circle or with prior narration timed in close temporal proximity, tended to garner shorter time to first fixation (TFF), longer fixation duration and more counts of fixation. This is consistent with literature findings (Boucheix & Lowe, 2010; de Koning et al., 2010). In particular, in a very busy scene such as in AOI 5, multiple events were occurring, such as the "tugging" between the silver and copper, the motion of the ejected copper ion and the clustering of water molecules around it. With quite a number of simultaneous features shown, the non-annotated AOI 5 did not attract participants' attention at all. The same scene, replayed in AOI 6, with circles as the signalling cue and narration, showed heightened visual attention and shorter time to notice.

The verbal responses of the participants recorded during the cued gaze plots replay also supported the trend that well-annotated cues in an animation film attracted attention. Some examples of such responses are shown in Table 3.

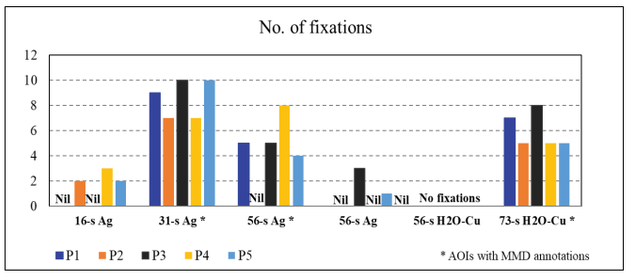


Figure 3. Number of fixations per participant per AOI.

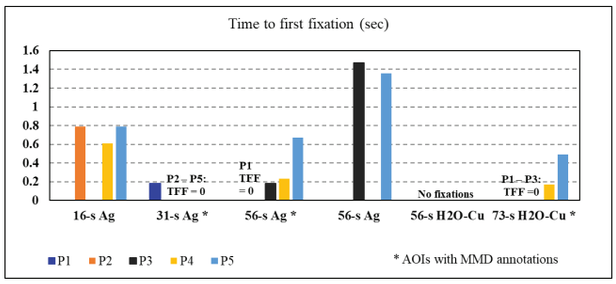


Figure 4. Time to first fixation per participant per AOI.

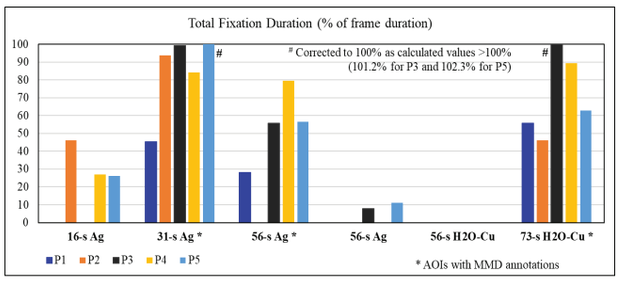


Figure 5. Percent fixation duration per participant per AOI.

Table 4 compared the features in the molecular sketches of each participant, before and after watching clip **M**. It can be seen that the most commonly omitted feature, even after review of **M**, was the water molecule.

Only participant 1 (P1) added water molecules in the post-**M** sketch. P1 also uttered more frequently about water molecules during the gaze plot replay, as evidenced from the verbatims:

"I was also when the copper was leaving, looking at all the water molecules that seemed to be surrounding it."

"I was trying to count the number of water molecules I thought was around the silver."

"And then here again, I was trying to count the number of water molecules around the copper."

Table 3. Participants' verbal responses supporting MMD features.

MMD feature	Participants' utterance
Temporal contiguity (of narration)	*„But it did like, repeat itself. So it said "let's watch that again", and then, then I looked at the parts, so like there are parts that I missed, that I made up for". (P2)*
Temporal contiguity and signalling	*"Well, in general, it was mostly the first time, ya, I was not looking at it. And then when they, when the animation was like "did you notice that, let me replay it", and then they highlighted it, then that was when I looked it at." (P5)*

A scene-by-scene qualitative examination of P1's gaze patterns in AOI 6 also revealed that this participant tended to also fixate on non-annotated features, such as the water molecules and copper atoms.

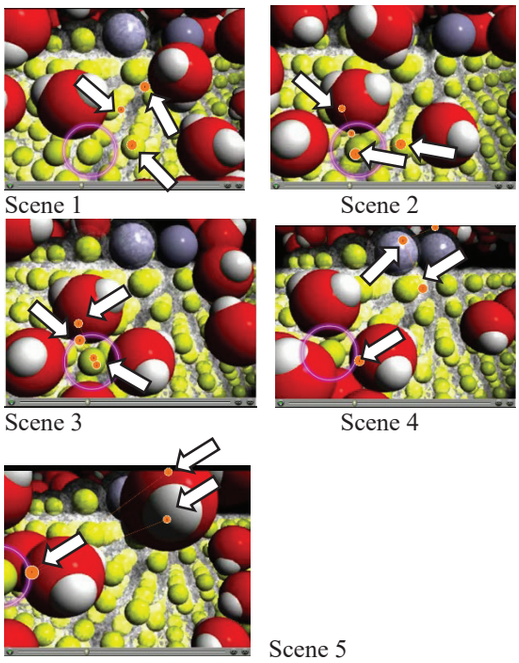


Figure 6. Gaze patterns of participant 1 (AOI 6). Dots indicate fixation locations, highlighted by arrows.

Although participants had multiple opportunities to describe the relationship between clips **M** and **E**, none of them spoke about the effect of water molecules on the color change. While P1 took notice of water molecules, there was no mention of the concept that the color change was caused by the clustering of the water molecules around the copper ions as they left the lattice. Other participants did not take much notice of water molecules, as seen from the eye movement data.

Table 4. Features of molecular sketches before and after watching clip **M**.

P	Before **M**	After gaze plot replay	Still missing features
1	• Correct Ag charge • Correct Cu charge • NO_3^- ions • Cu lattice • Electron transfer	• H_2O molecules around Cu	H_2O molecules around Ag
2	• Correct Ag charge • Cu lattice	• Cu charge to +2 • Mol ratio of 2 Ag to 1 Cu	• H_2O molecules around silver • H_2O molecules around copper • NO_3^- ions
3	• Correct Cu charge	• Ag charge to +1 • Mol ratio of 2 Ag to 1 Cu	• H_2O molecules around silver • H_2O molecules around copper • Cu lattice
4	• Correct Ag charge • Correct Cu charge • Cu lattice	• Mol ratio of 2 Ag to 1 Cu	• H_2O molecules around silver • H_2O molecules around copper • NO_3^- ions
5	• Correct charge on silver • Correct charge on copper • NO_3^- ions • Mol ratio of 2 Ag to 1 Cu	• Cu lattice	• H_2O molecules around silver • H_2O molecules around copper

Conclusions

Although statistical analysis would not be meaningful due to its sample size, the current study highlighted the usefulness of eye tracking to evaluate MMD elements in technology-based learning and teaching aids. The eye movement data revealed a trend that a well-designed multimedia tool, integrating both cueing and vocal narration timed at appropriate intervals, would make learners pay visual attention. Retrospective cued replay

followed by interview would be a useful method to corroborate the eye metrics.

However, it does not necessarily imply that noticing a critical feature would mean learners could translate its intended conceptual meaning to another representational mode. Despite a very clearly annotated and conceptually correct clip **M** to show the unfolding of molecular interaction, none of the participants uttered a relationship between the critical role of water molecules to the macroscopic color changed in clip **E**. A more intentional approach to facilitate this conceptual linkage is necessary in classroom teaching strategies.

One key takeaway from this work is that eye tracking requires clarity on what data to look for, as it generates a massive amount even for this small-scale pilot study. Eye tracking and data analytics embedded in AR/VR technology learning aids could be well-poised to evaluate learning efficacy, as such tools see increasing application in the classroom.

Acknowledgements

The data for this paper was collected as part of a cross-institute collaborative project to investigate multiple representation in Chemistry. The first author would like to thank Prof. Resa Kelley (San Jose State University) and Prof. Roy Tasker (Purdue University) for their permission to use the stimuli materials and to participate in the study. Special thanks also to Prof. John B. Black for his guidance on research practicum methods and to Dr. Peter Gordon (TC) for his kind admittance to the eye tracking facilities.

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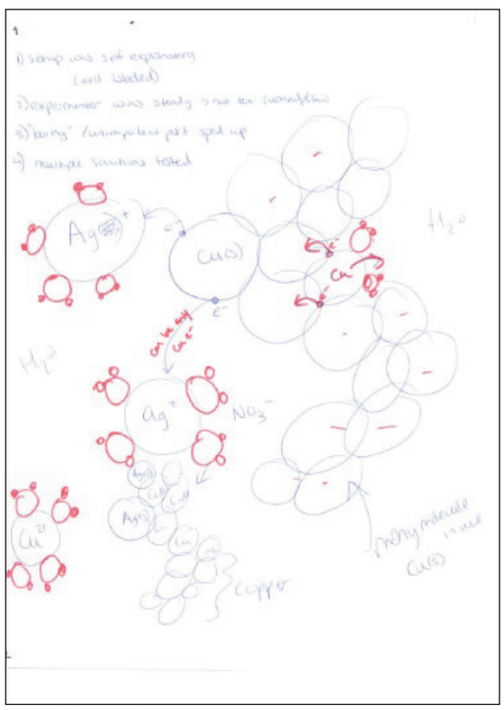
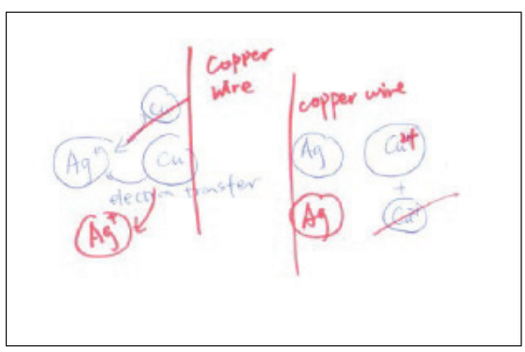
Sample of participants molecular sketches. Bold ink shows additions after gaze plot replay of clip **M**.



Participant 1



Participant 2

GAME ON THE SPHERICAL SURFACE

NOBUYUKI SOCHI*

National Institute of Technology, Yuge College/ Department of General Education, Associate Professor, Ochi, Japan

*sochi@gen.yuge.ac.jp

Abstract

As a mathematical teaching material for students at the national college of maritime technology, we devised the spherical game. A ball is exchanged like tennis on a spherical court in our brains instead of a rectangular court. In this game, one who makes the opponent move a longer distance wins. Both teams have the same number of people. One will throw down a ball farthest from the opponent closest to the falling point and the closest opponent picks it up. The quantity of the distance is the score of the throwing team. The opponent had better be in a position where the maximum value of the distance is the minimum. We came up with this material from the fact that we want our students to understand that the shortest distance at sea is the distance between two points on the great circle. Also, we can understand the strategy of the game by comparing the fixed arrangements, i.e. by using the metric invariant. Another purpose of the research is to observe this process. We clarified the process of thinking the strategy on the sphere and the hemisphere. Further, by using the metric invariants, we can have understanding about the value that characterizes the shape of the space. It is not only educational concern of the sea but also an introduction to geometry and network science. We tried using this material. In the first step, only 30 percent of students thought of the strategy, but by inducing them to compare the fixed arrangements, almost all students understood it. We obtained the following comments from our students; "I understood the meaning of the shortest line at sea." "It was somewhat difficult to master the metric invariant, but I found out the meaning of it and the strategy by fixing some arrangements." Fixing is an important tool. We use it in many fields of mathematics, such as partial derivative. Finally, we presented a similar problem including another theme to the students, and observed that they solved the problem with same strategy. We noticed the diversity of this game and confirmed the educational effect.

Keywords: *teaching material, mathematics, geometry, sphere, hemisphere, metric invariants, fix, compare, maritime technology, network science*

Introduction

Initially, it was the starting point of the idea of this teaching material that we wanted students studying the ocean to understand through this game that the shortest distance between two points on the ocean is the distance on the great circle. In the figure below, when asking for the shortest path through two points A and B, there were many students who answered that the route with two points on the small circle is the shortest (Figure 1). Actually, the shorter route with two points on the great circle is the shortest (Figure 2). On the map, the shortest path on the great circle may seem to be on the detour, but in fact it is heading straight to the other point on the curved surface.

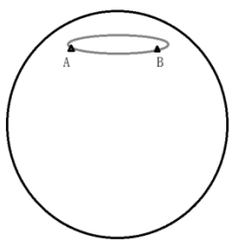


Figure 1.small circle

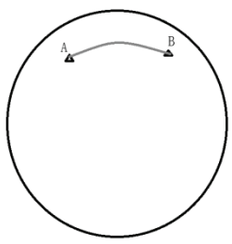


Figure 2.great circle

This time, we played the game not only on the sphere but also on the hemisphere. In these spaces, by thinking about each strategy, the students will deepen their knowledge and understanding about the values that characterize the shape of the space, and it will also be an introduction to geometry on curved surfaces. In other words, we think that it will be a bridge to mathematics at university, starting with thinking about the strategy of this game. When considering the game strategy, we will fix moving things and compare their placement. And we find better placement. This time, we observed and revealed this thinking process. The strategy is understood by comparing the fixed placement, and considering the strategy is equivalent to finding the metric invariant $m_k(X)$. We can know that the shape of the curved surface is characterized by this metric invariant. Finally, in quite different questions (Problem A, Problem B) to which we could apply the same strategy, we investigated whether the students were able to think like the spherical game strategy. In other words,

we examined the diversity of the strategy concept of this game.

In this paper, we denote the 2 dimensional unit sphere as S^2 and the 2 dimensional unit hemisphere as S^2_+. Here, the lower limit of the length of the curve connecting the two points x and y on the curved surface is called the geodesic distance of x, y. Or it is simply referred to as the distance, and is represented by dist (x, y).The curve connecting two points is called a geodesic. When two points are antipodal points on the 2 dimensional unit sphere, there are countless geodesics, and the length of the geodesic is π as a length of half of the great circle. A triangle with geodesics on three sides is called a geodesic triangle.

Materials and Methods

(1)Spherical game rules

Battle game is performed on the spherical surface with k people versus k people. First of all, members of both teams move freely and decide their placement. One out of k people in the attack-first team will throw a ball on the spherical surface. It is assumed that 2k members of both teams cannot move until the thrown ball falls. At the moment the ball falls, k members of the opponent team leave at the same time for the position of the ball and head for picking it up at the same speed at the shortest distance. At this time, it is assumed that some of the opponent team's k members may not head in the direction of the ball and may head in another direction. Then k members of the attack-first team may move freely. The person picking up the ball throws it. And one out of k people in the attack-first team goes to pick it up. Continue playing the game as well. A ball should be thrown as far as possible. When one out of the opponent's k members picks it up, the throwing team scores the quantity representing the distance traveled by the player. A team who reaches a certain score wins. Continue playing game by replacing attack-first with post-attack. Suppose that 2k people all move at the same speed.

The spherical surface is a 2 dimensional unit spherical surface S^2 or a 2 dimensional unit hemispherical surface S^2_+, and it is a colorless and transparent skeleton. It is assumed that each player can know whether the distance to the falling point of a ball is farther than π/2 (¼ of the length of the great circle).

(2) Metric invariant

In the game, we consider the strategies that both teams should take by using the metric invariant $m_k(X)$. First, we consider the maximum value when x is moved at the minimum value of the distance from k points to a point x. Further, when k points are moved at this maximum value, the minimum value is represented by m_k. Its value in space X is represented by $m_k(X)$.That is, a point x on X is set such that $\min_{\{l=1,2,\dots,k\}}\mathrm{dist}(x, x_l)$ is maximized with respect to k points $x_1, x_2, \dots, x_k$ on the curved surface X, and its maximum value is represented by $p_x(x_1, x_2, \dots, x_k)$. Furthermore, $x_1, x_2, \dots, x_k$ are selected so that $p_x(x_1, x_2, \dots, x_k)$ is minimized, and this minimum value is denoted as $m_k(X)$. That is,

$$p_x(x_1, x_2, \dots, x_k) = \max_{\{x\ in\ X\}}\min_{\{l=1,2,\dots,k\}}\mathrm{dist}(x, x_l)$$

$$m_k(X) = \min_{\{(x_1,x_2,\dots,x_k)\ in\ X\times\dots\times X\}} p_x(x_1, x_2, \dots, x_k)$$

$$= \min_{\{(x_1,x_2,\dots,x_k)\ in\ X\times\dots\times X\}}\max_{\{x\ in\ X\}} \min_{\{l=1,2,\dots,k\}}\mathrm{dist}(x, x_l)$$

Here, $m_k(X)$ is a metric invariant known as k-covering radius, and several values are known in sphere S^n, hemisphere S^2_+, real projective space RP^2, etc. ([3]). Since we deal with the minimum value, we take an initial letter "m" and denote it by $m_k(X)$. K-covering radius is studied not only in mathematics but also in code theory in network science ([1], [2]).

(3) Relationship between the game strategy and the metric invariant $m_k(X)$

On X (sphere S^2, hemisphere S^2_+), members A_1 to A_k of team A play against members B_1 to B_k of team B. It is a match of k people to k people. First, A_1 throws and drops a ball on X. One out of members of team B closest to the falling position picks up the ball. At that time, A_1 will throw as far away as possible from B_1 to B_k in order for team A to score high. In other words, at the minimum value of the distance from k persons of team B to the falling point x, we consider the maximum value by moving x. This value is $p_x(x_1, x_2, \dots, x_k)$ and it is the score for team A. Therefore, in order to reduce the score of team A, members of team B may move in advance to the arrangement that minimizes $p_x(x_1, x_2, \dots, x_k)$. This value is $m_k(X)$. If team B is in the optimal arrangement, $m_k(X)$ is the score for team A. In this way, team A and team B can similarly make strategies in this game by using the metric invariants.

(4) Teaching method

In the previous paper ([5]), we treated only the sphere. Then about 30% of students could understand the strategy immediately in the case of 2 to 2 battles on S^2. But most students could understand the subject by comparing the fixed arrangement. This time, we also deal with the sphere and the hemisphere.

① First, we have students consider the following problem A. We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. After students' consideration, we explain this problem.

Problem A: "Suppose the radius of Mars is 1. Martians set up missile intercept systems at k locations on Mars. However, the following conditions should be satisfied.

Q1. When a missile bombardment is made at a point x on Mars, martians intercept the missile at the point x at the shortest distance from the point closest to x in the k points.

Q2. The entire Mars is subjected to intercepts and bombardments.

Q3. Martians set up k bases so that the interceptable distance (the distance in Q 2) is minimized.

In the case of k = 2, consider the arrangement of bases on the spherical area of Mars.

Also consider the placement of bases when targeting only the hemispherical area of Mars in the case of k = 2."

② We explain the rules of the spherical game. Let students think about 1 to 1 matches on X (sphere S^2, hemisphere S^2_+). We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. Here, our aim is to have students understand the rules and get interested in the game. In addition, we will explain the hemisphere by using a ball. After students' consideration, we explain this problem.

③ We consider 2 to 2 battles on X (sphere S^2, hemisphere S^2_+). We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. We explain the shortest line and the metric invariant by using a ball. Since it is difficult to explain the definition of the metric invariant $m_k(X)$, we explain $m_k(X)$ after introducing the definitions of the diameter, diam X and the radius, rad X which are simpler metric invariants by using a ball. The diameter, diam X represents the maximum value of the distance $\mathrm{dist}(x, x_1)$ from an arbitrary point x to an arbitrary point x_1 on X. The radius, rad X is the minimum value when x_1 is moved at the maximum value of the distance $\mathrm{dist}(x, x_1)$ from an arbitrary point x to x_1 on X. The metric invariant $m_k(X)$ is obtained by replacing the distance from one point in rad X with the minimum value of the distance from k points. We explain $m_2(X)$ by fixing the arrangement of points, so that the students can understand the relationship between the game and the metric invariant $m_2(X)$. After students' consideration, we explain this problem.

④ In case of stall, we instruct them to fix some placement and to consider the value of $p_x(x_1, x_2, \ldots, x_k)$, and to compare it with the value in other placement. In the case of the arrangement for which it is difficult to calculate the distance, we measure the shortest distance by using a piece of string.

⑤ If we can afford it, we think about 3 to 3 battles. In order to calculate an accurate value, we explain the spherical trigonometry.

⑥ Finally, we ask students to consider the following problem B:

We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. After students' consideration, we explain this problem.

Problem B: "Suppose that the radius of the earth is 1.We establish rescue bases at k locations on the earth to make an international safety system. It may also be installed on the seawater surface. However, the following conditions should be satisfied.

R1. When there is an accident at one point x on the earth, we head for rescue from the point closest to x in k points.

R2. We cover the whole earth area for rescue.

R3. We set up the bases so that the movable distance is minimized.

Consider the placement of rescue bases on the spherical area of earth in the case of k = 2.

Also consider the placement of bases when targeting only the Earth's hemispherical in the case of k = 2."

Results and Discussion

(1) Value of $m_k(S^2)$ and strategy

Members A_1 to A_k of team A fight against members B_1 to B_k of team B on X. First, A_1 throws a ball. One out of members of team B closest to the falling position goes to pick up the ball.

The results of several cases are listed below.

① The case of k = 1

In the case of k = 1, $m_1(S^2) = \mathrm{rad}\, S^2 = \pi$ holds. A point x which realizes $m_1(S^2)$ is the antipodal point of B_1 ([5]). Here, an antipodal point of a point p on the sphere S^2 is a point -p different from p, where a straight line connecting p and the center O of the sphere intersects S^2. A member A_1 of team A plays against a member B_1 of team B on S^2 by 1 to 1. First, A_1 throws a ball. A_1 throws as far as possible from B_1. Since team B consists of only one person, B_1 is in the same condition no matter where B_1 is. Since $m_1(S^2) = \pi$ holds, A_1 may drop the ball to the opponent's antipodal point (Figure 3).

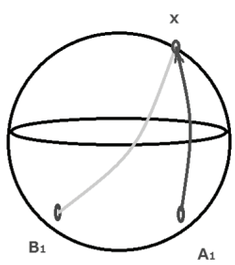


Figure 3.$m_1(S^2) = \pi$

② The case of k = 2

We should consider the value of $m_2(S^2)$. In the case of k = 2, $m_2(S^2) = \pi/2$ holds. Then B_1 and B_2 are antipodal each other on the spherical surface, and x is the middle point between the two points ([5]). In Figure 4, no matter where A_1 throws the ball, the minimum distance from the members of team B is π/2 or less. Therefore, it is a good strategy to drop a ball on the point where the distance from B_1 and B_2 is π/2. For team B, one out of B_1 and B_2 closer to x goes to pick up the ball and the other goes to the opposite antipodal point and prepares for the next. If the distances from B_1 and B_2 to x are equal, the ball can be picked up by either.

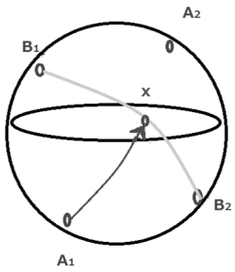


Figure 4.$m_2(S^2) = \pi/2$

③ In the case of k = 3

We should consider the value of $m_3(S^2)$. In the case of k = 3, $m_3(S^2) = \pi/2$ holds. When three points are on the great circle (equator) and the sum of the distances between any two points is 2π (we call this situation "not biased"), and x is at the pole position, $m_3(S^2)$ is realized (Figure 5). In particular, when two of the three points are at the antipodal position and the other one is arbitrary, and x is in the middle of two points which are antipodal, and the distance from the other point to x is π/2 or more, then $m_3(S^2)$ is realized (Figure 6). It is only necessary for three people to stay on the great circle without being biased. If two people are at the antipodal position, it is only necessary for the remaining one to be at an arbitrary position. In the case of Figure 5, there are three people who are not biased on the great circle. Since the minimum distance from members of team B to an arbitrary falling point is π/2 or less, it is better to drop a ball on the pole to which the distance from three people is π/2. In the case of Figure 6, since B_1 and B_2 are antipodal points, it is good to drop a ball on the point at the distance π/2 from B_1 and B_2 and π/2 or more from B_3. One closest to x among B_1, B_2 and B_3 goes to pick up the ball and the others prepare for the next.

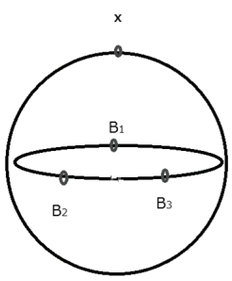


Figure 5.$m_3(S^2) = \pi/2$

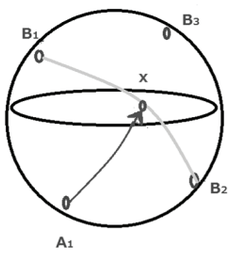


Figure 6.$m_3(S^2) = \pi/2$

(2) Value of $m_k(S_+^2)$ and strategy

The results of several cases are listed below.

① In the case of k = 1

In the case of k = 1, $m_1(S_+^2) = \text{rad}\, S_+^2 = \pi/2$ holds. Then B_1 is in the middle of the hemisphere (we call this position the pole), and the point x that realizes $m_1(S_+^2)$ is an arbitrary point on the great circle of the boundary (Figure 7).

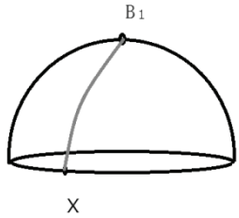


Figure 7.$m_1(S_+^2) = \pi/2$

② In the case of k = 2

In the sphere, B_1 and B_2' are antipodal points. Move B_2' to B_2 symmetrically with respect to the great circle of the boundary containing x. Since $B_1x + B_2'x = \pi$ holds, we obtain $B_1x + B_2x = \pi$ (Figure 9). Since there are countless great circles passing through B_1 and B_2' (Figure 10), $B_1x + B_2x = \pi$ holds at arbitrary point x on the great circle of the boundary (Figure 11, Figure 12). $m_2(S_+^2) = \pi/2$ is realized in the arrangement of Figure 11 which satisfies $B_1x = B_2x = \pi/2$. Also, as shown in Figure 13, even if B_1 and B_2 are shifted up and down, $B_1x = B_2x = \pi/2$ is kept. However, if B_1 and B_2 are shifted to the left and right, the maximum value at the shortest distance will exceed π/2. From the above, in the case of k = 2, $m_2(S_+^2) = \pi/2$ holds. Then two points B_1 and B_2 are on a semicircle containing the pole between the two points (Figure 13). A point x is on the great circle of the boundary and it is in the position where $B_1x = B_2x = \pi/2$ holds (Figure 13).

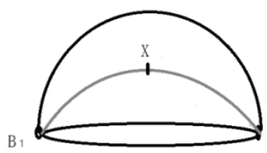


Figure 8.$m_2(S_+^2) = \pi/2$

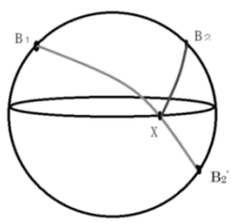


Figure 9.antipodal points

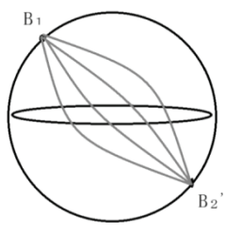


Figure 10.great circles

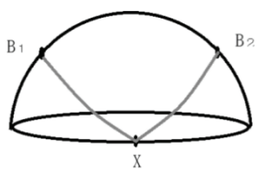


Figure 11.$m_2(S_+^2) = \pi/2$

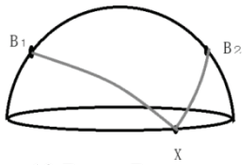


Figure 12.$B_1x + B_2x = \pi$



Figure 13.$m_2(S_+^2) = \pi/2$

③ The case of k = 3

In Figure 14, B, C and D are three points on the great circle, and it is assumed that $AB_1 = DB_1 = BB_1 = AB_2 = BB_2 = CB_2 = AB_3 = CB_3 = DB_3$ holds. Here, let A be the pole point that satisfies $AB = AC = AD = \pi/2$. There is a point x which realizes $m_3(S_+^2)$ at any position of A, B, C, D on the hemispherical surface. Let E be the foot of the perpendicular drawn from B_2 to BC. Let $BB_2 = l$, then we get $B_2E = \pi/2 - l$. BE = π/3.
The cosine theorem on the spherical surface in the geodesic triangle B_2BE is $\cos BB_2 = \cos B_2E \cos BE + \sin B_2E \sin BE \cos \angle B_2EB$. By applying the above numerical values to the equation, we get $\cos l = \cos(\pi/2 - l)\cos\pi/3 + \sin(\pi/2 - l)\sin\pi/3\cos\pi/2 = 1/2 \sin l$. Furthermore, since $\sin^2 l + \cos^2 l = 1$ holds, we get $l = \sin^{-1}\sqrt{4/5}$. From the above calculation, in the case of k = 3 we have $m_3(S_+^2) = \sin^{-1}\sqrt{4/5}$. Here, three people of team B are arranged at equal intervals on the circumference where the distance from the pole is $\sin^{-1}\sqrt{4/5}$, and x is at the pole position A, or B, C, D on the great circle of the boundary.

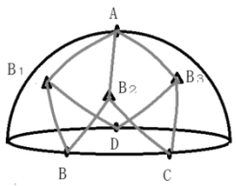


Figure 14.$m_3(S_+^2) = \sin^{-1}\sqrt{4/5}$

(3)Consideration on teaching materials

At the college of maritime technology, we used the spherical game as the teaching material for about 100 students in mathematics classes and personal contributors. We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. In a few 90-minute math lessons, we asked the students about Problem A, spherical game, and problem B in this order. We carried out problem B after several days after training of the spherical game. Problem A, spherical game, problem B have different themes, but those problems can be considered with the same strategy. In the following, the correct answer rates in the case of k=2 are summarized in Table 1.

Table 1.correct answer rates on S^2, S_+^2 for k = 2

	Problem A	Spherical game	Problem B
S^2	82%	90%	95%
S_+^2	76%	82%	87%

Here, on the hemispherical surface S_+^2, it is divided into two STEPs. The degree of achievement is expressed in two stages. In the case where $m_2(S_+^2) = \pi/2$ is obtained by drawing at least one arrangement of Figure 8 or Figure 11 or Figure 13, we call this case STEP 1. In the case where $m_2(S_+^2) = \pi/2$ is obtained by drawing two or more arrangement of Figure 8 or Figure 11 or Figure 13, we call this case STEP 2. For S_+^2, the numerical values in Table 1 above are those in the case of drawing at least one (STEP 1).

Problem A was an introduction to deepen the understanding of the spherical game. As a concrete problem that could be solved by the same strategy as the spherical game, we initially presented Problem A and asked the students to think about it. After that, we had students think about the spherical game which could be thought with the same strategy, and explained that we used the metric invariant as the strategy. Finally, since even the problem of another theme could be solved with the same strategy as the spherical game, we presented problem B to the students to touch the diversity of strategy of this game.

Problem B seems to be unrelated to the spherical game, but "going to rescue from nearest base" in the condition R1 means "a closer person goes", and "the whole earth is to be rescued" in the condition R2 means "to think about the maximum value at the shortest distance to the trouble point", and "considering the establishment of the bases so that the movable distance is the shortest" in the condition R3 means "to think of the minimum at the maximum value in R2". In other words, we should think about $m_k(X)$.

The defense problem of problem A is essentially similar to problem B and the spherical game.
In the 2 versus 2 battles, by moving the points little by little and comparing the fixed placement on S^2 and S_+^2, we may arrange it so that the opponent's score is the smallest.

Table 2 shows the correct answer rates in the cases of two STEPs on S_+^2 for k = 2.

Table 2.correct answer rates on S_+^2 for k = 2

	Problem A	Spherical game	Problem B
STEP 1	76%	82%	87%
STEP 2	29%	34%	63%

In the students who reached STEP 1 in Problem A, 50% of the students drew Figure 8 before others and the remaining 50% of the students drew Figure 11 or Figure 13 before others. In the students who reached STEP 1 in the spherical game and Problem B, about 70% of the students drew Figure 8 before others, then they thought by shifting the points and comparing it with Figure 11 or Figure 13, etc. In the students who have reached STEP 2, in all problems, they came up with Figure 8 before others, then drew Figure 11 or Figure 13, and there were many cases considered as compared with the case where the points were shifted as Figure 12 or Figure 13.

Conclusions

From the above, it can be said that understanding the game strategies is related to the ability to use the characteristics of geodesics; "there are countless

geodesics of length π between B_1 and B_2 when these two points are antipodal on the unit spherical surface". (we denote this property by P1)
Also, we can say that "the length of the geodesic drawn to the opposite side from the vertex of the geodesic equilateral triangle with sides of length of π/2, which is a 1/8 sphere, is all π/2" is related to reaching STEP 2. (we denote this property by P2)
For both S^2 and S^2_+, many students noticed that the placement with not biased reduced the opponent's score. It is one of the conclusions obtained by fixing and comparing the placement.

Problem A, spherical game, and problem B have different themes. And Problem A, spherical game, and problem B are presented to the students in this order, but we carried out problem B after several days after training of the spherical game. Looking at Table 2, we see that more than 60 percent of the students answered that $m_2(S^2_+) = \pi/2$ held by understanding the metric invariant when they considered problem B. As the result, what the students had got before was settled and the students noticed that these problems could be solved with the same strategy. In other words, we think that the way of thinking became established in the students and the rate of correct answer rose.

From the above, it can be considered that the handling of geodesic characteristics such that (P1) and (P2) was improved through this training. And by fixing and comparing the placement, they noticed that the unbiased placement was related to the better strategy.

After this training, there were a few students who found that $m_k(X)$ is the minimum value of the radius r when covering X entirely with k disks with radius r.
For S^2 and S^2_+, the metric invariants for k = 2 are the same value, but in the case of k = 3 they are different values. When covering the sphere or the hemisphere with the same two disks, the radius of disk is π/2. When covering the sphere with the same three disks, the radius of disk is π/2. But the hemisphere can be covered with the same three disks with radius less than π/2. It can be seen that the value of $m_3(X)$ varies by the shape of the curved surface. In the case of k = 3 we will treat it as a teaching material in the future. Next time, we are going to summarize the battles on the real projective space.

Finally, we conducted a questionnaire. There were nearly 90% of students who said that they had understood the diversity of the spherical game idea.

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INDUSTRIAL ENGAGEMENT IN ENGINEERING EDUCATION TO NURTURE SMART PEOPLE

Tommy H. Y. Cheung*, [a], Billy M. H. Chow [a] and Frankie Y. C. Leung [a]

[a] Department of Engineering, Hong Kong Institute of Vocational Education (Haking Wong), Hong Kong SAR

* tommychy@vtc.edu.hk

Abstract

In the end of 2017, the Office of the Government Chief Information Officer (OGCIO) of the Government of the Hong Kong SAR released a report of consultancy study on Smart City Blueprint for Hong Kong. The blueprint includes 'Smart Mobility', 'Smart Living', 'Smart Environment', 'Smart people', 'Smart Government' and 'Smart Economy'. To co-creating a smarter Hong Kong, there is a necessary to sharpen and nurture students' practical skills in an authentic "real-world" work experiences. The Hong Kong Institute of Vocational Education (IVE) Engineering Discipline of Vocational Training Council (VTC) encourages teaching and learning with the engagement of industry exposure and in a Project-based environment in order to encounter complex systems and processes in a competitive environment.

To nurture smart people fit for the future and fulfil the needs of industry, it requires collaboration and good team player skills from engineers working in industry, bringing both theory and practice together in the students' study. A solar car team project under that philosophy is developed and more than twenty students from electrical and mechanical engineering field participated the team year by year. The project features collaborative teaching and learning where the industry stakeholders and institution supervisors work together to provide practical environment. Design thinking process is adopted to engage and motivate students to learn and develop in the project, which include 'Empathize', let student learn about the audience for their designing process; 'Define', construct a point of view that is based on user needs and insights; 'Ideate', brainstorm and come up with creative solutions; 'Prototype', build a representation of one or more of student ideas to show to others and 'test', return to original user group and testing their ideas for feedback.

This paper would further elaborate how the industry engagement help students in terms of developing important soft skills and their technical capability, which beneficial to their whole person development and hence co-create a smarter Hong Kong.

Keywords: *Smart people, Industrial Engagement, Project-based environment, Design thinking process*

Introduction

The Smart City Blueprint for Hong Kong issued by the Office of the Government Chief Information Officer (OGCIO) of the Government of the Hong Kong SAR is set to build Hong Kong into a world class smarty city, the policy objectives are to make use of innovation and technology (I&T) to address urban challenges, enhance the effectiveness of city management and improve people's quality of living as well as Hong Kong's sustainability, efficiency and safety, to enhance Hong Kong's attractiveness to global businesses and talents, and to inspire continuous city innovation and sustainable economic development. The blueprint made recommendations in six major areas, namely 'Smart Mobility', 'Smart Living', 'Smart Environment', 'Smart people', 'Smart Government' and 'Smart Economy'.

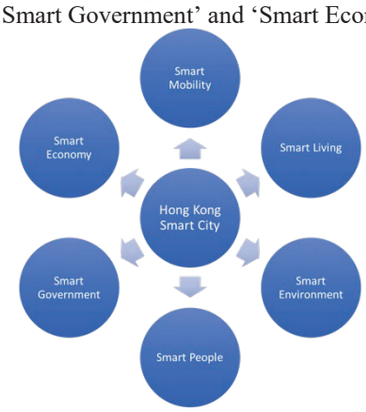

Figure 1. Smart City Blueprint of Hong Kong

In particular, the goal of 'Smart people' is to have more students selecting Science, Technology, Engineering and Mathematics (STEM) as their education and professional careers and thus have a local supply of data scientists and other technology practitioners in need, hence having more successful entrepreneurs in their new ventures.

To co-creating a smarter Hong Kong, there is a necessary to sharpen and nurture students' practical skills in an authentic "real-world" work experiences especially in the STEM area. The Hong Kong Institute of Vocational Education (IVE) Engineering Discipline of Vocational Training Council (VTC) encourages teaching

and learning with the engagement of industry exposure and in a Project-based environment in order to encounter complex systems and processes in a competitive environment.

The higher diploma programme in engineering discipline provides an opportunity for students apply their professional knowledge acquired from the lecture to the real workplace, solving problems that happen in the real world and obtaining working experience before graduation via an authentic working environment with industry partners in a Project-based environment. The scheme stated is Industry-based Student Project (IBSP), which aims to equip students with technical knowledge and help them to get ready for the workplace as well as to facilitate their transition from study to work.

Engagement with Industry Stakeholders

Involvement of and collaboration with industry partners are the critical factors for the success of the IBSP scheme. Students will gain knowledge through their own research and application of findings to solving problems associated with the work in a creative manner and will be under the similar work pressure as the employees of the company, students will also be required to take certain level of responsibility for their projects. To support the students, teachers will act as facilitators and guide the students throughout the project. Borego et. al. (2013) provide a review to assist engineering educators in understanding and applying industrial and organizational psychology to engineering education.

In this connection, the facilitator and the second project assessor which nominated from the industry, will assess the students' performance in terms of engineering and professional competence and soft skills aspects. The engineering and professional competence aspects include the comprehension of the problem; idea, concept, design and build; testing and development, realization and implementation; problem solving skills and environmental and safety awareness, meanwhile, the soft skills aspects include planning of the work; investigation and research; motivation and independent work; communication skills and leadership and team work. Students will also be required to maintain a project log of activities, which includes the project plan and details of work undertaken, including results obtained.

There are some major differences when IBSP comparing with the traditional internship scheme, first, the involvement of the teachers and industry assessors will be more and assess students in an all-round aspect, second, students are required to develop theoretical and engineering solution to specific problems in carrying out design work on system, hardware or software and third, students need to have proper documentation and presentation throughout the process.

To unleash student's potential and build up their confidence, "Design Thinking Process" is adopted to give them inspiration. Brown (2008) and Kumar (2009) discussed design thinking as part of the innovation process. Under facilitator's guidance and supervision, students learn how to empathize and identify the needs or problems, conduct data analysis, and find suitable solutions to address the needs in the industry. Through brainstorm and technical exchanges with facilitator and industry assessor, students are able to identify a topic in the industry based on their experiences gained in the workplace. Students are encouraged to build out a prototype of his/ her solution and test it with improved version of these prototypes, and thus the project outcomes are being demonstrated. Throughout the whole process, most of the students realized they cannot simply applying the theory to the workspace since in a real environment, there would be a lot of limitation. These experiences broaden their view in terms of problem solving, design concept and technology application, thus self-confidence was highly enhanced.

Results and Discussion

A set of survey was given to each of the collaborating industry stakeholders from 58 different companies to (a) Evaluating Student's improvement in (i) Communication skills, (ii) Managing information, (iii) Critical thinking and problem solving and (iv) Demonstrating positive attitudes and behavior, while 1 means no improvement; 10 means great improvement.

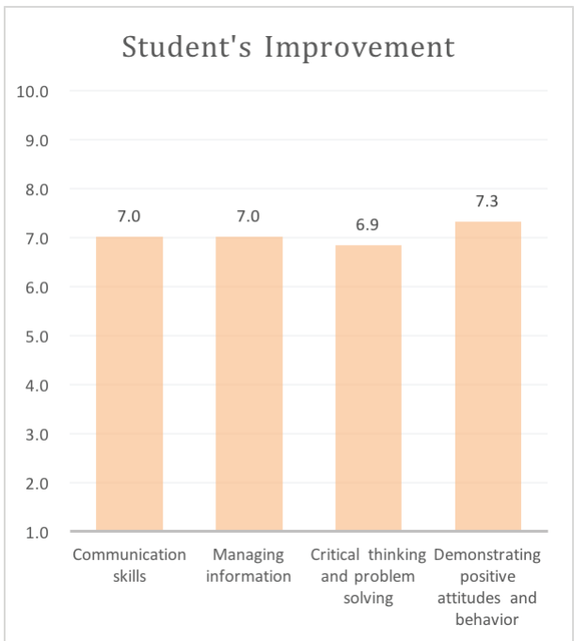

Figure 2. Student's Improvement Evaluated by Employer

The figure and the observation support that while IBSP is implemented, there is a positive improvement in students' communication skills, managing information aspect, critical thinking and problem-solving performance and able to demonstrate positive attitudes and behavior. For modern engineers, his communication skills also need to expand to good listening, visual, interdisciplinary and intercultural skills as well (Riemer (2007)). Students could be benefited by exchanging ideas with peers, teachers and industry supervisors. Students could also practice knowledge and applying ideas by action, giving them an enhanced learning experience which a traditional lecture cannot offer.

Advanced Industry-based Student Project (IBSP)

The project groups will normally be formed with one or two students per group. On a need basis, facilitators can put more project groups to work together on a large-scale project. There is an innovative and sustainable project which consists of students from Electrical Engineering and Mechanical Engineering working together, aiming to design a solar powered vehicle called 'SOPHIE', in order to demonstrate the viability of renewable energy through using the green transportation. Students learnt about solar power technology and advanced application, high-tech automotive design and fabrication, logistic management and team cooperation via the IBSP platform. Students gained practical knowledge and hands on experience from the discussion and working with industry stakeholders.



Figure 3. Students were working on molding at car garage



Figure 4. Students designed suspension system and CNC with magnesium alloy



Figure 5. Students were learning wheel alignment

The vehicle 'SOPHIE' allow students to learn by doing and applying ideas, which is also the key feature of project based learning (PBL) which discussed in Bulmenfed (2000). With the supporting of industry stakeholders, seven 'SOPHIE's were built under the massive effort of students. Four of them participated in world class races under students' leadership, 'Shell Eco-Marathon Asia 2012' with SOPHIE SEM, 'World Solar Challenge 2013' with SOPHIE IV, 'World Solar Challenge 2015' with SOPHIE V and 'World Solar Challenge 2017' with SOPHIE VI. In each competition, students demonstrated their telnets in building solar vehicles. Students have applied the knowledge learned in classroom to design and fabricate the solar vehicle for competitions and showed their confidence and interest in building the solar vehicle.

As a kind of PBL, IBSP showed positive attitudes toward learning itself, team communication, and collaborative behaviour which were discussed in literature (i.e. Dominguez & Jaime, 2010; Kaldi, Filippatou & Govaris, 2011; Van Rooij, 2009). Furthermore, PBL was examined with respect to increasing students' interest, self-confidence, and self-efficacy, found by Baran & Maskan (2010), which was highly related to the components of PBL such as collaborations in group work and contextual problems reflecting students' real-world experiences.

Conclusions

The IBSP enriches students' professional knowledge and develop their creativity, innovation, collaboration, communication and problem-solving skills throughout the engagement with industry stakeholders. This engagement is also important for nurture students to embrace changes and future development of technology and hence co-create a smarter Hong Kong.

To nurture more young talent as 'Smart people', facilitator's guidance and team collaboration play important roles, resources and structured planning are also required for implementation.

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MIRROR IMAGES ON THE SURFACE OF THE WATER

NOBUYUKI SOCHI *

National Institute of Technology, Yuge College /Department of General Education, Associate Professor, Ochi, Japan

*iputiko@yahoo.co.jp

Abstract

As a mathematical teaching material for students at the national college of maritime technology, we used mirror images on the surface of the water. The aim is to make attractive unique teaching materials. From the viewpoint of fusion of mathematics and art, we analyzed paintings mathematically. We deal with the distortion of the mirror image in the landscape paintings drawn by Henri Le Sidaner. He is a French painter who worked at the beginning of the 20th century and painted many mirror images in stippling influenced by impressionists and symbolism. In the mirror images of his paintings, we mathematically investigated whether Desargues's theorem holds and whether there is stretching and shrinking of the mirror image on a concave curved surface. The reason for studying his paintings mathematically is that there is only one painting whose mirror image is collapsed in a few paintings depicting the landscape of the same canal. This time, we introduced the distortion of the mirror image to our students as a mysterious story. We showed pictures to them and observed the process they solved the puzzule, and examined their educational outcomes. Henri Le Sidaner's drawing style is to express the existence of absence, which is to imply signs without drawing people or creatures on the screen. We explained his style to our students and examined the distortion mathematically. Here, we explained the geometric perspective in the mirror image and the elongation of the mirror image in the depression of the water surface. Our students tried to solve the mystery about the mirror image distortion. The cause of the mirror image distortion was stated by our students as follows; "After a ship passed", "Someone threw a stone", "After throwing away the garbage", "After an animal passed by", "There was a fish", "The mirror image is shifted by the waves", "The surface of the water was shaking", and so on. From the results of the questionnaire, we got impressions that 80 percent of our students had been interested in elementary geometry through solving the art puzzle.

Keywords: *teaching material, mathematics, geometry, mirror image, Desargues's theorem, paintings, art, Henri Le sidaner, maritime technology*

Introduction

We develop teaching materials to active motivation for mathematics. We incorporate games and puzzles into lessons to revitalize students' motivation and autonomy and to improve academic ability. This time, we aim to study the geometry of mirror image, perspective, etc. in paintings under the viewpoint of fusion of mathematics and art and to make use of them as teaching material. Also we aim to research "fun mathematics fused with art".

In the first half of this paper, we describe the mirror image shift in landscape paintings by French painter Henri Le Sidaner. In the mirror image of the paintings, we mathematically consider whether the Desargues's theorem holds and whether the mirror image is elongated in a dented horizontal plane or curved surface. In the second half, we describe the use of mysterious stories as teaching materials in class. After we showed the picture to the students, they gradually solved puzzles by taking some steps. We investigated the outcome. In particular, we examined changes such as motivation.

Materials

(1) About Henri Le Sidaner ([2],[3],[5],[6])

Henri Le Sidaner (1862-1939) is a French painter born in Mauritius Island in the Indian Ocean. He belonged to a sailor family originated in the Brittany region, in fact both father and grandfather were captains of oceanic shipping vessels. At the age of ten, he moved to Dunkirk, a neighbor of Belgium in the northern part of France. After that, Henri Le Sidaner moved to Paris and entered private school of the academic school painter Alexandre Cabanel, and also entered the National Art School. He painted a stipple drawing under the influence of Impressionists, New Impressionists and Symbolism. He pursued drawing the light. However, he stuck to subtle pale light such as twilight, moonlight and thin light, which was not the bright sunlight shining drawn by Impressionists such as Monet but the momentary light at the turn of day and night. He left many landscape paintings mainly on coverage of the northern part of France such as the Normandy region. In the early 1900's, he left many landscape paintings at Gerberoy in Oise, which is an important place in the lifetime of Henri Le Sidaner. He set up a residence and atelier in this rural town which is less than 100 km from Paris, and remodeled the garden, and left a lot of

familiar landscape paintings. From this time, he stopped painting people on the screen. In many cases, he painted familiar landscapes under thin light such as garden and alley where rose flowers bloomed, houses along canals and rivers, stairs and windows of houses, tables and chairs, etc. People are not drawn anywhere, but he painted something like a sign as if someone passed by a while ago, a trace as if a person was relaxed, and a window light that suggested family activities there in a quiet space. The characteristic of his work is to express "the existence of absence". His paintings make us feel the thickness of time and the warmth of a person. He is said to be one of the intimists who draw familiar objects. Intimism was established by Vermeer and De Hooch in the 17th century, and Bonnard and Vulliard were intimists of the same era as Henri Le Sidaner. Since Henri Le Sidaner drew many mirror images when drawing houses along canals or rivers, he could be said to be a "mirror image painter". As an aside, since Henri Le Sidaner planted many roses in Gerberoy, Gerberoy came to be known as one of the most beautiful towns in the world.

(2) On the mirror image of the canal in Nemours

Henri Le Sidaner has repeatedly painted the canals in Nemours. Nemours is the city facing the Loire river located in the southern part of Fontainebleau in the region of Ile-de-France, which is a little away from Paris. Among the works of Henri Le Sidaner there are a lot of paintings depicting houses along the Nemours canal in various media such as drawings, oil paintings, pastel drawings, lithographs. "Small table in evening dusk" drawn in a large size of 100 cm × 81 cm is an oil painting on the canvas. It is in the Ohara museum which is the first Western art museum in Japan. "Small table in evening dusk" drawn in 1921 is a stipple drawing of the canal in Nemours. It is a beautiful painting gathered up by cold colors peculiar to Henri Le Sidaner. It is a stipple painting of somewhat slender touch drawn by superimposing blue and orange of its complementary color. It seems to be one of the most popular works since many people gathered in front of this painting in the retrospective exhibition of Henri Le Sidaner in Japan from 2011 to 2012. The first step of the painting method of Henri Le Sidaner is to paint on small panels with oil painting outdoors. Next, he confirmed the difference in color value of croquis and drew a more accurate sketch. After drawing the sketch, he transferred it to canvas by using grid lines at the atelier. The painting drawn on the small panel of 22 cm × 28 cm in the Valenciennes Art Museum was drawn in 1920. With regard to the canal in Nemours, it was drawn in the relatively early stage. It is presumed that other Nemours works by Henri Le Sidaner such as drawing, oil painting, pastel were created based on this painting. As for the work "Small table in evening dusk", firstly it was painted outdoors, then the one with colors put was drawn and a table and chairs were added in the atelier of Gerberoy. Then again, he returned to Nemours for about two days. He checked the details and finally completed it with another atelier in Versailles. Mr. Yann Farinaux-Le Sidaner, who is a great grandchild of Henri Le Sidaner and an art critic, told me the above in 2012. At this time, Mr. Yann Farinaux-Le Sidaner told that Henri Le Sidaner was interested in the mirror images on the water surface. A small pastel painting (30 cm × 20 cm) drawn in almost the same composition as the work in the Ohara museum is in the Lambinet Museum in the vicinity of the Palace of Versailles (Figure 1). But what is placed on the table is different from the work in Ohara museum. In both paintings, the roofs of the houses and the mirror image are heading for a single vanishing point. In his works in 1920, there is "houses along the river under the moonlight" (Figure 2). In the title there is "along the river", but this is a lithograph depicting the canal in Nemours under the moonlight. Lithograph is a stone print making use of repulsion of water and oil, and the picture which is drawn becomes print as it is. There are many lithographs by Henri Le Sidaner. "Stairs", "Pavilion", "Balustrade", etc. were drawn. Those are landscape paintings where people are not drawn, and the things around us such as stairs and windows are focused on. The same canal is also drawn on the cover of the Le Sidaner study book by Camille Mauclair published in 1927 (Figure 3). Figure 4 is the scenery of the Nemours Canal in December 2015. We looked for the place by Google Street View. We went to the scene. Although it is a landscape after about 100 years, we confirmed the present mirror image. We confirmed that the perspective on the houses and the mirror image in "Small table in evening dusk" is the same as the actual one and is correct.



Figure 1."Small table in evening dusk" (Pastel, Photographed with Permission by the Lambinet Museum)



Figure 2."Houses along the river under the moonlight"
(lithograph, Owned by the author)

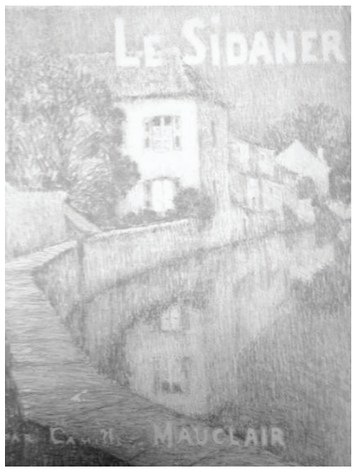

Figure 3. Le Sidaner by Camille Mauclair
(Owned by the author)



Figure 4.The Nemours canal in December 2015

Figure 5 shows the simplified representation of three points of the roof on land and three corresponding points in the mirror image in "Small table in evening dusk". In Figure 5, we draw straight lines connecting two points (A and B, B and C, C and A) out of three points of the roof on land. Also we draw straight lines connecting two points on the corresponding mirror image (A' and B', B 'and C', C' and A'). There are three intersection points (D, F, E). The three points D, E and F are on a straight line and satisfy the Desargues's theorem. In general, there are three vanishing points when looking up or looking down at the building without looking at it from the front. The case of Figure 6 is the general Desargues's theorem for three vanishing points. And this case is the Desargues's theorem for AA', BB', CC' whose extended straight lines intersect at a single point G (G, common point). Figure 5 shows the Desargues's theorem in the case where AA', BB', CC' are parallel and the common point is infinite. In the "Small table in evening dusk", the Desargues's theorem holds, and the roofs of the houses along the canal and the mirror image reflected on the water surface also is headed for the vanishing point faithfully to the geometric perspective. However, in the lithograph, the mirror image reflected on the water surface is not headed for the vanishing point (Figure 2).

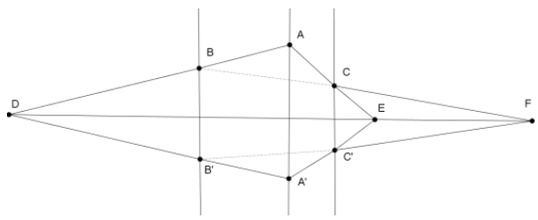

Figure 5.two vanishing points

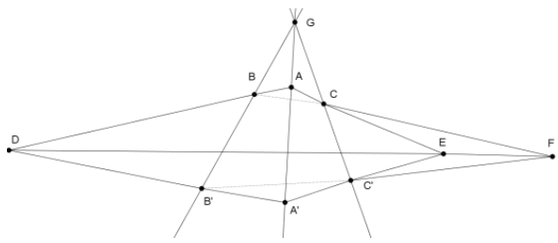

Figure 6.three vanishing points

Discussion

(1)Deviation of mirror image on the water surface

In the lithograph "Houses along the river under the moonlight", the houses along the canal on land are faithful to the geometric perspective and headed for one vanishing point (Figure 2). However, the image of the houses reflected on the surface of the water is not an accurate mirror image (Figure 2). Meanwhile, the roofs of the houses along the canal and the mirror images of roofs reflected on the surface of the water in the painting called "Small table in evening dusk" and other paintings depicting Nemours canal are headed for the vanishing point (Figure 1, Figure 3). They are paintings about 100 years ago, but they agree with the current mirror image (Figure 4). Why did such the deviation occur in the same scenery? Henri Le Sidaner studied at the National Art School and also acquired painting techniques. In Dunkirk he received a scholarship in painting and was selected also in the salon. Later he was elected president at the Institute of France. In this

discussion, we assume that Henri Le Sidaner who had repeated the studies in one motif did not make trivial mistakes in perspective. In fact, as we mentioned in the previous section, he painted drawings first and transcribed them to canvas by using grid lines, then returned to the field to check the detail. From the above, we can say that Henri Le Sidaner was cautious. In other words, it is unlikely that he was careless enough to make an easy mistake in perspective and overlook it.

(2) Position of absence as existence

We further thought about the deviation of the mirror image in the lithograph from the viewpoint of "absence as existence" which was the style of Henri Le Sidaner which implied a sign of a person without drawing a person. It can be inferred that the scenery of the lithograph "Houses along the river under the moonlight" was the state just after a transport boat passed by or a water bird dived into the water. Probably at that moment about a hundred years ago, a mirror image artist Henri Le Sidaner would have watched closely the situation along this canal. Immediately after the ship passed, the water surface was still dented and the mirror image might be distorted. Alternatively, it may be that a waterfowl dived in the water and a part of the water surface was dented into a concave mirror, and the mirror image was elongated. When we actually went to this place in Nemours in December 2015, we saw a lot of water birds dive and the water surface was dented and the mirror image was elongated. Everywhere along the canal there are facilities with old roofs for feeding waterfowls. From this, it can be inferred that waterfowls have existed here since long ago. On the other hand, the scene after passing through was not drawn in "Small table in evening dusk". There are chairs and a table, and the light of a window in the painting (Figure 1). By adding them in Nemours canal, it seems that Henri Le Sidaner's nature that makes us feel a sign without drawing people, etc. was fully satisfied. Henri Le Sidaner did not dare draw human beings and water birds and other living things on the screen, but we guess that he implied the existence and business by drawing the partial deviation of the mirror image in the lithograph. In this lithograph, we think that Henri Le Sidaner would have expressed their existence without drawing ships and waterfowls, etc. It can be said that Henri Le Sidaner expressed and arranged the absence in this screen as one of various existence by drawing a partial mirror image deviation in the lithograph.

(3)Mirror image on the water surface

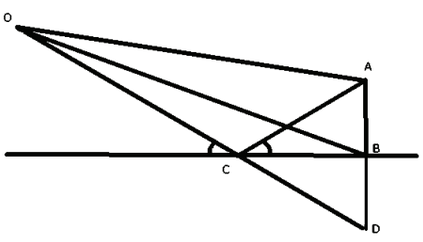

Figure 6.Mirror image on a horizontal plane

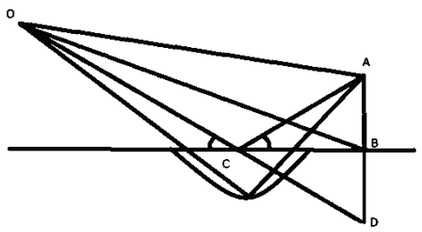

Figure 7.Mirror image on a dented horizontal surface

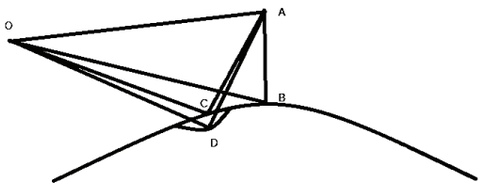

Figure 8.Mirror image on a dented convex surface

We see the landscape from O. When AB is perpendicular to the horizontal plane, a mirror image is seen on CB of this horizontal plane or convex surface. Here the incident angle and the reflection angle at C are equal. If the water surface is dented, the mirror image becomes larger than CB.

Methods and Results

(1)As a teaching material for puzzling

It was utilized as a mathematical teaching material for our students mainly in the department of Maritime Technology. The reason for targeting students mainly in the department of Maritime Technology is that they are in contact with the mirror image on the water surface on a daily basis, such as training at sea.

We compared the lithograph "Houses along the river under the moonlight" (Figure 2) with the photo of "Small table in evening dusk" (Figure 1 or other painting of the same composition in the Ohara museum, etc.) and tried to solve the mystery of the mirror image shift. First of all, we explained the era and the background of Henri Le Sidaner and how to solve the puzzle by taking some steps. We proceeded in the order of ① to ④ below for about 100 students and raised the level according to what the students noticed. And we pulled out of the students more interesting opinions which were likely to be closer to the truth and finally approached the elucidation of the mystery of the collapsed mirror image. For good opinions and awareness, and unique ideas, we praised them and gave points (1 point, 2 points, · ·) as games.

① First of all, we asked the first impression of the painting and lithograph. There were impressions such as "A stipple drawing is beautiful", "The same landscape, but somewhat different", etc.

② Next, we asked what the students noticed. The first one we took up as a good opinion was "It's a mirror image so it's the same even if it is turned upside down." There was also an opinion that "The window is lit with light." Here, we explained the perspective method by using the picture of "Small table in evening dusk," and told them that the Desargues's theorem holds. In addition, we explained the principle of mirror image.
③ We asked if there was something incompatible with each other in the mirror images of the two pictures. Some students realized that the Desargues's theorem didn't hold in the mirror image of the lithograph.
④ Finally, we have the students think why the mirror image collapsed. Here, we explained "absence as existence" which was the style of Henri Le Sidaner. And we asked why the mirror image collapsed with reference to the style of Henri Le Sidaner. The cause of the mirror image distortion was stated by our students as follows; "After a ship passed", "Someone threw a stone", "After throwing away the garbage", "After an animal passed by", "There was a fish", "The mirror image is shifted by the waves", "The surface of the water was shaking", "Viewed from multiple perspectives", and so on.

(2) Result of the questionnaire

Finally, a questionnaire was conducted by anonymous. 77% of the students felt that this puzzle was interesting, 75% of the students thought that mathematics was related to their future jobs and professionals, 80% of the students felt that they had to do mathematics after solving this puzzle.

Conclusions

Actually, there are many students who usually dislike mathematics and are not interested in mathematics in our college. About 80% of the students felt that they had to do mathematics by solving this mystery. From this, it can be said that there was some effect as their motivation. Furthermore, we will continue to investigate the correlation between the results and motivations especially in the field of geometry.

Acknowledgements

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STUDY ON THE EFFECTIVENESS OF MINI-AQUAPONICS STEM WORKSHOP ON ENHANCING STUDENTS' STEM CAREER ATTITUDE AND AQUAPONICS KNOWLEDGE

Carmen P.Y. Wong

Hong Kong Institute of Vocational Education (Sha Tin) Department of Applied Science, Lecturer, Hong Kong

carmenwong@vtc.edu.hk

Abstract

The study aimed to study the effectiveness of the workshop on improving career attitude and aquaponics related STEM knowledge on the participants. A series of STEM workshop - 9-hour in 6 sessions based on mini-aquaponics system was designed and carried out in four runs for four local Chinese-medium Instruction secondary schools over a period of 12 weeks. Total 117 secondary 1 to 3 students were recruited voluntarily from four schools.

A teaching package containing topics DIY mini-aquaponics system, system monitoring and technical setup modification, growth monitoring and sustainable farming was designed and delivered to participants as an experiential learning. Students involved in the activities that required them to carry out experiments after studying the manual, operated hand tools for assembly the system and fitting the tubes and electrical pumps, apply different scientific instruments e.g. balance, colour chart, dissolved oxygen meter to optimize the conditions of the aquaponics.

For studying the effectiveness of the workshop delivery, the pre-workshop and post-workshop questionnaires on students' interests in STEM content and careers and career attitude were conducted. Total 100 responses were received by the end of the workshop.

The survey on interests in STEM content and careers were adopted and translated from the STEM Semantic Survey by Tyler-Wood, Knezek and Christensen (2010). It is a 25-item instrument that measures interest in science, technology, engineering, and mathematics as well as interest in STEM careers generally.

The aquaponics related STEM knowledge was rated by analysing the results of worksheets submitted by the students after each session.

There was no large difference on students' interest on STEM content by comparing the average score values of before and after the workshop. That meant the 6-session workshop lasted for 3 months did not help improving students' interest and perception on STEM related topics or knowledge. Generally students are more interested in Science among all area and Technology is the second most interested area among all participants. This observation was same after the workshop. However the general perception on STEM career were decreased by 22.3% which is significant.

However the workshop was not designed to mention and discuss about the possible STEM career pathways explicitly with the students. They were expected to experience the tasks related to different area of STEM and internalised that experience on the sustainable farming tasks into a career aspiration. That was too difficult to junior secondary level students.

Keywords: *Aquaponics, STEM workshop, Career attitude, Interest on STEM content, Experiential learning, STEM semantic survey.*

Introduction

STEM career attitude development of a students was based on their STEM interest. Development of STEM interest is affected by many factors. These factors includes parents' support, peer, academic results on STEM related modules, and experience and participation in STEM related activities, like reading on science related books or programme, workshops, day-camp and even competition.

Aquaponics STEM workshop as an out-of-school time science activities aimed to cultivate students' interest on STEM.

Materials and Methods or pedagogy

Design of STEM learning programme and teaching package. A STEM teaching package related to aquaponics and sustainable farming for junior secondary students (secondary 1 to 3) were designed. It is a 9-hour programme for delivery of 6 lessons. The package consists of PowerPoint slides, teacher guide – the

session rundown and material plan, worksheet and suggested answer.

Recruitment of participants: Open recruitments were carried out by sending initiation emails to all local Chinese-medium instruction (CMI) secondary schools during summer of 2016 by email. The email addresses were provided by External Relation Office of VTC. First come first serve principle were adopted in the recruitment. The four schools are Sing Kung Hui Lui Ming Choi Secondary School (36 students), HKCCC Ho Fuk Tong College (24 students), Ling Liang Church MH Lau Secondary School (27 students) and Po On Commercial Association Wong Siu Ching Secondary School (30 students). Total 117 participants were enrolled and they were from secondary 1 to secondary 3. Finally 90 participants completed all 6 lessons of the workshop.

The workshops conducted as scheduled except Ling Liang Church MH Lau Secondary School and HKCCC Ho Fuk Tong College both requested to reschedule one of the lessons due to clashing to their school activity. All the workshops were completed by 17 December 2016.

Data Collection

Preparation of workshop evaluation: For studying the effectiveness of the workshop delivery, the pre-workshop and post-workshop questionnaire on students' interests in STEM content and careers (Appendix I) were adopted and translated from the STEM Semantic Survey. The STEM Semantic Survey was based on Knezek and Christensen's (2008) Teacher's Attitudes Toward Information Technology Questionnaire (TAT) derived from earlier Semantic Differential research by Zaichkowsky (1985). It is a 25-item instrument that measures interest in science, technology, engineering, and mathematics as well as interest in STEM careers more generally. The five most consistent adjective pairs of the ten used on TAT were incorportated as descriptors for target statements reflecting perceptions of science, technology, enfineering and mathematics (each separately). A fifth scale representing STEM career interests was also added by Tyler-Wood, Knezek and Christensen (2010). This instrument had been proved valid and reliable by Tyler-Wood, Knezek and Christensen (2010).

Focus group interview questions to voluntary participants were designed to collect any feedback from participants that may not be covered by the questionnaires. Those questionnaires and interview questions were submitted to research ethics committee and approval were obtained.

The questionnaires survey on students' interest in STEM content and Career had been conducted before first session of the workshop started and after the last session of the workshop finished. Total 100 responses were received by the end of the workshop.

Students' Interest in STEM related learning content: Study on Students' Interest in STEM related learning content before and after the workshop were carried out with the STEM Semantic Survey. It was expected to increase students' interest in STEM after they had participated in the 6-lesson totally 9-hour STEM workshop with mini-aquaponics system.

Since some students were absent in the first and some were absent in the last session of the workshop, direct matching of each students' response were not meaningful. 99 responses were received in pre-workshop survey and 85 responses were received in post-workshop survey. Overall response with average values on each STEM area were compared as in table below.

The average score values of the sematic survey before and after the workshop were compared as data analysis to see if students' interest had been improved.

Participants' STEM Career attitude after the workshop: It was expected to be improved after the workshop. Instruments for assessing Interest in STEM Content and Careers (Appendix II) designed by Tyler-Wood, T., Knezek, G. & Christensen, R. (2010) were adopted. The Chinese translation of survey instrument is attached in the appendix. The average scores on three parts - Part 1 – Perception of supportive environment for pursuing a career in science, Part 2 - Interest in pursuing educational opportunities that would lead to a career in science and Part 3 - Perceived importance of a career in science were all at point 3 – undecided over a 5-point scale. Students were not sure about their career perception about science, although they relatively recognised the perceived importance of a career in science by giving a higher average score.

Results and Discussion

STEM Semantic Survey: The pre-and post-workshop Semantic Survey results were compared in table 1. There was no large difference observed out of the 7-point scale questions, where 1 represents least interested and 7 represents the most positive impression on that area. That meant the 6-lesson workshop lasted for 3 months did not help improving students' interest and perception on STEM related topics or knowledge. Students are more interested in Science among all area and Technology is the second most interested area among all participants. This observation was kept the same after the workshop. However the general perception on STEM career were decreased by 22.3% which is significant.

	BEFORE THE WORKSHOP	AFTER THE WORKSHOP	DIFFERENCE
SCIENCE (Q1-5)	4.29	4.12	-3.96% (-0.17)
MATHEMATICS (Q6-10)	3.70	3.62	-2.16% (-0.08)
ENGINEERING (Q11-15)	3.41	3.36	-1.46% (-0.05)
TECHNOLOGY (Q16-20)	4.01	4.10	-2.24% (-0.09)
CAREER (GENERAL) (Q21-25)	3.76	2.92	-22.34% (-0.84)

Table 1: Average score on different area of STEM Semantic Survey

Workshop design and STEM Career Attitude: STEM Career attitude was expected to be improved after the workshop. However the workshop was not designed to mention and discuss about the possible STEM career pathways explicitly with the students. They were expected to experience the tasks related to different area of STEM and internalised that experience on the sustainable farm tasks into a career aspiration. The skills in managing the aquaponics system was too difficult to junior secondary level students who may have no experience in growing plant or fish.

The workshop topics were all science and technology knowledge based. They were Lesson 1 - Aquaponics system set up – Potti® (Superfarm, 2016) ; Lesson 2 - water quality and plant and fish growth; Lesson 3 – Do-it-yourself aquaponics system set up; Lesson 5 – scientific instrument for water quality monitoring; and Lesson 6 – Aquaponics and sustainable farming. Although different farming technologies and techniques with science and engineering background were discuss during the workshop activities – farm design to participants in small group, no job function were mentioned in the discussion, like Energy Engineer designs the solar system and grit system to provide electricity need for aquaponics system; or Biologist or microbiologist studies the fermentation and breaking down of nutrients in composting. Since there were no explicit discussion on how the farming technology – aquaponics correlate to any career in all the workshop sessions, students could most probably directly correlate farmer as the related career of the workshop. This could explain why the average responsed scores on all three parts were all in the grade 3 – undecided.

Hong Kong is a highly commercial society that over 90% of food import from other countries (Censes and Statistics Department, The government of the Hong Kong Special Administrative Region, 2018) Hong Kong students and their families are mainly not working in aquaculture and agriculture sectors. They cannot visualise how much STEM knowledge is needed to have good produce and harvest. What Hong Knog student may only know that being a farmer is a tough job that no one would like to do it. That's why the participants could not decide on their STEM career after the workshop. They were not sure about their career perception about STEM and had a decreased perceived importance of a career in science after the workshop.

Our studies showed that Students' overall interest in pursuing educational opportunities that would lead to a career in science increased significantly by 4.8% (Table 2), but this was not a strong evidence as the average score after the workshop was still below 4. Only insignificantly number of students were affected by the workshop. That meant many participants had still not decided about the career to be STEM related and the workshops cannot improve students' career perception.

There was nearly no change in average score on the level of agreement on the participants' perception of supportive environment for pursuing a career in science. This parts focused mainly on the supportive environment the participants encountered, for example from family and school. Since the programme only last for three months, it is difficult for observing the change in supporting environment change for individual participant.

Career attitude development started late in Hong Kong: Currently Hong Kong New Senior Secondary School encourages a multidisciplinary development of students and analytical and problem solving skills instead of selecting a certain major scopes of study area before tertiary education. Although the student should have a stronger foundation for undergraduate STEM course if he or she could confirm to take STEM related subjects in sensior secondary school, it is still common that students has not yet decided on their specialism until getting into university. 4-year undergraduate learning programme allows students to select their major within their faculty after first year study. That means students could decide on their major until 18 or 19 year-old. The participants of our workshop were around 12-15 year-old. It seemed that the workshop discouraged students to define their STEM career. The truth is that it was still far way to go before students' had make their decision.

A comprehensive study (Dabney et al., 2012) that surveyed on university students about their frequency of joining different kinds of out-of-school time science activities and their development of career interest in STEM revealed that it took a long period of time to develop career interest in STEM. The time frame should be the whole middle school age. The frequency of participation should be at least several times per year for years in variety of activities, like workshop, day-camp, competition, as well as school science club, science non-fiction or science fiction reading or watching.

	BEFORE THE WORKSHOP	AFTER THE WORKSHOP	DIFFERENCE
PART 1 - PERCEPTION OF SUPPORTIVE ENVIRONMENT FOR PURSUING A CAREER IN SCIENCE	3.23	3.24	+0.3% (+0.01)
PART 2 - INTEREST IN PURSUING EDUCATIONAL OPPORTUNITIES THAT WOULD LEAD TO A CAREER IN SCIENCE	3.14	3.30	+4.8% (+0.16)
PART 3 - PERCEIVED IMPORTANCE OF A CAREER IN SCIENCE.	3.85	3.77	-2% (-0.08)

Table 2: The change in average score on the level of agreement on the perceived opportunities for developing career interest in science – supportive environment, eudcation and importance.

Many studies had showed that the probability of a student choosing a STEM career without previously established interest in STEM is far lower that that for a student who has had an interest since middle school with formal class activity (Krapp, Hidi, & Renninger, 1992; Lent, Brown, & Hackett, 1994). Our 12-week workshop with STEM related activities that increased participants' experience in working on STEM related learning skills like observation, data collection and processing, evidence to support decision, and hands-on experiment conducting skills. These experiences are the foundation to establish students' interest in STEM career. Hosting this kind of short-term, out-of-school time science activities were important to motiviate students (Lavonen et al., 2008) on developing such interest, attitude (Prokop, Prokop, & & Tunniclidde, 2007) and career choice within STEM field.

Due to the limitation of resources, our study could only cover four secondary schools for a duration of 3 months. Our study positively demonstrated that short-term activities could not help much in developing students' career in STEM. Without a proper elaboration, the activity could even drive the students away from STEM interest. It is advised that parents and teacher should encourage students to participate more in differnt varieties of STEM activities for a longer duration of time, like two to three years at least, to see if the students could develop the STEM interest.

From the focus group interview, participants expressed that they loved joining the programme as they did not have good chance to work on experiements in Integrated Science practical class. Although they could not decide on the career in STEM after the programme, the programme did increase their interest on STEM that they could not have though before. It improved their impression on science subject. Participants reflected that some of the experiments were difficult for them. Even the teachers of the participating schools were shocked that their students could manage to handle six test kits and instruments in monitoring the water quality as well as fish body weight by completing the record sheet by the end of the session.

It is a matter of trust on students' performance, but it is also a matter of technical support from school. Each workshop session of our programme was supported by trainned workshop helpers in a ratio of 1 helpers to 5 or 6 participants which is impossible for a secondary school to provide for each Integrated Science practical class. The workshop helpers were final year students of aged 18 or 19. They are from Higher Diploma in Environmental Protection and Management of Hong Kong Institute of Vocational Education (Sha Tin). They received training from all the workshop material planning, preparation as well as activity design. This may be also a good chance to recruit some tertiary students with related background to assist secondary school science practicals. This should facilitate an exchange on STEM related learning and career between students of different levels.

Conclusions

Mini-aquaponics STEM workshop was a well-constructed out-of–school time science activity. It was beneficial to developing studnets' interest in STEM content and career if it is being part of the longer time engaging STEM activities that students joined, for several years and several times per year. Joining once may increase their interest on STEM content shallowly by enhancing the related STEM working skills. Students can gain achievment from working on some tasks. Students need more practice and spiral the skills for creating new experiments in order to fully develop a STEM career. Family suppport is also important for students to acknowledge their direction. More training opportunities as out-of-school time activities should be provide to students so that they can learn without the pressure from academic performance.

Acknowledgements

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Appendix I – STEM Content and Interest Survey Form

香港專業教育學院(沙田)應用科學系
魚菜共生 STEM 工作坊
課程前問卷 – 參加者對職業生涯興趣調查

學員編號：_____ 性別：男／女 學校：_____
(格式: 班別-MMDD, 例 2C 班 12 月 14 日出生- 2C-1214)

本問卷內容關於了解同學對你未來職業生涯興趣。問卷有共有三部份。細閱每部份的句子後，選擇最能描述你對該句子的感覺。

本問卷以不記名方式進行，但以學員編號作比較同學在工作坊前和後的轉變。問卷收集所得的資料旨在了解工作坊的成效而不會用作評估參加者的表現。

填寫指示：請在圈出要選擇的答案。

第一部份	非常不同意	不同意	未決定	同意	非常同意
1. 我想從事科學事業。	①	②	③	④	⑤
2. 我的家人對我修讀的科學科目感興趣。	①	②	③	④	⑤
3. 我會享受從事科學事業。	①	②	③	④	⑤
4. 我的家人鼓勵我修讀科學。	①	②	③	④	⑤

第二部份	非常不同意	不同意	未決定	同意	非常同意
5. 我會為著我從事科學事業的理想而努力學習，將來會進入大學主修相關學科。	①	②	③	④	⑤
6. 我將會取得跟我理想事業相關的大學學位。	①	②	③	④	⑤
7. 我將會有一個專業的事業並對科學作出大量貢獻。	①	②	③	④	⑤
8. 我會得到一份跟科學相關的工作。					
9. 有一天當我跟別人說自己的事業時，他們會尊敬我，因為我從事科學事業。	①	②	③	④	⑤

第三部份	非常不同意	不同意	未決定	同意	非常同意
10. 從事科學事業使我跟別人更有意思地合作。	①	②	③	④	⑤
11. 科學家令世界作出意義的改變。	①	②	③	④	⑤
12. 從事科學事業是具挑戰性的。	①	②	③	④	⑤

問卷誦譯出處：Tyler-Wood, T., Knezek, G. & Christensen, R. (2010). Instruments for Assessing Interest in STEM Content and Careers. *Journal of Technology and Teacher Education, 18*(2), 345-368. Chesapeake, VA: Society for Information Technology & Teacher Education.

Appendix II – STEM Career Interest Survey Form

香港專業教育學院(沙田)應用科學系
魚菜共生 STEM 工作坊
課程前問卷 – 參加者對 STEM 學科觀感調查

學員編號：_____　　性別：男／女　　學校：_____
(格式: 班別-MMDD, 例 2C 班 12 月 14 日出生- 2C-1214)

本問卷內容關於了解同學對科學相關學科的印象和觀感。問卷有共有五部份。
你應只需要約五分鐘完成全份問卷。一般而言，你的第一感覺便是最好的答案，不應花長時間思考問題。

本問卷以不記名方式進行，但以學員編號作比較同學在工作坊前和後的轉變。問卷收集所得的資料旨在了解工作坊的成效而不會用作評估參加者的表現。

填寫指示：請在圈出要選擇的答案。

對我來說，科學是。。。的科目

1.	令我著迷	①	②	③	④	⑤	⑥	⑦	平凡
2.	很吸引我的	①	②	③	④	⑤	⑥	⑦	不吸引我的
3.	令我興奮	①	②	③	④	⑤	⑥	⑦	不使我興奮
4.	不算得甚麼	①	②	③	④	⑤	⑥	⑦	很有意思
5.	苦悶	①	②	③	④	⑤	⑥	⑦	很有趣

對我來說，數學是。。。的科目

1.	苦悶	①	②	③	④	⑤	⑥	⑦	很有趣
2.	很吸引我的	①	②	③	④	⑤	⑥	⑦	不吸引我的
3.	令我著迷	①	②	③	④	⑤	⑥	⑦	平凡
4.	令我興奮	①	②	③	④	⑤	⑥	⑦	不使我興奮
5.	不算得甚麼	①	②	③	④	⑤	⑥	⑦	很有意思

對我來說，工程是。。。的科目

1.	很吸引我的	①	②	③	④	⑤	⑥	⑦	不吸引我的
2.	令我著迷	①	②	③	④	⑤	⑥	⑦	平凡
3.	不算得甚麼	①	②	③	④	⑤	⑥	⑦	很有意思
4.	令我興奮	①	②	③	④	⑤	⑥	⑦	不使我興奮
5.	苦悶	①	②	③	④	⑤	⑥	⑦	很有趣

對我來說，科技是。。。的科目

1.	很吸引我的	①	②	③	④	⑤	⑥	⑦	不吸引我的
2.	不算得甚麼	①	②	③	④	⑤	⑥	⑦	很有意思
3.	苦悶	①	②	③	④	⑤	⑥	⑦	很有趣
4.	令我興奮	①	②	③	④	⑤	⑥	⑦	不使我興奮
5.	令我著迷	①	②	③	④	⑤	⑥	⑦	平凡

對我來說，若我職業生涯是關於科學、科技、工程或數學的，這是一件。。。的事。

1.	不算得甚麼	①	②	③	④	⑤	⑥	⑦	很有意思
2.	苦悶	①	②	③	④	⑤	⑥	⑦	很有趣
3.	令我興奮	①	②	③	④	⑤	⑥	⑦	不使我興奮
4.	令我著迷	①	②	③	④	⑤	⑥	⑦	平凡
5.	很吸引的	①	②	③	④	⑤	⑥	⑦	不吸引的

問卷誦譯出處：Tyler-Wood, T., Knezek, G. & Christensen, R. (2010). Instruments for Assessing Interest in STEM Content and Careers. *Journal of Technology and Teacher Education, 18*(2), 345-368. Chesapeake, VA: Society for Information Technology & Teacher Education.

MULTI-DISCIPLINARY OVERSEAS INTERNSHIP PROGRAM IN CHINA RADIO INTERNATIONAL

K. Ohya

National Institute of Technology, Nagano College/Dept. of Electronics and Computer Science, Associate Professor, Nagano, Japan

ohya@nagano-nct.ac.jp

Abstract

Our Department of Electronics and Computer Science provides the course "Practical Training" for 4th-year students. The course is compulsory and students go to their local companies and learn about work there for two weeks. Although overseas internships are increasing yearly, these run for less than two weeks, and some departments do not certify them as practical training. Moreover, some departments state that their courses are "not held in a company, but in universities or colleges," so they do not certify these as practical training either. However, I believe that overseas internships are very valuable and have been seeking ideal overseas internships that all departments can certify as practical training. Six years ago I visited Japanese companies in Shanghai and Shenzhen in China. Some companies I visited admitted to doing practical training but, due to certain problems, such training was not conducted. I took the chance to travel to China Radio International (CRI) in Beijing, and I soon found this place to be ideal. After negotiation, the first overseas internship in CRI was held there in 2015, with three members participating. The purpose of CRI is to broadcast to the world about China. Workers at CRI mainly broadcast, make Web pages, and conduct interviews. In our school, however, we mainly study engineering and experiments. There is a lack of group communications in many companies in our society. This overseas internship is held during the summer vacation and, as university students in China also come to CRI, our students can conduct international exchanges with them. In this way students can study the company in China and the company's ways of communication, while learning from Chinese students. The two weeks of the course are prepared through discussion with CRI staff, and I have based this on what worked and did not work in the past. The second time the course ran, there were four participants, but the third time saw this increase to 14 members in 2017. This was an ideal number for a multi-disciplinary overseas internship program. Some students became tutors to international students. Accordingly, we should see improvements in their communication skills.

Keywords: *Multi-disciplinary, Overseas Internship, Communication Skills*

Introduction

Our school has been finding new companies for years that accept overseas internship programs. Our school had overseas internship programs for Taiwan, Hong Kong, and Indonesia, but our school had no relationship with China.

Kosen is located in Nagano Prefecture, where there are many manufacturing companies. There used to be many factories in Nagano Prefecture, but they were almost all moved to foreign countries (mainly China). In this way, our school has a strong relationship with China and has been finding new companies there that accept overseas internship programs. I started to search for such companies in China six years ago.

Initially, I asked some companies with factories in China whether they could accept overseas internship programs. Internship programs in our school run for only two weeks and, although most students go to local companies, some join overseas internship programs. Companies often answer that they agree with overseas internship programs in China, but they believe that people in Nagano Prefecture are unwilling to travel abroad. In fact, many companies in Nagano Prefecture have factories in China; therefore, they are willing to adopt young people who do not hesitate to travel. Conversely, they do not generally accept overseas internship programs because they are anxious about how students might commute to work. Factories are located in the suburbs as well as in Japan. They are also anxious about places to live during the two weeks. Workers in China live in a room with many double-deck beds, with no washing machine, and they wash their clothes in buckets.

Teachers at Kosen were gathered in Hong Kong in May 2012, and I participated in this as a representative of our school. I took the opportunity to travel to Shenzhen and visited a factory of a company from Nagano Prefecture. The factory was very clean, but how to commute there was a problem, even if I were to stay in a hotel.

If overseas internship programs in factories of companies based in Nagano Prefecture are not practical, what do we do? I have heard that many Japanese live in Shanghai where some of them conduct business. What if overseas internship programs were possible in large cities like Shanghai? Surely subway systems will mean that there is no problem in commuting? I traveled to Shanghai myself in August 2012 where I visited some Japanese companies and met with some Japanese who do business in Shanghai, and I asked them about overseas internship programs. They told me that people working in Shanghai need Chinese language skills. Indeed, if students work in factories, perhaps they do not need Chinese language skills but, students working in large cities do. However, internships would be possible for some people who do their own business in Shanghai.

I had a chance to visit China Radio International (CRI) in December 2013. CRI is "a state-owned international radio broadcaster of China; its overseas reporting involves 65 languages." It has a Japanese Service section, in which about 30 Chinese people are involved. Here I heard about Chinese university students studying Japanese language who come to the Japanese Service section of CRI during summer. Consequently, I believe that overseas internship programs here would be ideal, because CRI is not a technology company, it has a vast range of people, and our students can experience a broad cultural exchange. I asked CRI if they accepted overseas internship programs and they said yes. Although it was too late to begin in 2014, our school began an overseas internship program running for two weeks at CRI in the summer of 2015.

The first overseas internship program at CRI in 2015

Three students (one male, two female) participated in the first overseas internship program at CRI in 2015. I made all the arrangements, bought air tickets, found hotels, and made reservations. Hotels with washing machines were required because of the two-week stay, but it was initially difficult to find such hotels in China. Buying air tickets was also difficult because it is too expensive in summer; however, I found cheaper tickets via Korea. There is no scholarship in this program, so some students participated with their own money from part-time jobs. I made every effort to save students money. By talking with CRI in advance, we had established what would be done in the internship program. Our program would involve the overseas visit and write an article online. We visited the Beijing branch of a company from Nagano Prefecture, another company begun by a graduate of our school, and a Japanese company CRI introduced me to that played an active part in Beijing. CRI's Japan section has eight Chinese university students whom ours interacted with because they could all speak Japanese. They introduced themselves, discussed what is hot in their home country, what APP is useful, who is popular, and so on. Afterward, they decided on songs to be sung a few days later—our students chose a Japanese song to be sung by Chinese students, and the Chinese students chose a Chinese song to be sung by our students. CRI invited a Japanese man, who was traveling by bicycle in China, to give a speech and Japanese and Chinese students asked him. As one of the Chinese students was a Beijing University graduate student, she invited us to Peking University, which people cannot enter without permission. The Peking University campus is vast, and it took a whole day to explore. She then invited us to a school cafeteria. We saw dormitories on the same



Figure 1 Self introductions



Figure 2 Singing a song together



Figure 3 Cafeteria in Peking University

campus and, as she explained many things about the life of Chinese students, our students asked her many questions. On another day one of the Chinese students invited us to where they live. In China, residential areas are separated and, as outsiders cannot enter them, this was a unique experience.

A few days later, all students gathered in a CRI recording studio where they sang. The Chinese students sang perfectly, though the Japanese students managed only to sing part of their song because that song was very rapid. Students praised one another and, in this way, the first overseas internship program ended.

The second overseas internship program at CRI in 2016

In the second overseas internship program in 2016, four male students participated (three were 3rd grade, one was 4th grade). Our students visited the editorial department of a magazine called "People's China." The students who had invited us to Peking University came



Figure 4 Peking University

to CRI for us this year and again invited us to the campus of Peking University. We were all deeply moved, and this shows the strength of our relationship. Also in 2016, a marvelous thing happened. When one of our students was reading a Japanese guidebook of Beijing on the road, two female Chinese university



Figure 5 Two female Chinese students

students discovered that it was a Japanese book, and talked to him. We then ate dinner together, and our students became acquainted with them. We traveled to Shijiazhuang—which is a sister city of Nagano—by high-speed rail. A woman who worked at the International affairs division of the Nagano Prefectural office guided us in Shijiazhuang because it was her hometown.

The third overseas internship program at CRI in 2017

At the third overseas internship program in 2017, participants increased to 14. Two were female, five members were 2nd grade, three members were 3rd grade, and the others were 4th grade. The reason for this increase might be due to holding a joint overseas



Figure 6 China Radio International

internship program meeting, involving Taiwan, Hong Kong, Indonesia, and China. Our students visited the Chinese Academy of Social Sciences, which is "the premier and the most comprehensive academic research organization and national center in China to study in the



Figure 7 Exchange meeting at Beijing Youth Politics College

fields of philosophy and social sciences." Moreover, our students also visited the house of an honorary professor at Peking University, who was one of the Japanese children left behind in China who wrote an autobiography. They also visited the Beijing Youth Politics College. At the Beijing Youth Politics College, representatives introduced their schools first; then

students talked to one another in groups. The college's students could not speak Japanese, so they spoke English. Afterward, some students guided us to the 798 Art Zone in Beijing, and they talked to each other while walking in the zone.

One of the Chinese university students that come to CRI's Japanese Service section is still in the 4th grade, but their Japanese skill is exceptional. She speaks Japanese very fluently, and she later won first prize in writing an essay in Japanese (competing with Japanese students in China), which was later published in Japan.



Figure 8 In Tianjin, two students are Chinese

Our students visited Tianjin by high-speed rail, while one of the students acquainted with the road traveled separately. We had a wonderful time in Tianjin.

Conclusion

Kosen is a technology school with more male than female students. Students study technology every day, they have to master many kinds of technology skills, tend to learn by themselves, and tend to have fewer opportunities to enhance their communication skills. In this overseas internship program at CRI, students freely talk to Chinese university students because the Chinese students can speak Japanese. They can talk about their cultural backgrounds, and gradually recognize cultural differences. Once friends are made, they can understand one another deeply through communication.

In many cases, technology schools have relationships with other technology schools. This has the advantage that they have similar knowledge bases and technologies. Nevertheless, there might be some disadvantages, as their knowledge is too closely related. Chinese university students who come to the CRI Japanese Service section study Japanese, which is their only common ground. Some of these students learn Japanese in a language department, while others mainly study technology but, also, study Japanese. By deepening their cultural exchange, they can enhance their communication skills.

In 2018 the fourth overseas internship program with CRI will occur, and eight members will participate. This will involve two 1st grade students for the first time. The air ticket from/to Tokyo has doubled from last year, so we have bought flights from/to Nagoya instead. I do not know why but the hotels we have used in the past were all full, and I had to find new hotels with washing machines.

Accordingly, this program has been challenging, but all the participants have enjoyed it immensely. They made friends with Chinese university students, and some came all the way to Nagano, where they were very pleased to meet each other again. I would like to continue this overseas internship program.

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THE COLLABORATIVE INTERACTIONS BETWEEN NIT, KURE, JAPAN AND RADFORD COLLEGE, AUSTRALIA

Yuko UESUGI*[a] and Dianne Fitzpatrick[b]

[a] National Institute of Technology, Kure College, Japan
[b] Radford College, Canberra, Australia
*uesugi@kure-nct.ac.jp

Abstract

This paper aims to provide the report on how effective the collaborative interactions between National Institute of Technology, Kure College, NIT, Kure, and Radford College in Australia in order to achieve the tandem education where both sides aim to develop their different target languages, English for the students in NIT, Kure and Japanese for those in Radford College. The collaborative sister-relationship between our schools has been conducted for 7 years. We send our students each year on the homestay programs with the purpose of the international exchange between our schools.

We also have Skype-used classes where both sets of the students exchange their cross-cultural information with each other both in English and Japanese. Within our collaboration we set about our next adventure, doing Skype with the students from the English classes at NIT, Kure and Radford College. This was difficult as timetable structures were different and there was always competing demands of classes and courses. However between the determination of us the teachers in charge of these classes, we successfully managed to have about 40 mins a fortnight in class time. What this provided to our students are as follows.

1. An opportunity within the learning environment for something new and exciting to look forward too.

2. An opportunity to actually use our different languages in a real face to face situation.

3. This Sharing of different cultural aspects of young people's lives.

4. An opportunity to build relationships between students through language and culture, so soon the students would be on Skype and recognise the students on the other end of the Skype, which made for more and more opportunities for students to feel more relaxed in using their language for communication.

This program will give you some unique educational insights from different cultural perspectives. Our goal and desire in the future is teacher exchange to allow for professional development for teachers from both schools. We will continue to explore every opportunity in the future to have cross collaboration, Skype sessions, exchanges both short and long term. We know that this continues to help students to cross cultural barriers, think globally and build understanding. I believe in the future this will help to build peaceful relationships across differences and divides.

Keywords: *sister-relationship, Japan, Australia, homestay program, tandem education, cross-cultural understanding, cultural differences*

1. What are the Purposes of this Paper?

This paper is focusing on how effective the collaborative interactions between NIT, Kure, and Radford College in Australia, under the collaborative sister-relationship. We made the official contract on March 25, 2015. Since then, we've been sharing the common goals to achieve: the tandem education where both sides aim to develop their different target languages, English for the students in NIT, Kure and Japanese for those in Radford College; the enhancement of cross-cultural understanding among both sets of the students; and the increase of the students' motivation toward learning.

How we have been conducting the interaction between our colleges effectively and collaboratively is presented from our different cultural points of view, which can give the future perspectives to our educational field in the different cultural context.

2. How We Started the Sister-Relationship

Why do students choose to study what they do? What motivates that choice of study? Most likely it is a combination of:

What they might be good at
What they think might get them a job in the future
Their parents advised them that this would be a good career choice.
Best of a bad choice.

However, at the time of the choice this probably doesn't matter as there is still a long way to go before the actual beginning of their working life. What matters, which perhaps they are also equally unaware of is that

in the global world we live in we all need to be able to speak languages other than the native language we speak. The more languages we speak the more doors will open up to our students.

Which brings me to, how are we teaching and what are we actually teaching to motivate and help our students be successful in a world where collaboration and communication between multinational countries will play a part in the work you are preparing them to do. So while it lasted important to teach the skills it is equally important to teach them about being a global citizen on a global stage.

This is where having a sister school where we can exchange our different languages has been an interesting journey, bringing about new learning opportunities for students in Australia and our sister students in Japan. It started with a friendship between myself and a member of staff at NIT, Kure. This then developed into a Memorandum of understanding to allow our two Colleges to enter into exchange opportunities. This included: both schools coming to each school on a two yearly basis on a study tour. This is where it started.

3. The Bridge over Cultural Gaps

There is so much more to explore than just a two yearly exchange, which in itself is an amazing opportunity for students to bridge cultural gaps. We will pause here to explain some of these gaps which has shown the huge cultural diversity from Australia to our neighbouring Japanese students. So picture it: You are a 16 year old Japanese student sitting in class eager to hear about life in Australia from the same age student.

What are they going to hear?

1. In Australia, we don't clean our classrooms at the end of the day.
2. In Australia, we eat our lunch outside in rain hail and shine.
3. In Australia, students can do more than one club activity after school. At public schools they just go home at 3:30.
4. In Australia, the students walk around the school to their different classes.
5. Size of classes are 26-28 students.
6. Most students are driven to school by their parents, we don't come by trains at our school as in the capital city in Australia there are no trains. Some students come by bus and bicycle.
7. On the weekend the school is shut, there are no students at the school or teachers.
8. We all get 12 weeks of holidays a year and there is no lengthy summer homework.
9. Studying a language is by choice.
10. There is a large amount of integration in the classroom between teachers and students with students asking and posing questions and solutions to the curriculum.

How do you react to this as a student in a Japanese school without thinking that life for you is unfair or way too difficult. Well it is a real opportunity in English classes to think and look at different aspects of culture that make up a nation. There is no right or wrong but just different and this builds understanding and global perspectives in your students.

4. Collaboration through Skype Communication

Within our collaboration we set about our next adventure, doing Skype with the students from the English classes at NIT, Kure and Radford College. This was difficult as timetable structures were different and there was always competing demands of classes and courses. However, between the determinations of us, we managed to have about 40 mins: 20 mins for English time and 20 mins for Japanese time, a fortnight in class time. It is so-called a reciprocal 'Tandem education' which can provide both of us the merits of learning the target languages, Japanese and English. What did this provide to our students?

1. An opportunity within the learning environment for something new and exciting to look forward too.
2. An opportunity to actually use our different languages in a real face to face situation.
3. This Sharing of different cultural aspects of young people's lives.
4. An opportunity to build relationships between students through language and culture, so soon the students would be on Skype and recognise the students on the other end of the Skype, which made for more and more opportunities for students to feel more relaxed in using their language for communication.

Thanks to one or two hour difference between our schools, we could arrange our class schedules and conduct the Skype sessions 10 times in 2017. Since we exchange our students regularly with each other, the students can have a reunion or re-reunion through the Skype sessions and the study tour program. They can make friends even before they go on a study tour, which is a remarkable element to point out. NIT, Kure students are shown a list of the topic for the semester in April 2017 so that they can prepare for the topic, using the Internet or books. Some students are well-prepared for the class with the PPT or pictures to show. This is the list of the topics for the Skype sessions in 2017.

Table 1: A List of the Skype Topics in 2017

	Date	Time	Topic
1	May 8	11:30~12:00	Self-introduction Major, Hobbies, Hometown
2	Jun. 5	11:30~12:00	Food Culture
3	Jun.19	11:30~12:00	Sports
4	Jul. 17	11:30~12:00	Campus Life
5	Jul. 31	11:30~12:00	Sightseeing Spots
6	Oct. 16	11:30~12:00	The students' questionnaires
7	Oct. 23	10:30~11:00	The students' questionnaires
8	Nov. 6	10:30~11:00	The students' questionnaires
9	Nov. 13	11:30~12:00	The students' questionnaires
10	Nov. 20	10:30~11:00	The students' questionnaires

According to the questionnaires done in NIT, Kure, the students felt the world is small because they can talk to the students in other country and see face to face in their study tour again. NIT, Kure students were amazed at the competency of Japanese of the Radford students. It can be a great incentive for NIT, Kure students to keep on mastering English. Finding difficulties in understanding the language and cultural differences can bring both sets of the students great motivation even though they felt confused and embarrassed at first. Having a companion in study encourages the students to get over the difficulties.

In fact, having a study friend beyond the monitor brings the students unique and positive effect on the course of studying a foreign language and culture.

5. Building our Sister-Relationship

We had to build closer ties. As sister school's we then sought to do more long term exchanges with students from each of the learning institutions. I decided to start to send some of my senior students on exchange on the long summer break in Australia as in Japan. They were continuing to have school throughout this period. Upon return after 6 weeks of school and homestay their language was vastly improved and they had built deep friendship bonds with homestay families and students at NIT, Kure. This then led to opportunities for my students to go for longer period of time. This has happened to two students who chose to go for one year in between finishing Year 12 our last year of High school. For many students in Australia this would replace a gap year which many take in between Year12 and their first year of university. This provided a longer time for these two students to study in NIT, Kure, learn the language, mix with the students, help in the English classes and form lasting friendships with the homestay families and friends at school.

An example of these lasting friendships is a young boy Thomas who is now studying Architecture and Japanese at RMIT University in Melbourne. The family which hosted Thomas for his 6 weeks exchange when he came to NIT, Kure had three boys who all studied at NIT, Kure. Thomas is now their fourth boy, and his host mother and grandmother talk to him and Skype with him when he is studying for his Japanese exams at a Melbourne University. Reciprocally, Radford hosted Koki their son for one month and he got the opportunity to stay with Thomas's family and become their second son. These are relationships that have bridged cultural differences and will last a lifetime.

In March, 2015, 10 students and one chaperone had a 11 day homestay program in Radford. They had a schedule Radford College prepared, and there they enjoyed being a part of the family and learning cultural differences very much.

Between Mar 2016 and Dec 2017, one Radford student, Michel came to NIT, Kure. He had a homestay with a NIT, Kure student for 6 months and then decided to live in a boarding school. This is his own choice to experience different life styles. He joined a brass band club and played oboe in some concerts in public. He also volunteered to be an assistant in public lectures for the Kure citizen twice, which I organized. He gave a presentation about cultures, nature, and history in Australia, Canberra, and educational systems at Radford College. It was quite a unique opportunity to teach his native language, English as an assistant to the local people in Kure. He was very popular among the attendees and enjoyed himself teaching English and different cultures.

Our fourth tier to our program came when Dianne decided to organise students from NIT, Kure to be our ALT in the Japanese department at Radford. We had our first one last year and it was a great success. Toi Murai, who was studying electrical engineering came and stayed with home stay families for his time at Radford with families who had either a son or daughter who was attending the school.

Then with some local funding another opportunity came into play. Last year NIT, Kure provided this opportunity for our IT teacher who leads our school's Robotics Club to go over to Japan with two top students to compete with the NIT, Kure team in the Tsuyama Robotics Competition. The team had to develop and make an ice-hockey playing robot. The team arrived at NIT, Kure and stayed in the boarding house. They spent two days collaborating and working with the NIT, Kure team and two days at the competition. While we didn't win the competition, we did take out the design award. We are hoping to make this a yearly collaborative event. As a result of this collaboration and the courses which NIT, Kure teach we are welcoming this year an IT Assistant teacher to work within the IT department and help in the Computing Club. This is a young girl who is taking time off her study in NIT, Kure to come and experience education in Australia. We are also hoping she may be able to attend some of our design classes as part of her knowledge gathering. Hopefully we will win another design award in 2019. This was an opportunity

to share tandem education in robotics and share design ideas across two very different schools.

In 2016, I hosted the principal of Radford, Ms. Fiona Godfrey as a host family for a week. We developed our bond even privately through some activities, such as taking hot spring baths together, showing her some viewpoints in Kure, and serving her traditional Japanese food. In return, Fiona took Uesugi and her husband out to a traditional Japanese restaurant. This event surely contributed to making our sister-relationship stronger and steady.

From April 16 to 23 in 2018, NIT, Kure accepted 9 students and 2 teachers from Radford College. The preparation to accept them started in March in 2018. The preparation is as follows: the recruit for the host families among the students; making the schedule including cross-cultural and exchange events such as watching a baseball game; visiting museums; visiting Peace Memorial Park in Hiroshima; and visiting a local junior high school nearby. The schedule was well-prepared in the hope of involving not only the students in NIT, Kure but also the local people and students nearby so that both sets of the students and people can get benefit of getting to know different cultures and broadening their own perspectives.

Table2: Schedule of Radford College Visit to NIT, Kure in 2018

6. Future Perspectives

Where do we go from here? Dianne recently took her school's Media Studies and Design teacher to NIT, Kure. We hope that we can do something in the future that may involve some kind of collaboration in a design or project that will benefit the students learning and project building skills. As they venture forth in the world it will be a good learning experience to work with people from all different cultures and backgrounds and how they manage the design process.

Our goal and desire in the future is teacher exchange to allow for professional development for teachers from both schools. We will continue to explore every opportunity in the future to have cross collaboration, Skype sessions, exchanges both short and long term. We know that this continues to help students to cross cultural barriers, think globally and build understanding. We believe in the future this will help to build peaceful relationships across differences and divides.

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PROFESSIONAL LEARNING FOR INTERNET OF THINGS (IOT) : A MULTI-DISCIPLINARY AND INDUSTRY PRACTICE PARTNERSHIP

Dr Liew Beng Keat[a], Seow Khee Wei[a], Tan Wee Siong[a], Vincent Lim[b]

[a] Republic Polytechnic, School of Infocomm, Senior Lecturers, Singapore
[b] Republic Polytechnic, School of Engineering, Senior Lecturer, Singapore

[a] liew_beng_keat@rp.edu.sg, seow_khee_wei@rp.edu.sg, tan_wee_siong@rp.edu.sg
[b] vincent_lim_by@rp.edu.sg

Abstract

A Global Smart City Performance Index that ranks the top 20 global smart cities in terms of their integration of Internet of Things (IoT) technologies and connected services across four key areas namely mobility, healthcare, public safety and productivity has Singapore emerging at the top of the ranking for 2017, as reported by Navin (2018). This paper posits that this is achieved in part with the educational and training programmes that are in place in the Republic to train such professionals. This paper describes the implementation, experiences and lessons learned of one such programme called the Specialist Diploma in Internet of Things (SDIoT) at a polytechnic in Singapore, which adopts Professional Learning (PL) practices such as industry case studies, industry projects, industry study tours as well as industry practitioner delivery in its programme. The role of industry is a key feature that will be elaborated. This paper also describes the adoption of multi-disciplinary collaborations in its curriculum as well as technology-assisted learning in the form of a mobile learning platform to complement the programme.

Keywords: *Professional Learning, Industry Engagement, Internet of Things, Smart Cities*

Introduction

Singapore has a Smart Nation programme that represents her journey of economic, business and public sector transformation where technologies such as the Internet of Things (IoT), data analytics, artificial intelligence (AI) are leveraged upon to transform herself into a smart city. A Smart Nation and Digital Government Group, GovTech was reported by Teo (2017), to have been formed to drive several of these national strategic initiatives. One such initiative is the Smart Nation Sensor Platform which is an island-wide network of IoT-connected sensors that facilitate data collection and sharing (across various government agencies) for which insights gathered from the data can contribute to innovative solutions that help improve the lives of its citizens.

As Singapore embarked on its Smart Nation initiatives, it was challenged with the ability to meet the demands of suitably trained ICT professionals as reported by Weizhen (2016). Since then, we have implemented a programme that is targeted at working professionals or adult learners in support of this demand. The design of the programme, specifically in the way it engages its students, considers the characteristics of adult as learners such as adult learners having experiences that are rich and which should be seen as an important learning resource, adult's orientations to learning being more problem centred than subject-centred and adults being more capable of self-direction as reported by Knowles (1990) and James (2013). These characteristics, in combination with the need to equip with skills that are industry relevant sees the application of an approach in the programme termed as Professional Learning (PL).

Professional Learning is defined as the development of professional capabilities through teaching and learning experiences and activities that integrate academic, discipline-specific and industry-referenced knowledge, skills and attitudes as reported in Lawson (2011) and Billett (2011). Specifically, professional learning, encompasses the skills, qualities and attributes required by industry, with students participating in industry-oriented processes by engaging in real industry issues which encourages deep learning and where industry partners can be engaged in the development and delivery (including evaluation) of the curriculum.

The literature on PL describes a number of main approaches, noting that the practice of these approaches are not mutually exclusive. These approaches include industry case studies, industry projects, industry study tours / seminars, industry practitioner delivery, industry simulation, industry mentoring, industry placement and industry competition. In our programme, the first 4 approaches listed have been adopted and their application are explained in this paper. Beyond the above, the adoption of technology assisted learning and other

initiatives to support a professional learning programme is discussed, including the issues faced.

Curriculum Design

The professional learning programme that we have designed is named the Specialist Diploma in the Internet of Things (SDIoT). To fulfil the manpower needs in a field where technology is fast evolving and the use cases of IoT as applied in the context of smart cities is expanding rapidly, the training programme for working professional's needs to be as industry relevant as possible. Besides skills training to fulfil job roles in IoT or to increase the job prospects of participants, the qualification obtained is recognized in Singapore and could articulate to other paths of more advanced learning.

The key considerations in shaping the SDIoT in terms of the subject matter coverage, the teaching approach, and the engagement model include the following:

1) The requirement of a multi-disciplinary approach, as demanded of any professional who is to work effectively in IoT. IoT project teams will be composed of different professionals who have to work collaboratively in teams and each need to have knowledge beyond their own areas of expertise to be effective, as described in Shenna (2015). Multi-disciplinary in our case refers primarily to computer science and engineering subject matter and specifically to foundational modules. Hence the inclusion of modules such as "3D Printing Fundamentals", "Engineering Basic", "Systems and Programming Basics" and "Introductory Statistics and Analytics" in the SDIoT programme.
2) Industry-relevant skills is a critical and key feature intended of the programme. As such, industry case studies, industry projects are some of the professional learning approaches adopted. Adult learners tend to be more inductive than deductive reasoners i.e. learn better from cases or examples and their response to cases or problems have to be driven from the practices and processes as applied in industry. This is reported in Duncan (2018).
3) A hands-on or very practical engagement to the modules is essential. Clear efforts are also made to ensure that the hardware used are industry-edge devices such as waspmote or Bosch XDK 110 as compared to just the use of Raspberry Pi or Arduino per se. The same applies to the use of software such as the ThingWorx IoT platform for developing industrial IoT applications. Besides, after a long day at work for these working professionals, lecture-based learning per se, where a classroom tends to be more passive, hardly aligns with efforts to engage and motivate student learner's especially adult learners.
4) Industry practitioner delivery, whether in the modules or in the form of industry study tours or industry seminars is also a key part of the intended programme. However, this is not possible for all engagements in the programme. Yet every effort is made for faculty staff to be trained by industry practitioners and gather relevant industry-level experiences beforehand. The programme that support the latter is named the Industry Attachment Scheme (IAS) and is described briefly later.
5) Technology enhanced learning was another feature that was introduced to deepen the students engagement with learning beside formal face-to-face sessions. In addition, such platforms afford for peer learning. In the SDIoT's case, a mobile platform called ULeap affords students the opportunity to engage with a wider community of learners outside of their peers. U-Leap is described later in this paper as well.

The structure of SDIoT therefore consist of two Post-Diploma Certificates (PDC's), with each to be completed within a six month semester, offered after office hours. The first PDC consist of 5 modules and the second PDC consist of 2 modules. See Tables 1 and 2. For some of these modules, students may be granted exemption on the basis of Recognition of Prior Learning (RPL) given the profile of adult participants that apply into this programme.

Table 1. PDC in Fundamentals of IoT

Post-Diploma Certificate (PDC) in Fundamentals of Internet of Things (IoT)
1) 3D Printing Fundamentals
2) Engineering Basics
3) System and Programming Basics
4) Introductory Statistics and Analytics
5) Internet of Things (IoT) in Consumer Electronics, Health, Homes – A Case Study Approach

Table 2. PDC in Advanced Applications in IoT

Post-Diploma Certificate (PDC) in Advanced Applications in Internet of Things (IoT)
1) Internet of Things (IoT) in Cities, Industry, Business – A Case Study Approach
2) Design Thinking Capstone Project

Upon successful completion of the SDIoT, the students will be well equipped to design, build and test complete IoT solutions that comprise sensors, wireless network connections, data analytics and display/actuators and write the necessary control software. Driving these outcomes are the design of assessment components, modes and weights that are industry or practice driven, in keeping with the professional learning approach adopted.

The Practice of Professional Learning

1. Industry Case Studies

The use of case studies are not new and their application in education is widespread especially in the fields of management, public policy, social sciences, medicine, law and engineering, as described by Bowe (2011), Yadav (2010) and Sarah (2011). Within the context of a professional learning programme, we have incorporated industry case studies as they afford an engagement that is more experiential, where students learn by doing. They are encouraged to ask questions and make informed decisions. They will need to participate and collaborate as they would as professionals at work where they need to understand the facts of a case and the variables to be debated, grasp what is going right and what is going wrong, what are the goals and objectives of the case and develop an action plan based on industry practices and standards, optimizing where necessary, in deriving a solution. The nature of such forms of engagement in learning enhance the employability or career of the students.

In our Specialist Diploma, two of the modules namely "IoT in Consumer Electronics, Health, Homes" and "IoT in Cities, Industry, Business" are taught using the industry case study approach where carefully selected case scenarios that are drawn from the projects of industry partners are used. These modules build on the foundation of the 4 introductory modules, though lesson matter content will still be taught within the two modules. But in this case, the lessons will be driven by the intended outcomes of the case scenario.

For a recent cohort undertaking the module, "IoT in Consumer Electronics, Health, Homes", students were engaged in discussion and in designing and solutioning activities for a case study related to the pest situation in Singapore, The module culminated in the development of various prototype(s) that demonstrate the different approaches students took to addressing the pest situation.

Case Study: Connected Mouse Trap
Background: Huiwen (2016)
Industry: Pest Control
Issue (In Brief):

- A company had wanted to improve their product offering and competitive advantage. They wanted to create an intelligent mousetrap that lets users know when the trap has caught a mouse, thus preventing the user from having to check the trap every day.
- In order to make this happen, the company needed a way to send signals from battery-powered traps to an email or mobile phone. Because the traps run on batteries, the company would need something low-powered but could still send a strong enough signal inside a building.

In the module, the students went through a few stages, starting with identifying/clarifying on the problem/opportunity. In this case:

- Each team was tasked to list down the possible business/operational challenges and address the "why" questions. For example, why is this company deciding to embark on a journey for a connected mousetrap? etc.
- Each team is also required to also think and estimate how much this particular problem would cost. They need to develop a Return of Investment (ROI) metrics and identify users, buyers and financiers.

Following from the above, the teams moved towards technical solutioning where they adopt industry informed processes or workflows for building IoT systems, such as that described in Fuller (2016). In this case, a 4 stage architecture is adopted in which the technical elements to be considered at each stage start with sensors and actuators to the internet gateway, then the edge IT processing systems and finally the data centre and the cloud. As expected, teams have competing views and proposed different solutions to the 'problem'. Figures 1 and 2 demonstrate the solutions from two teams.

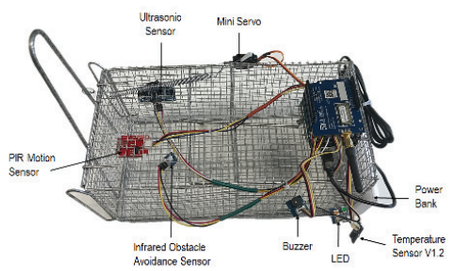

Figure 1. Student Prototype Mouse Trap

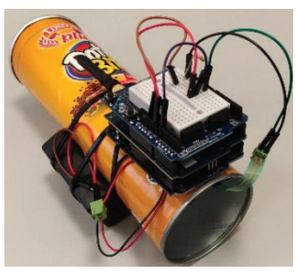

Figure 2. Student Prototype Mouse Sensor

For the same cohort undertaking the module, "IoT in Cities, Industry, Business", students were engaged in the case study below:

Case Study: Overall Equipment Effectiveness (OEE) of Collaborative Robots
Background: Woo (2017)
Industry: Manufacturing
Issue (In Brief):

- As more companies move towards the adoption of automation and robotics into their operations, IoT technologies are incorporated to track daily operational metrics. One such key metric is the OEE where uptime will directly impact the profitability of the company.
- In this case, the company concerned had purchased two sets of collaborative robots to help with their production assembly. To realize rapid deployment, they wanted to utilize the industry-ready IoT sensor – Bosch XDK110 and the Thingworx Application Platform to capture data that allows for an assessment of OEE.

A widely used industry-based 5-step problem-solving technique based on DMAIC (Define, Measure, Analyse, Improve and Control), as described in Ng (2014), was applied in this case. Solutions utilizing IoT were developed as students moved along the DMAIC methodology as they analysed the different data presented by the sensors in deciding which sensors data are effective in keeping track of the OEE.

A student survey to gather feedback on these modules that used an industry case study approach was conducted. The questions are shown in Table 3 and the outcome of the survey are shown in Figures 3 and 4. On the whole, the survey rated an average of at least 4 for all questions.

Table 3. Module Survey Questions

Q1	The objectives of this module are clearly stated.
Q2	The module has achieved its learning objectives.
Q3	The coverage of the module is adequate.
Q4	The depth of the module is appropriate.
Q5	The lesson materials (lecture notes/hand-outs, worksheet questions, laboratory and practical worksheets) are well designed and organised.
Q6	The lesson materials (lecture notes/hand-outs, worksheet questions, laboratory and practical worksheets) have aided my understanding of the topics covered.
Q7	The contents (such as concepts and skills) presented in this module are useful and relevant to my work.
Q8	The amount of work required in this module is reasonable.
Q9	The assessment method(s) for this module is appropriate and fair.
Q10	The recommended list of readings and resources are useful in increasing my understanding of the contents covered.
Q11	My overall rating of module delivery is…

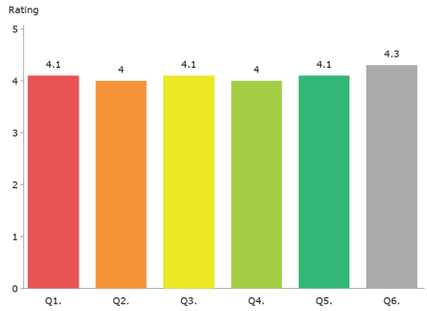

Figure 3. Survey Result for Q1 – Q6

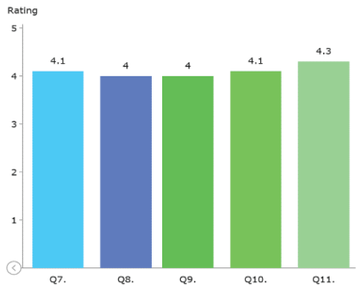

Figure 4. Survey Result for Q7 – Q11

Qualitatively, the overall student feedback was encouraging and on the whole, positive as well. Students claim greater confidence, skills and professional awareness after these modules as they experience the benefit of applying theory and knowledge to practical problems. Even though the problems may be more challenging, they found them energizing.

2. Industry Capstone Projects

In this module, students will demonstrate their competencies in designing, architecting and building a larger scale prototype IoT solution in response to a problem scenario that is provided by an industry partner. In some cases, a problem scenario from the student's workplace can be accepted. It was a clear decision in the design that we wanted students to work on actual industry projects. And student will also work in teams as they would do in the real-world, as much as they will be required to synthesize and apply the IoT knowledge and skills acquired to real-world issues and opportunities. Students will also use this module to further deepen their skills in specific domains of their interest.

A unique feature in this module is the incorporation of Design Thinking as described in Dam (2018). Design Thinking is described as a methodology that is used to solve complex problems and find desirable solutions for clients. The mind-set is solution-focused and action is oriented towards creating a preferred future. Design thinking will draw upon the imagination, intuition, logic and systemic reasoning of the individual and/or team which we wanted to develop in the students as they explore

possibilities of what could be and to create desired outcomes that benefit the end user or client. Especially pertinent in the area of smart cities.

To facilitate such an engagement, students will attend a series of design thinking workshops in the module and come up with a proposal for their project based on the industry scenarios. Once the project proposals are submitted, students will be matched with their respective project supervisors and/or industry sponsors for further consultation.

3. Industry Study Tours

The purpose of study tours is to allow students to see theory in practice and enquire of the professionals on site their specific issues/challenges on the ground which can enrich and complement, as well as connect their classroom learning to industry practice. On this, study tours are arranged for internal and external sites. One such study tour was a visit to the Centre of Innovation for Supply Chain Management (COI-SCM) which was jointly set up between RP, SPRING Singapore and the Economic Development Board. This centre specializes in innovation, process re-engineering, and the adoption of technology, including IoT to help companies improve on their supply chain capabilities. In this visit, practitioners shared how IoT solutions used in their supply chain eco system allowed them to gain insights that were previously not possible.

4. Industry Practitioner Delivery

The SDIoT programme actively engages industry practitioners, from the teaching of modules to delivering specialized lectures or seminars including assessment of student projects where possible. These engagements afford students direct exposure to the varied experiences of industry practitioners and often, on topics outside or more advanced than those of the declared learning outcomes. At the point of writing this paper, at least 2 industry seminars had been conducted by industry leaders on such topics. One is briefly described below:

Seminar Title: *Cyberattacks on IoT Systems*.
This seminar addressed the state of security in the IoT space, the pros and cons of current security technologies and standards in IoT, the challenges of Public Key Infrastructure (PKI) in IoT and future security challenges envisaged in IoT.

Industry Associate Scheme

To support professional learning, there are a number of enablers that are key.

- Institutional support in encouraging professional learning is important e.g. putting in place policies and procedures that are "friendly" when engaging external industry partners. Part of this include staff training and development on industry practices to ensure their relevance and currency to the programme.
- Staff being encouraged and trained to develop their teaching practices for professional learning. Staff within the institution need to also work with industry partners to ensure academic rigour.

In RP, one such policy or scheme is called the Industry Associate Scheme (IAS) in which academic staff are encouraged to be associated with the industry in a systematic, coordinated and sustainable way so that the experience that they gather through their association with industry would augment their pedagogic training. Staff are kept abreast with industry trends and are exposed to cutting-edge technologies which increases their ability to create relevant educational problems centred on the institution's unique Problem-based Learning (PBL) pedagogy. In the case of the SDIoT, our practice of Professional Learning.

Mobile Learning and Extended Community Engagement

In keeping with current trends on learning, we have also complemented the programme with the inclusion of a mobile learning platform for professionals called ULeap. ULeap is an initiative of The National Trades Union Congress' (NTUC) e2i (Employment and Employability Institute) in Singapore, in partnership with RP, amongst other institutes of higher learning.

The students, as working professionals, can tap on this convenient learning application to get quick, up-to-date, bite-size information on issues (see Figure 5) and exchange know-how with other experts in the field, including trending discussions, as part of a wider learning community (see Figure 6). This platform and its learning community offers "timely" and a real-world perspective that sets it apart from other learning portals and courses.

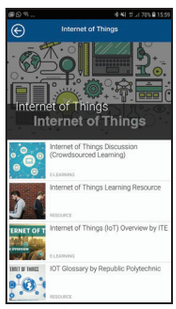

Figure 5

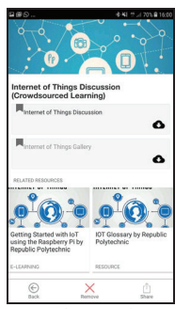

Figure 6

Industry Support – Lessons / Insights

Engaging industry is not always easy for reasons of time and effort, for which the benefits to the organization if any, are not immediately or necessarily measurable. We have experienced instances where the benefits of such an engagement from "industry" lay

solely on a said individual or two and may be guised as a Corporate Social Responsibility (CSR) initiative. The latter suggest that the position is precarious. For our program, we have expanded and spread our industry engagements across a diverse group of industry partners whose motivations are similarly varied.

Conclusion

The practice of professional learning in SDIoT has seen a number of benefits for both the institution and students. The use of industry case studies and projects, with industry practitioner engagement in the curriculum, brings authenticity and relevance to the curriculum where the students ability to apply the multi-disciplinary knowledge and skills gained to tasks has seen students being more engaged and enthused with their learning. The application of industry practices in addition exposes students to actual workings within industry and they are better equipped to fulfil job functions or seek (new) employment or opportunities. Industry practitioner engagements in the form of study tours and seminars further expose students to the varied experiences of industry practitioners, especially on issues, problems on the ground through 'corridor conversation' that stretch beyond a formal curriculum.

Developing industry engagements is key in a professional learning programme. Initially, it will be time consuming and arduous but as relationships become more established and win-win in structure and nature, the efforts will moderate. On the long term, a virtuous cycle that benefits the institution, its students and industry is on offer.

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Sub Theme 4

International Connectivity



FREE VIBRATION OF CRACKED FUNCTIONALLY GRADED BEAM WITH AN EDGE CRACK UNDER TEMPERATURE EFFECTS

May Mei-fung Tam[a], Chuang Feng[b] and Jie Yang[c]

School of Engineering, RMIT University, PO Box 71, Bundoora, VIC 3083 Australia

[a] s3407314@student.rmit.edu.au, [b] chuang.feng@rmit.edu.au, [c] j.yang@rmit.edu.au

Abstract

Functionally graded structures have been attracting great attention due to their unique attributes and benefits. It is well accepted that cracks occasionally exist in engineering structures, which introduce a local flexibility and significantly influence the dynamic performance of the structures when subjected to vibration.

Keywords

Functional graded materials, free vibration, beam, composite structure, thermal environment

Introduction

Investigation of the effects of the cracks on the vibration characteristics of the structures is essential for their engineering applications. In addition to cracks, when structures are exposed to temperature, thermal expansion of the functionally graded materials also plays important role in altering the vibration of the structures. Extensive studies [1, 2] have been found on the free vibration of functionally graded beam with the consideration of crack. However, the majority of previous works are focused on analysis without considering temperature effects. This paper will investigate the free vibration of a functionally graded beam with considering both cracks and temperature effects by finite element simulation.

Finite element analysis

A functionally graded beam as shown in Fig. 1 will be modeled by finite element package ANSYS. The lengths, width, thickness of the beam are L, b and h, respectively. As can be seen, there is a crack on the top edge of the beam. The location of the crack is denoted by length L1 while the depth of the crack is represented by a.

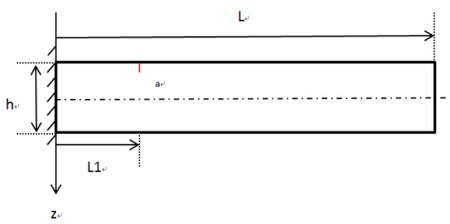


Fig. 1 Configuration of FGM beam with edge crack

For this functionally graded beam, the top surface of the beam is 100% aluminum with Young's modulus being E_1 = 70 GPa and mass density being ρ_1 = 2780 kg/m^3. The material properties of the beam in the thickness direction are expressed as following exponential equations

$$E(z) = E_0 e^{\beta z}, \rho(z) = \rho_0 e^{\beta z}, \alpha(z) = \alpha_0 e^{\beta z} \quad (1)$$

where E_0, ρ_0 and α_0 are the Young's modulus, mass density and thermal expansion coefficient of the materials at $z = 0$, and β is an index determined by the material properties of the top surface of the beam. The Young's modulus of the bottom surface of the beam is denoted as $E2$. By setting the value of E_2/E_1, the parameter β and the Young's modulus E_0 will be obtained. Particularly, when $E_2/E_1 = 0$ the functionally graded beam reduced to an isotropic homogeneous beam.

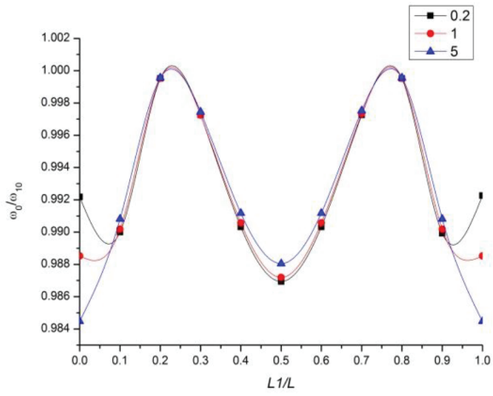
To simplify the modelling, plane 182 element is used for build the beam. Here it should be noted that for finite element modelling it is possible to obtain the continuous varying material properties in thickness direction as described in equation (1). From our previous modelling, it is found using 30 layers will be accurate enough to get functionally graded beam. For each individual layer, the material properties will be calculated by equation (1) by substituting z with corresponding values. For modal analysis of the beam in ANSYS, Block Lanczos method is adopted by extracting the first 5 mode shapes. The reference temperature of the structure is set as 300 K. In order to take the thermal effect into account, the beam is analyzed when temperature increase is applied. Then the modal analysis is done by considering pre-stress effects.

Results and discussion

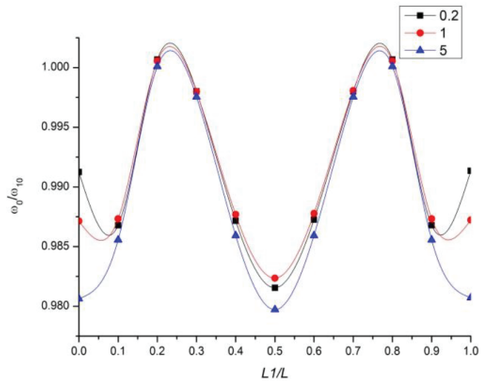
For the finite element analysis in this study, the beam is clamped-clamped and the slenderness ratio of the beam is L/h = 20. The crack angle is 1 degree and the ratio of crack depth to the thickness of the beam is 0.2. The Young's modulus ratio E_2/E_1 is set as 0.2, 1.0 and 5.0, respectively. Fig. 2 plots the variation of frequency ratio ω_0/ω_{10} with the location of the crack, which is described by L1/L. ω_0 and ω_{10} denote the natural frequency of the functionally graded beam and the isotropic homogeneous beam, respectively.

L_1/L =0.1 to 0.9 nearly overlaps in the graph. Fig. 2a shows the frequency ratio without considering thermal expansion. It is found that beams with E_2/E_1 = 5 have the lowest natural frequency at when the crack happens at the ends of the beam. In contrast, beams with E_2/E_1 = 0.2 and 1 have the lowest frequency when the crack at the mid-span of the beam. Figs. 2b and 2c are demonstration the frequency ratio with considering temperature effects. The temperatures are increased to 400 K and 500 K, respectively. Compared to Fig. 2a, it is obviously the natural frequency of the beam is reduced. This is attributed to the thermal expansion, leading to the decrease in the rigidity of the beam when clamped at the both ends. In addition, it is found that the temperature not only reduces the frequency but also change the distribution of the curves. With considering temperature effects, the beams with E_2/E_1 = 5 have the lowest natural frequency at L1/L = 0.5. With the increase of the temperature, the natural frequency becomes more sensitive to the Young's modulus ration E_2/E_1. From the above analysis, it can be seen that both the crack and the temperature play important role in the vibration characteristics of the beam.

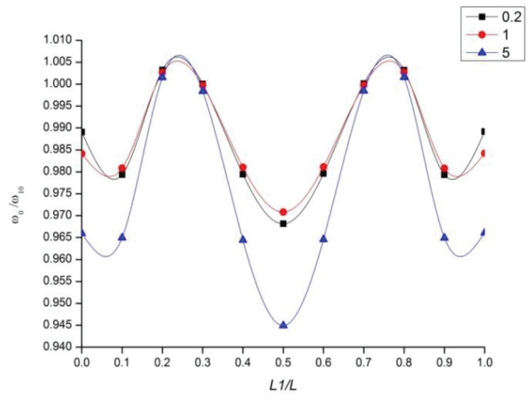
Without considering any each of them might induce inaccuracy and error in predicting the performance of the beams.



(a) 300 K



(b) 400 K



(c) 500 K

Fig. 2 Variation of frequency ratio with crack location for C-C FGM beams (a) 300K; b) 400 K; c) 500 K.

Conclusion

Free vibration characteristics of a functionally graded C-C composite beam is studied by finite element analysis with consideration of crack and temperature effects. It is found that the natural frequency of the beam is highly dependent on the location of the crack and the material distribution in the thickness direction of the beam. The increase of the temperature can significantly decrease the natural frequency of the beam. The natural frequency of the beam is more sensitive to the material gradient when the temperature is high. It is also noticed that without considering temperature, beams with the ratio $E_2/E_1 = 0.2$ has the lowest natural frequency when L1/L = 0.5. However, beams with the ratio $E_2/E_1 = 5$ have the lowest values when considering temperature effects.

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IMPLEMENTATION AND THE CONSIDERATION OF THE GLOBAL ENGINEERING EDUCATION

Fumitake KATO *

* National Institute of Technology, Ibaraki College,
HITACHINAKA, JAPAN

*katobnbf@mech.ibaraki-ct.ac.jp

Abstract

In the field of engineering education, Toyohashi University of Technology (TUT), Nagaoka University of Technology (NUT), and National Institute of Technology (NIT) have conducted the construction of the global educational environment (Tri-Institutional Collaborative/Cooperative Educational Reform Project), since 2014. As one of the global activities, TUT has provided Global Faculty Development (GFD) project since 2013 including the preparation. In GFD project, teachers from TUT, NUT, and NIT joined to develop and brush up the teaching skill to conduct lectures and practical workshops, for the global engineering education. The project has been carried out in three places: TUT Head Quarter, City University of New York Queens College (CUNY QC), and TUT Penang Campus in Malaysia. The acquisition of teaching and learning skill in the area of multi-cultural and multi-ethnic society was very effective and meaningful to step up the international skill of teaching. After the training in New York, actual lectures have been carried out in polytechnics and a university in Malaysia, to complete the outcome of the project. The technical subjects based on engineering field such as mechanical, electrical, chemical, architecture, civil engineering have been lectured in Politeknik Tuanku Sultanah Bahiyah (PTSB), Politeknik Seberang Perai (PSP), and Universiti Sains Malaysia (USM). The author made lectures of image processing technology for production engineering. In order to lead the students for the introductory learning of the industry field, basic and fundamental topics were lectured and explained. To encourage the comprehension of the learning contents, simple but useful concepts of image processing theory and practical examples were provided. In this paper, the detail of the trial of the technical subject lecturing, the evaluation, and considerations are described.

Keywords: *image processing, quality control, production engineering, industry 4.0, engineering education, faculty development of teaching, international activities*

1. Introduction

As the growth of global economy and industry, ethnic diversity has been spread and developed in many regions of the world. It has also given rise to the needs of globalization of education, especially in the fields of science, technology and engineering (e.g., Banks, J.A. (2007) and Downey, G.L. (2010)). In a part of conventional and traditional style of higher education, teaching and instruction had been done to the native students as the majority, and to the foreign students as the minority in the native language. However, as the worldwide movement of ethnic diversity spreads, the new trials of education have been needed to respond to the globalization of education (e.g., Ness and et al. (2017) and Moore C.B. and et al. (1997)). In order to fulfil the needs, teachers and instructors have to have the teaching skill in common language such as English even in Japan, and the sense of mutual understanding in international circumstances (e.g. Hoff, E. (2009)).

As described in the abstract, the author joined the GFD project in 2017. It was one-year project, and the trainees including the author have developed and reinforced the teaching skill under the international educational environment. In order to complete the project, and as the final stage of training of the project, the trainees had an opportunity to make lectures in three educational institutes in Malaysia. They were conducted mainly in mechanical, electric, electronic, and computer science classes. The contents which the author lectured are oriented to learn the fundamental and basics of image processing for industries, so that the students can easily start the study, and be interested to learn the technology.

This paper describes the details of conducting the lecture. It consists of main three parts, the preparation, the implementation, and the feedback & assessment. In the section 2, the concept and the topics of the lecture are described as the preparation. In the section 3, the implementation of the lecture is described. In the section, the contents of the lecture, the class going, and the communication with the students are described. In the section 4, as the results and the discussion, the survey of the lecture by the students and the results are described. In the section 5, overview and the consideration are described as the conclusion.

2. The preparation of the lecture

2.1 Structure and the flow of the class

When we make lectures, especially in the case of the students' backgrounds are academically and ethnically varied, such as internationally circumstanced class, the teacher/lecturer needs to design the lecture contents more cautiously and properly than domestic and conventional case. To avoid the situation of misconception and/or low comprehension of the learning contents, it has to be carried out with organized and consistent flow (e.g., Caspi and et al. (2005) and Ambrose and et al. (2010)). In order to realize the organized lecture, the flow should be consisted mainly three parts: introduction, main part (subject matter), and conclusion. In the part of introduction, warming up and ice break talk should be included as the start up. After showing the contents list and outline of the lecture, the back ground and the objective of the subject are explained sufficiently, to clarify the purpose of learning the subject. At the end of the introduction part, small quiz and Q&A are also useful to simply check the comprehension and the reaction.

Next to the introduction, as a first step into the subject matter, a fundamental theory of the main theme is explained, and an example is given to understand the theory easily. To encourage the students' interest, the example should be easy and/or familiar to imagine and figure out the problems. Using the first example of the subject, a basic and easy question is given to the students. To solve the question, the topic can be discussed with the group. If they seem difficult to figure out, giving hints is also effective. By the interactive communication with the students, finally reach the correct answer and the essential part of the theory. After the small comprehension check with Q&A and short discussion, proceed to the next level of the subject. At the second step, to accelerate and to deepen the comprehension of the subject matter's concept, middle level (or advanced) question is provided. Using the concepts and the skill which are obtained in the first question, students try to solve an advanced problem. In this step, the combination with the former question and the concept to learn, new concept, and the related skill are given to the students. Through the communication of the comments and questions from the students, the teacher should overview and recognize the level of students' comprehension and the interests of the subject matter. As the third part of the subject matter, advanced level of the contents are explained and displayed to make students to have wider knowledge and skill of the subject. Where needed, another quiz or assignment could be provided to step up the higher level.

As the final part of the lecture, the conclusion of the class is explained. In this part, the important and effective points of the contents should be listed to summarize the subject matter. This is also an important part to deliver the useful, practical, and essential part of the lecture. To set up these process for the lecture's preparation, the teacher has to be aware of international sense of communication with the students, supposing the students are consisted of multi-national background. To share the concepts of the subject with the students, the delivered message should be constructed with the global mind set.

2.2 Build-up of the contents of the lectures

In order to conduct the lectures for the students of three institutes in Malaysia (PTSB, PSP, and USM), fundamental theory and basic skills of image processing have been applied. At the step of the preparation, the students' academic profile, such as the learning background of mathematics, physics, and engineering was previously informed. The target students belong to mechanical engineering, electric/electronic engineering, and computer science departments. Addition to that, the age-group and the students' attitude (e.g. quite positive and/or shy), are also useful as a prior information, to make a good matching with the contents and the students. The contents is mainly based the software part of the technology, and specially oriented to apply the field of production engineering such as plants and factories. To keep the good quality of the product which are assembled on the production line, quality control is crucial and essential. As one of the solutions to realize the quality control, image processing technology is very practical to detect the defects and problems of the products on the production line. On the other hand, the demands of the engineer who has the skills of image processing are rapidly growing, especially in the field of factory and logistics engineering (e.g. Industry 4.0). As we know, East and Southeast Asia regions have big potential as markets and manufacturing bases. To respond the potential also, the learning the basic of image processing for the industry is quite effective and useful.

To start the introductory learning for the image processing technology, the color image structure, the color decomposition, threshold process, and size-selection are introduced. As one of the color structure of digital imaging technology, RGB (Red Green Blue) is widely known and used. The conceptual scheme is shown in Figure 1.



Figure 1: Color decomposition and three primary colors

Each color component's intensity is numerically digitized in the range of 0 to 255, from darkest to brightest i.e. 256 levels. A color which is displayed in digital imaging, are combined with the three color-components. The combination number is numerically calculated as shown below:

$$256(R) \times 256(G) \times 256(B) = 16{,}777{,}216$$

That is to say, digital imaging color is able to theoretically display 16,777,216 colors.

As the next step, one example is given. That is supposing we are the engineers to manage the quality control of a production line of a factory. The products are toys, so that the students can tackle the problems in familiar way. The mission of the engineer is to check the quality of the products from the image of the product inspection. The concept of the production line is shown in Figure 2.

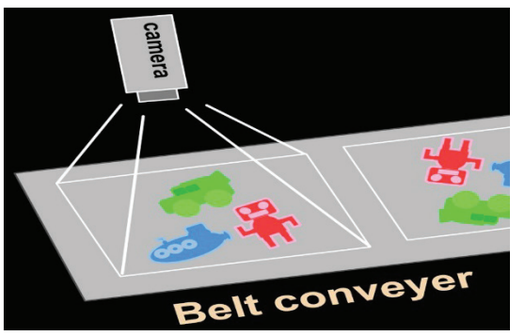

Figure 2: The concept image of the production line

As shown in the figure, a camera for the products inspection is installed above the belt conveyer. The aim of the lecture is to learn the function and the algorithm to detect a standard and/or defective item in the image for the product inspection. To correspond with the three primary colors components, products are designed, as shown in Figure 3. They are Red Robot, Green Car, and Blue Submarine.

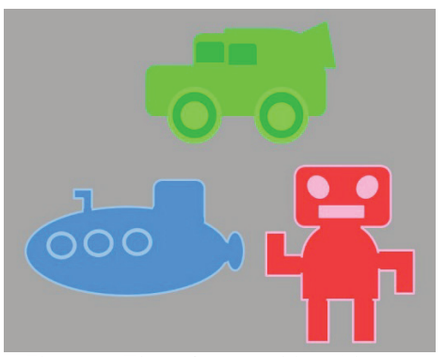

Figure 3: The reference objects' image

These three objects are the standard products, and these are the reference images to compare with objective images. Each product has each color, shape and size. These factors (color, shape, and size) are the key to differentiate with other standard and/or defective items. The concept is the precondition for the introductory learning of fundamental and basic of learning image processing. The next section describes the implementation and the related matter of the lecture.

3. Implementation of the lecture

After the preparation as described in the previous sections, the implementation of the lectures is carried out. In the part of introduction, the industrial needs, importance of image processing were explained, as the background, and the direction of the lecture which is introductory learning of image processing. As the next step, the basic concept of the lecture which is described in the section 2.2 was presented in detail. In order to display the process of color-decomposition which is shown in Figure.1, an example image is decomposed in each color. Using the image processing software, the color-decomposition process is demonstrated in front of the students. The reference image (Figure.3) is decomposed as shown in Figure.4.

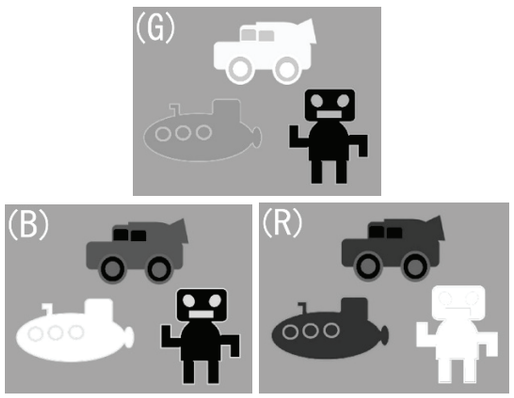

Figure.4: Color-decomposition of the reference image
(R) Red-component image,
(G) Green-component image, and
(B) Blue-component image

As shown in the Figure, Red Robot is brightest in the Red-component (R), Green Car is brightest in the Green-component (G), and Blue Submarine is brightest in the Blue-component (B) image. It tells us the relationship between each reference product's color and the color-decomposition result. As a common rule, "brightest part is the target" to detect the standard object (reference image) in an image area. In other words, to detect the red object, red-component image should be chosen, to detect the green object, green-component image should be chosen, and to detect the blue object, blue-component image should be chosen.

3.1 The first step for the basic problem solving

As the next step, a basic question is given in the class. The image of the question is shown in Figure 5. The question is as follows:

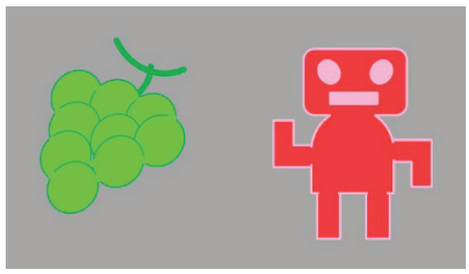

Figure 5: The image of first question

"To detect the standard item, which color-component would you choose, red, green or blue?"
As shown in the figure, one item (green fruit) which is not a standard item (wrong object) is displayed. The aim

of the question is to choose the correct color-component image to detect the standard object i.e. Red Robot in this case. The selection of color-component of the image is important and practical for the detection of the target object in color. Thus the color-component selection is asked as the first question. After the question is given, the students had several minutes for the discussion among them. The color of the standard item (target object) is red, so the red part of the image has to be the highest intensity (brightest) in the component image. After the discussion, let them choose and raise their hand for the correct option, from red, green, or blue component images. And several students are asked why they chose the color-component image. The reaction and the comprehension of the lecture can be checked by the discussion. As previously described, the red object is brightest in red component image. After their choice, color-decomposition process is demonstrated in front of the students. The image of the result is shown in Figure 6.

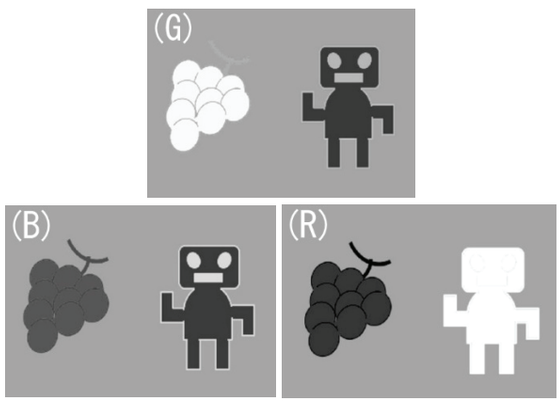

Figure 6: Color-decomposition of the target image
(R) Red-component image,
(G) Green-component image, and
(B) Blue-component image

As we see from the Figure, the red-component image has a brightest part at Red Robot. Therefore, the correct answer is **(R) Red-component image**. By the thresholding process to search and mark the brightest part in the image, the question which is searching the standard item in the image can be solved. The result of the software performance is shown in the Figure 7.

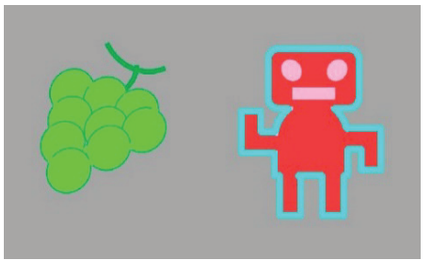

Figure 7: The detection of target image (Red Robot) by thresholding process

As shown in the figure, Red Robot part is bordered with light-blue line. By the detection of Red Robot in the image, the shape, size, and the location are also obtained as the numerical value. Through the solving the problem, students can learn the concept of color-decomposition of the image and thresholding process.

3.2 The second step for the further level problem

As the further step, another problem is given. The image of the question is shown in Figure 8. The question is as follows:

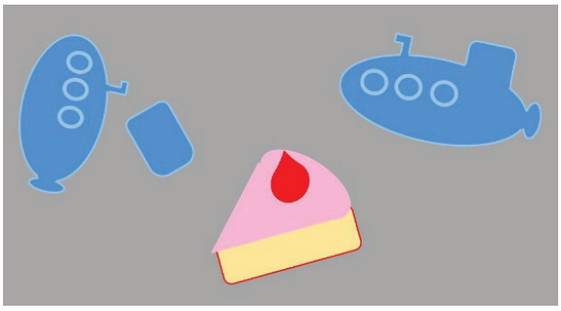

Figure 8: The image of second question

"To detect the defective item and wrong object, which color component would you choose, red, green or blue? (You can choose 2 components)"
To avoid confusions and misconceptions, the options are listed.

A) Green & Red
B) Red & Blue
C) Blue & Green

As shown in the figure, one item (reddish cake) which is not a standard item, is displayed as a wrong object. Addition to that, a broken submarine is seen in the left hand side. The aim of the question is to figure out how to choose the correct components combination to detect the cake as the wrong object, and the broken submarine as the defective item. To solve the problem, several steps are needed to find out the wrong object and the defective item. As we did in the first problem which is described in the previous section, the color-decomposition is done as the first step. The image is shown in Figure 9.

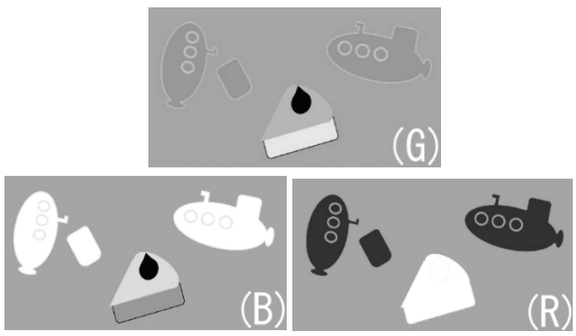

Figure 9: Color-decomposition of the target image
(R) Red-component image,
(G) Green-component image, and
(B) Blue-component image

As we see in the figure, all of objects are not bright in the figure (G), and that suggests the Green-component image is not suitable for the detection of the target images which are red and blue objects. That is to say, the correct

answer of the question is the option **B) red & blue**. In order to find out the two targets (red cake and broken blue submarine), two steps of image processing are applied. At first, the red cake which is wrong object is detected by the thresholding process in the Red-component image (Figure10).

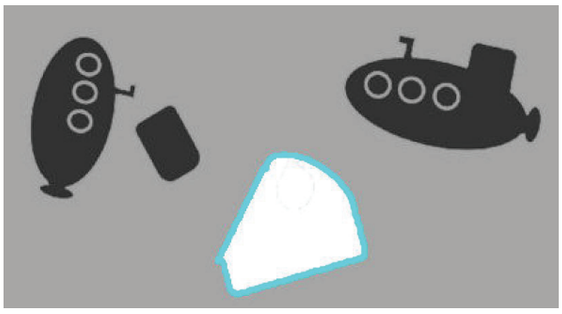

Figure 10: The detection of target image (red cake) by thresholding process in the red-component image

As the second step, thresholding process is applied to the Blue-component image. As shown in Figure 11, both of broken and standard submarines are detected.

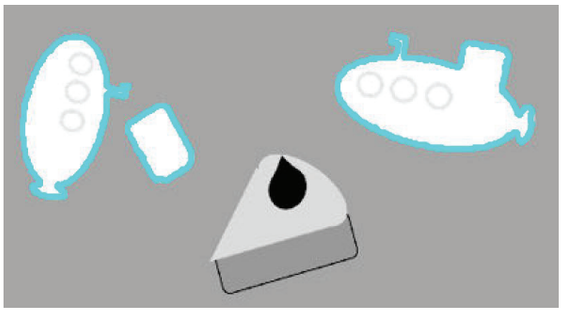

Figure 11: The detection of broken and standard submarines in the blue-component image

As the third step, size-selection processing is applied after the thresholding. Based on the size of reference object (the standard product), smaller size of the object is selected as the target object (defective product). The result of the processing is shown in Figure 12.

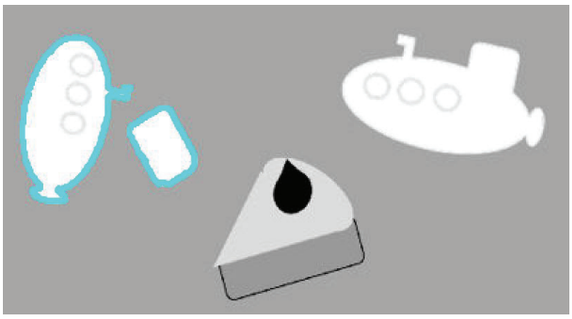

Figure 12: The detection of broken submarine by the size-selection processing

As the final step, combining the process results for the Red-component and the Blue-component images, the target objects are detected and displayed as shown in Figure 13.

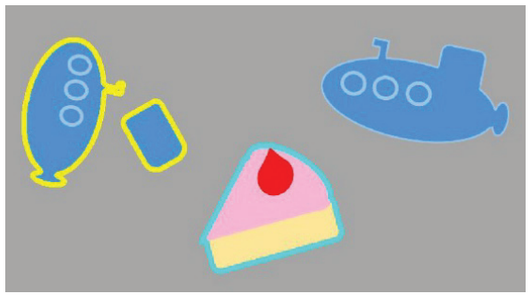

Figure 13: The detection of defective product and wrong object

The step of solving the question was also demonstrated by the software's performance, and the students could realize how the image processing works for the product inspection. After the Q&A and discussion, the practical concepts are explained as the summary. Through the lecture, students have learned practical image processing methods (color-decomposition, thresholding, and size-selection) for the production engineering.

4. Results and Discussions (The evaluation of the lectures)

At the end of the lecture, the survey of the class has been conducted, to evaluate the quality of the lecture and the class going. The contents of the survey is as follows:
The evaluation of the lecture

(1) Organization
(2) Interest level of the topics
(3) Comprehension level
(4) Satisfaction

The lecturing skill

(5) English skill
(6) Attitude of the teacher (gesture, posture and eye contact)

Each item's evaluation is ranged from 1 to 5. Higher number is, higher the evaluation is. Totally five lectures were carried out in three institutes, and every class is surveyed for the evaluation of the lecture. As one of the result, the evaluation which was surveyed in USM is shown as radar chart in Figure 14.

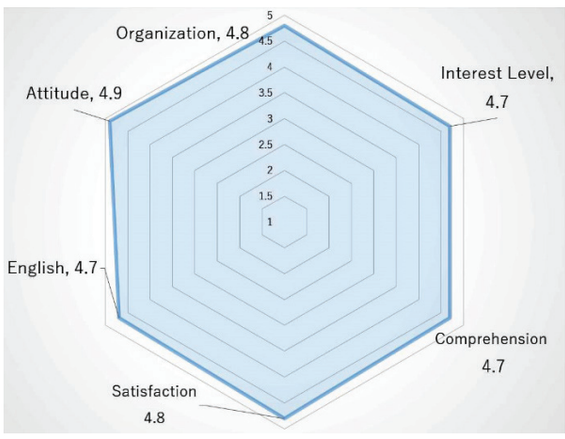

Figure 14: Evaluation of the lecture in USM

The class has 54 students, the ratio of boy and girl students was roughly 50% and 50%. They belong to Sixth semester (Third grade) of the Electric & Electronics Engineering Department. They were good attitude, positive behaviour, and well concentrated to the lecture. Their reaction and response to the questions were good, and the discussion with the students was also active. These students' reaction, response, attitude, and the communicated class going between the students and the teacher are reflected to the results of evaluation which is displayed in Figure 14. To clarify the detail of the result above, the breakdown of each item is shown in Figure 15.

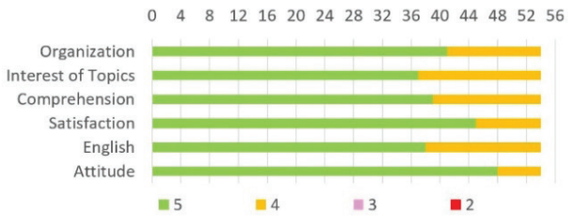

Figure 15: Breakdown of each item of the evaluation

As shown in the figure, the variation of the data is not so high, and it suggests that most students could learn and understand well about the main theme of the lecture. Addition to that, similar good evaluation results were obtained in PTSB and PSP as well. These results imply that the learning motivation of students in polytechnics and universities in Malaysia have quite positive and high feasibility of further level of learning in the field of advanced image processing technology and quality control engineering for the practical level of the industry.

5. Conclusion

In order to realize the implementation of engineering lecture in the international circumstances, Global Faculty Development project has been carried out. The author has joined the project in 2017, teaching and communication skill in English has been reinforced in TUT and CUNY QC. For the implementation of actual and practical lecture of engineering, the introductory learning for the image processing of the production engineering is designed. It is oriented to teach to the students of engineering such as mechanical, electric & electronic, and computer science. The implementation of the lectures were evaluated by the participated students in three institutes in Malaysia. The evaluation results have been feed backed, and considered. And the further steps for the global engineering education will be carried on. To maintain the global connection and the network of engineering education, international exchange of teachers and students will be more important and should be more developed world wide. Trials as described in this paper may be a part of the realization of the movement. However, the activities are hoped to be more spread and developed in the educational institutes of the world.

Acknowledgement

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IMPROVING CRITICAL THINKING AND MEDIA AWARENESS THROUGH CLIL

REVIS Curtis*[a], AMANAI Kazuhito[a]

[a] National Institute of Technology, Tokuyama College/Liberal Arts Division, Shunan, Japan

*crevis4594@yahoo.com

Abstract

As educators, we should develop in our students an intellectual stance of healthy skepticism, so they become wary of simplicity and directness. This is essential to citizens who are bombarded daily with messages designed by professionals to influence their thinking as consumers and as voters. Teaching critical thinking in relation to media studies is a highly effective means to achieving this goal. Critical thinking in relation to media studies can focus on the development of students' ability to judge the veracity of information sources. This can be accomplished by implementing CLIL classes focused on examining English-language news sources for trustworthiness. Such classes could be implemented during high school or the first years of university, in a Global Issues or similar social studies class. In this course, students would read news articles at home to discuss at school during the following lesson. The challenge is having students use English to discuss news sources, so the articles studied should be kept below the students' actual English reading level. Students identify differences between news sources, and discuss what effect these differences had on their relative trustworthiness, all the while providing support for their choices. Teachers could employ role-playing, construct debates, have students draw pictures to illustrate ideas, or even write their own news stories. Because this is a CLIL course, new content and lexical items should be kept to a minimum. While teachers can provide guidance, suggestions, and clarification, the process of inquiry should be driven by students: the development of critical thinking skills requires a great deal of self-reflection; it cannot be taught. By exploring this topic in a second language, students gain experience with how language choices shape discourse. Students would also learn how to examine sources, and to discern emotional appeal from rational argument. There are many benefits to such a course: 1) increased awareness of news and events outside of student's own country, 2) increased attention to connotation and nuance in English, 3) increased sensitivity to how language is used, and 4) increased opportunities to discuss and be aware of current events.

Keywords: *critical thinking, media studies, CLIL, english, second language, global education*

The Importance of Critical Thinking Skills

The goal of education must be more than the training of new workers; it must be the development of new citizens. And in today's world, that means fostering students' ability to consider themselves as not only citizens of a certain country or culture, but of a globalizing society.

In the context of fostering students who are more able to consider themselves, and their positions, in a global network of people, the ability to critical analyze one's sources of information, and the communicate effectively with others about the relative reliability of such information sources, is an essential skill to becoming an productive member of societies. Critical analysis of information sources is one aspect of critical thinking. Classes designed to expose students to various types of news sources, to get them thinking about these news sources, and to making decisions about which are more trustworthy, can be vitally important to global education.

The importance of critical thinking to society cannot be understated. Unfortunately, there is no single definition that satisfies everyone; but a key aspect of critical thinking necessary to its definition self-reflection. This definition by "The Foundation for Critical Thinking" is a useful starting point: "critical thinking is that mode of thinking … in which the thinker improves the quality of his or her thinking by skillfully analyzing, assessing, and reconstructing it" (2015). Critical thinking is a skill, a skill based on self-reflection and self-awareness of ones own biases and presuppositions. As with any skill, it does not come naturally; it requires cultivation, guidance, and practice from a young age.

Critical thinking enables members of a society to be better able to perceive their relationships to other members of their community, and better able to fulfill their role as effective citizens. People who lack critical thinking skills have, for example, difficulty forming independent opinions and making independent decisions: actions we educators genuinely wish our students could master, especially in a time of increased reliance on social media for news and opinion confirmation, two activities which can lead to a narrowed worldview.

Critical thinking "entails effective communication and problem-solving abilities, as well as a commitment to overcome our native egocentrism and

sociocentrism" (Foundation for Critical Thinking, 2015). "Egocentrism" refers to an inability to consider the opinions of others; and "sociocentrism" refers to the assumption that one's own social group is always correct. Neither mode of thinking is valued by societies desiring members that are conscious and respectful of other people's cultures and beliefs. Also, [c]onsidering the rights and needs of others does not come naturally," says Dr. Kim O'Reilly (2008). Students generally cannot develop critical thinking on their own; that is why education is so important. Additionally, humans privilege their own points of view, and tend to seek those out for confirmation via social media, which leads to increased egocentrism and sociocentrism. As educators within increasingly globalized societies, combating these mindsets is essential to enabling students to make well-informed decisions, both in their school years and in their adulthood.

Examples of egocentrism and sociocentrism could easily be seen in the 2016 U.S. Presidential campaign, and the continuing divisiveness of American politics since that time. In the U.S. and across the world, people watch with alarm Donald Trump, the most recent President of the U.S.A., insistent that he is the best, the most intelligent, and most productive President in history (egocentrism) and see his calls to "Make America Great Again" as a thinly-veiled repetition of the idea "America is the Greatest" (sociocentrism). The divisiveness between Trump supporters and Trump criticizers has only increased since his inauguration. It is not so much that Donald Trump as President is a problem (though few outside of his supporters would argue it is not); it is, instead the continued and strengthening divisiveness of political parties, fueled by a decreased willingness to engage in meaningful dialogue and debate that is a significant problem in an democracy. When politicians can exploit their supporters distrust—and even complete rejection—of information from outside their own ranks, the foundations of democracy are weakened.

Lack of Development of Critical Thinking Skills

Simply put, the problem arises from a lack of educational focus on critical thinking. In America, the formal teaching of critical thinking typically begins at university. For those who do not attend university, however, the recognition of and training in critical thinking is lacking. These people tend to have a lower skill in critically examining claims made in various media. It is no coincidence that the majority of people who voted for Donald J. Trump for President hold no college degree. In fact, according to the Pew Research Center: "Trump's margin among whites without a college degree [was] the largest among any candidate in exit polls since 1980" (Tyson and Maniam, 2016). This paucity of educational focus on critical thinking is not, of course, limited to the U.S. Japanese educators in particular lament their students apparent inability or disinterest in forming independent opinions and analyzing information sources.

A lack of critical thinking skill leads to an increased susceptibility to false or misleading news. With an increasing number of young people getting their news online, exposure to false or misleading news can only increase, as the tools for ensuring the reliability of online news do not exist in any meaningful sense. Research finds that around half of America's young adults get their news from online platforms, and the researchers say this percentage will be even higher in the future (Mitchell, Gottfried, Barthel, and Shearer 2016). With an increase in online consumption of news and the online sharing of news sources, the need for critical evaluation of these news sources increases. Therefore, there is a great need for educators to develop students' abilities to question sources of information, recognize problems with those sources, and formulate their own methods of overcoming these problems.

Critical Thinking and Media Studies

Teaching critical thinking in relation to media studies is a highly effective way to create better educated, more aware global citizens. To improve global education in Japan, educators must develop students' ability to judge the veracity of information sources. This can be accomplished by implementing CLIL classes focused on examining English-language news sources for trustworthiness. By actively engaging students in this discussion, and encouraging them to discuss the issues together in English, a heightened awareness of language, of discussion, and of needs for reliability can be fostered.

Such classes could be implemented during high school or the first years of university, in a Global Issues or similar social studies class. Of course, it would be better to begin training students in critical thinking at an earlier age, and that might be possible in terms of other subjects, but to do so in the context of evaluating the reliability of news sources, high school or university students might better be able to engage with the subject and materials.

There are many benefits to such a course: 1) increased awareness of news and events outside of Japan, 2) increased attention to connotation and nuance in English, 3) increased sensitivity to how language is used, and, of course, 4) students will be aware of and discuss current affairs.

As students learn to evaluate the trustworthiness and reliability of news sources, they will also learn to communicate with each about these issues in a critical fashion. Active learning plays a key role, in that students must engage each other in discussion in order to improve their critical thinking skills.

Proposed Curriculum

These courses should be conducted in English, with a CLIL approach. CLIL stands for "Content and Language Integrated Learning," which places, in this case, the academic focus on media studies, not on English language acquisition. Learning of English comes out of the students' engagement with the content, and the English used in the lessons arises out of its necessity for communication between students and teacher on the subject. New vocabulary should be kept to a minimum

whenever possible, with the focus of activities being to promote active communication between students in English. The vocabulary and grammar used must be that which is necessary for the students to effectively engage with the materials and with each other. The focus of the lesson is to explore the materials and gain a better understanding of the subject, not necessarily to improve the students' use of English as a second language.

Essential language-acquisition activities should be a part of each lesson: speaking, listening, reading, and writing. The preponderance of class time would be devoted to reading and speaking; listening and writing would comprise a smaller percentage of time. Of course, these allotments are at the discretion of the individual teacher, dependent upon the needs of the students and the teacher's own particular educational approaches.

Students would read news articles at home, preferably with questions to guide their reading and consideration of the articles. These articles and questions would then be discussed at school during the following lesson. Because the challenge is having students use English to discuss news sources, the articles should be introduced using a scaffolding technique that step-by-step enables the students to engage with the materials. The reading-level of the materials should be kept at or just above the students' actual English reading level. There are sources available online for both determining the reading levels, and for providing different reading levels of articles. For example, "Breaking News English" (https://breakingnewsenglish.com/index.html) is an online site that provides news articles tailored to differing reading levels.

Each lesson should begin with a question to engage the students in the topic. The purpose of this question is the get the students thinking about the subject in English, and to establish an English-predominate environment. This also enables the teacher to identify student strengths and weaknesses in regards to the day's material, and to tailor the subsequent lesson steps accordingly. This is a key component in a CLIL approach: lessons must be adapted to the students needs, which may require fine tuning in lesson depending on what the students have already mastered or what they are struggling with.

The teacher would then show another news source on the same event students had read about at home. Ideally, this news source would provide a different take or interpretation of events. It is essential that students are introduced to differing viewpoints of events.

One of the end-goals of the course is to get the students generating critical questions about news sources, so the teacher should be modeling such questions throughout. For example: "Who is the source of the information? Does the source have training in that area?" Students need to learn to extrapolate information from a news source, or to research that information on their own.

The goal is to identify differences between the two sources. Students would then work in groups to discuss what effect these differences had on the relative trustworthiness of each source. Finally, students would rank sources in order of veracity while providing support for their choices.

Teachers could employ role-playing, construct debates, have students draw pictures to illustrate ideas, or even write their own news stories. The main goal is to get students exploring the topic in a second language and to increase their sensitivity to how language shapes discourse; also, we could help them recognize biased language choice, examine sources, and discern emotional appeal from rational argument. This is best accomplished by ensuring class time stays focused on students, with the teacher acting less as a lecturer and more as a guide to both English and to critical thinking.

Student Evaluation

Frequent questions are raised on how to evaluate or assign students grades in such courses. Do we focus our evaluation on their English ability? their vocabulary retention? their mastery of the grammar? The answer is: none of these, necessarily. In a CLIL approach, students should be evaluated on their engagement with the content and with each other.

(Before presenting some practical suggestions, let me state that in my experience, formal evaluation of student performance does not necessarily enhance the educational quality of a lesson. For a variety of reasons—all of them well documented in the educational literature—some students react well and some react negatively to evaluation. This author is in favor of removing evaluation from lessons in order to encourage participation and reduce apprehension about the correctness of the language used during lessons. The main focus of these lessons is, again, communication through English and the development of students' critical thinking skills.)

Consider the following recommendations, understanding others will of course exist:

1. Peer evaluations: at the end of each lesson, students assign their group members a score for the day's participation. Teacher takes the average score for each student.
2. Final presentations: students give presentations at the end of the course, in English.
3. Written essays, either individual or group work.
4. Continual assessment based on in-class participation, regular quizzes, and peer evaluations.

Conclusion

Because we are teachers as well as concerned citizens, we should be developing in our students an intellectual stance of healthy skepticism, so they become wary of simplicity and directness. Simplicity and directness of speech are not necessarily hallmarks of honesty and good intentions; they are key ingredients in effective marketing and political propaganda. Understanding this is essential to citizens who are bombarded every day with messages designed to influence their thinking as consumers and as voters. In

this Information Age, if we wish to foster effective, thoughtful, and well-informed citizens, we need to develop their critical thinking skills. Too often, propaganda is being substituted for ideas and complex discussion, feelings for knowledge and wisdom. People who lack experience and development in media analysis and critical thinking skills find it harder and harder to discern bias in news media even though they must form opinions on matters of real importance—and it is increasingly difficult to discern what is important.

U.S. voters choosing Donald J. Trump as their President was a reminder of how difficult our task as global educators remains. A significant portion of the U.S. electorate rejected the complexity of political discourse and demanded the simplicity of a straight-talker and deal-maker, and the continued rhetoric and policies of this President confirm that this is what his supports most value. What is more, media sources are divided into "fake" and "not fake" based more on the confirmation of those sources to preexisting beliefs rather than critical analysis, and this is detrimental to the health of free societies.

It is vitally important for educators to help students become citizens who can make well-reasoned, well-informed decisions independently. As Aldous Huxley rightly pointed out, one of the greatest dangers to Democracy is a population unaware of the use of language to mold opinion. Teaching courses in how to analyze news media and determine what is a reliable source for information is an essential first step—and if we can do that while improving our students' English, so much the better.

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INTRODUCTION OF ONE DAY EXPERIENCE OF KOSEN CLASSES - A NEW PROGRAM FOR INTERNATIONAL EXCHANGE ACTIVITIES AT NIT, NAGAOKA COLLEGE -

Katsumi Ichimura*[a], Yosuke Shimamune[b], Shuichi Sato[a], Shigeru Ogawa[a], Rumi Shindo Togashi[a]

[a] National Institute of Technology, Nagaoka College, Division of General Education, Nagaoka, JAPAN
[b] National Institute of Technology, Nagaoka College, Department of Electrical and Electronic Systems Engineering, Nagaoka, JAPAN

*E-Mail: ichimura@nagaoka-ct.ac.jp

Abstract

National Institute of Technology, Nagaoka College (Nagaoka KOSEN) has been actively implementing international exchange programs for more than ten years. For the past decade, Nagaoka KOSEN has sent a great number of students to the overseas institutes with whom it has academic exchange agreements and this number has been steadily increasing year by year. As of today, however, Nagaoka KOSEN has not received the same number of students from the overseas institutes, and thus the student exchange program is not well-balanced. There are several reasons for this unbalanced student exchange such as focusing only on specific engineering educational programs such as LEGO Robot programming, which restricts only particular teachers involved and leads to less participation of teachers from the Division of General Education.

In order to increase the number of students from the overseas institutes with academic exchange agreements for their short-term study at Nagaoka KOSEN, one practical solution would be to devise a new program for international exchange activities at the Division of General Education. By doing so, more professors belonging to the Division of General Education can also participate in the international exchange, which might lead to increasing the capability of accepting international students. In March 2018, a group of twenty-two consisting of twenty students and two teachers from an institute in Singapore visited Nagaoka KOSEN for one week. As a first attempt, a new program was created by the Division of General Education, called One-Day Experience of KOSEN Classes. This one-day program including a math class (titled as Fastest Finger First Quiz), a chemistry experimental class (titled as Neutralization Titration), and a physics experimental class (titled as Swing of Pendulum) was added to a whole one-week-program. In order to assess the effectiveness of the program, a questionnaire was given to the visitors. In the questionnaire, a four-point Likert's scale was used to evaluate the effectiveness of each program held in the one-week program.

Keywords: *Active Learning, International Exchange Program, One-Day Experience of KOSEN classes, ice-breaker activity, Fastest Finger First Quiz, Neutralization Titration, Swing of Pendulum*

Introduction

Global education has been actively implemented worldwide these days. National Institute of Technology, Nagaoka College (Nagaoka KOSEN), has its history of international students exchange for more than a decade. Nakamura (2016) has summarized the recent achievements of international exchange activities at Nagaoka KOSEN in his report. The reason for tackling such an international exchange activity at the institute is to meet the requirement from the society which advocates that the academy should foster students in order to possess broader views of globalization. Nakamura (2016) states that the first students' overseas program was held in the Heisei 17th year or 2005. Since then students in Nagaoka KOSEN have experienced their studies aboard in Asian countries such as China, Malaysia, Thailand, Vietnam, and Singapore.

Not only have the students in Nagaoka KOSEN studied abroad at overseas institutes which have academic exchange agreements with the institute, but also students from these overseas institutes have visited the institute. In April 2009, in order to promote international exchange activities, International Affairs Center has been launched at Nagaoka KOSEN. The main functions of this Center are the following three: to exchange and conclude an agreement with overseas institutes, to plan students' overseas program as well as to help support Japanese students who wish to study abroad, and to help support non-Japanese students who enter from the 3rd year and study at the institute.

There was, however, an unbalance of the gap in the number of students between those sent to overseas and received from overseas. As a matter of fact, it was found that the number of students visiting the overseas institutes from Nagaoka KOSEN has been steadily increasing since 2007, while that of the receiving students ten years ago was none and has just started increasing in the past few

years when the first author conducted researching the past international exchange activities in Nagaoka KOSEN. The limitation of program availability when receiving students is thought to be one of the main reasons why this unbalanced student exchange occurs.

Nakamura (2016) has mentioned that LEGO Robot Program has been mainly utilised at the time of both sending and receiving students at Nagaoka KOSEN. Taking for example, Nakamura (2016) explained that when eight lecturers from ADTECK Melaka and 3 teachers from Mongolia KOSEN visited Nagaoka KOSEN for a month in May and September 2015 respectively, the programs applied were 3D CAD training for the first two weeks and LEGO Robot program for the last two weeks. Since these programs require certain skills with the basic knowledge of CAD and/or computer programming, only a limited number of teachers from engineering departments can conduct and participate in it. Whereas teachers and professors who belong to the Division of General Education are less likely to, due to the fact that they teach the subjects of liberal arts, and therefore have less chance to make use of the engineering educational tools like 3D CAD or LEGO Robot programming.

In order to be able to increase the capability of receiving students outside Japan for their short-term study at Nagaoka KOSEN, one practical solution would be to devise a new program organized by the Division of General Education. By doing so, unlike specific engineering programs like LEGO Robot Programming, more teachers and professors of the Division of General Education can also be involved in the international exchange program at the institute. In this paper, the new program called One-Day Experience of KOSEN Classes is explained as the first attempt applied to the opportunity in March 2018 when Ngee Ann Polytechnic from Singapore visited the institute for their study trip in Japan. On Wednesday March 7th, the One-Day Experience of KOSEN Classes was implemented.



Figure 1. Twenty-two Ngee Ann Polytechnic visitors (in blue T-shirts)

Pedagogy

Participants of the Students Exchange Program

The main participants of both parties during the six-day program are as follows: a group of twenty-two (two teachers, three female and seventeen male students shown in Figure1.) from the Mechanical Engineering Division, Engineering Department of Ngee Ann Polytechnic in Singapore, three 2nd year and seven 4th year students, three teachers from the Division of General Education, one teacher from the Department of Electrical and Electronic Systems Engineering, and two staff from International Affairs Centre of Nagaoka KOSEN.

Students Exchange Schedule in Nagaoka KOSEN

For the preparation of receiving visitors from Ngee Ann Polytechnic in March, the conventional student exchange program called LEGO Robot program was utilised for one-and-a half day, followed by, as a first attempt, a new one-day program, called One-Day Experience of KOSEN Classes, was installed. After that, a one-day excursion including a visit of museums and manufacturing companies in Nagaoka City was conducted.

In early March 2018, a group of twenty-two from Ngee Ann Polytechnic in Singapore visited to Japan. The main part of their itinerary was to visit Nagaoka KOSEN for six days, hence, in preparation of receiving them, the International Affair Center at Nagaoka KOSEN mainly steered the program. The schedule during their stay in Nagaoka KOSEN is as shown in the Table 1. As it can be seen in Table 1, they arrived at Nagaoka KOSEN at midnight on Sunday March 4th, and checked-in at the student dormitory which is located on the campus of Nagaoka KOSEN. The educational program immediately started on Monday morning, the day after their arrival. After the completion of the campus tour, one-and-a half day LEGO Robot Programming activity was conducted until the evening of Tuesday March 6th, followed by a One-Day Experience of KOSEN Classes.

Table 1. Schedule of Ngee Ann Polytechnic in Nagaoka KOSEN

Day/Date	Itinerary
4 Mar (Sun)	Depart Singapore for Nagaoka Arrive at Narita Airport (15:35), leaving for Nagaoka by chartered bus Arrive at the dormitory of NIT, Nagaoka College (23:00)
5 Mar (Mon)	08:30 Breakfast 09:30-10:20 Welcome (Meet president and take commemorative photo) 10:30-12:10 Campus Tour (EE10:20-EC11:10-M11:30-CI11:50) 12:10-13:00 Lunch 13:00-16:00 LEGO program (Prof. Shimanume) - Ice-breaking 16:00-17:00 Welcome Dinner
6 Mar (Tue)	08:30 Breakfast 09:30 - 12:00 LEGO program (Prof. Shimamune) - Lego Line-tracing Competition 12:00 - 13:00 Lunch 13:00 - 15:00 Wrap up 15:00 - 16:00 Presentation 16:30 Dinner
7 Mar (Wed)	1 Day Experience of General Education Classes (Math, Chemistry and Physics) 08:30 Breakfast 10:30 - 12:00 Math (Dr. Togashi) - KOSEN Fastest Finger Math Quiz 12:00 - 13:00 Lunch 13:00 - 14:30 Chemical Experiement (Prof. Ogawa) - Neutralization Titration 14:40 - 16:10 Physics Experiment (Prof. Sato) - Swing of Pendulum 16:30 - 17:30 Farewell Party
8 Mar (Thu)	Visiting history museum and local manufacturing companies 08:30 Breakfast 09:30 Leaving for History Museum 10:00 - 11:30 History Museum 11:40 - 13:00 Lunch (at Eguchi Dumpling) 13:00 - 14:30 Omori Machinery Co., Ltd. (Nagaoka Manufacturing Plant) 15:00 - 16:00 System Square Co., Ltd. 17:00 Arrive at dormitory 18:00 Dinner
9 Mar (Fri)	08:30 Breakfast 09:30 Leaving for Tokyo by charterd bus

LEGO Robot Program

LEGO Robot Programming activity this time consisted of three parts: ice-breaker, LEGO Robot programming and presentation. Since it is a group work activity, making use of ice-breaker techniques at the beginning of the group work is essential for better cooperation to tackle against tasks as a team. For the ice-breaker this time, the use of Origami, a traditional Japanese paper craftwork was firstly conducted. There are some reasons why Origami was selected — it is the simplest yet one of the traditional Japanese craftworks, which can be readily experienced; students are inevitably required to communicate with each other; Japanese students can demonstrate how to manufacture and Singaporean students can then copy them, which is a kind of a reverse engineering; it can let students learn how to reach the geometrical design goal logically.

In addition to this activity, business card exchanging was also implemented. Moreover, Ping-Pong Ball-Toss Game, in which balls are thrown into a paper-made basket, or in other words, an open-top hat on a team-mate's head was applied (see Figure 2). After the ice-breaker, the lecture of LEGO Robot programming, called Line-Trace Competition, took place with thirty-two-page long slides, one of which is shown in Figure 3. After the programming activity, each team finally made a short presentation in front of the participants and audience.



Figure 2. Snapshot of ice-breaker: Ping-Pong Ball-Toss Game



Figure 3. One of the Presentation Slides of 1.5 Day LEGO Robot Programming Activity

One-Day Experience of KOSEN Classes

The One-Day Experience of KOSEN Classes is devised for aiming to have teachers, who belong to the Division of General Department, participate in international exchange activity. This time, the One-Day Experience of KOSEN Classes consists of the following three liberal arts classes: mathematics class titled as Faster Finger Math Quiz, chemistry experimental class titled as Neutralization Titration, and physics experimental class titled as Swing of Pendulum. Each subject had a ninety-minute class taught in English.

Math Class: Fastest Finger First Quiz



Figure 4. Snapshot of Math Class: Fastest Finger First Quiz

In this mathematic class, a lecturer, who took care of the class, did not apply any traditional lecture styles. Instead, the lecturer was making use of the pedagogy of Active Learning. For conducting the class, the following two things had been prepared in advance. One was an apparatus designed for the Fastest Finger First Quiz, which has 15 electric button or buzzer cases connected to each other. Each of the apparatus has two different sound buttons: one is pushed when the answer is correct, whereas the other is selected when the answer is incorrect. For instance, the apparatus is used as follows: a person who solves out a math problem has to quickly push the button in order to obtain the right to answer first. If the answer is correct, the person who sets the question pushes the correct buzzer and if the answer is incorrect, he or she pushes the incorrect buzzer or vice versa. Second, the day before the class, the lecturer asked the ten Japanese students to create and bring one mathematic quiz in Japanese to the class, and prepare the oral explanation of the quiz in English, which could be solved by average high school students, who have fundamental knowledge of mathematic problems learned within or by the end of 2nd year of high school. The rules of the Fastest Finger First Quiz are as follows:

1. Quizzes are mathematical problems.
2. Each of the Japanese group members present in turn problems in Japanese.
3. Japanese students in other groups translate the problems into English.
4. Group members (mainly Singaporean students) try to answer the quizzes. (See Figure 4)
5.The team that obtains the most points is the winner.

Chemistry Experiment: Neutralization Titration

As shown in Figure 5, this chemistry experiment requires the usage of several experimental equipment. Students at Nagaoka KOSEN learn this experiment when they are 1st year students. Since the educational background of students from Singapore was unknown, this fundamental experiment was selected. Rice vinegar, a Japanese traditional fermentation product was used as an acid solution in this experiment. Before the experiment, the lecturer introduced the traditional Japanese vinegar production method for the study of cross-cultural understanding, by using both a video and a slide which is shown in Figure 6. After the instruction and lecture, the chemical experiment was conducted as shown in Figure 7 and all groups successfully completed the experiment without any trouble, and then the experimental results were filled into the handout as shown in Table 2.

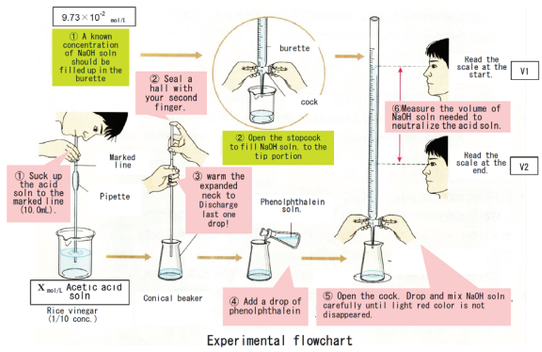

Figure 5. Schematic Drawing of Experimental flowchart for Neutralization Titration

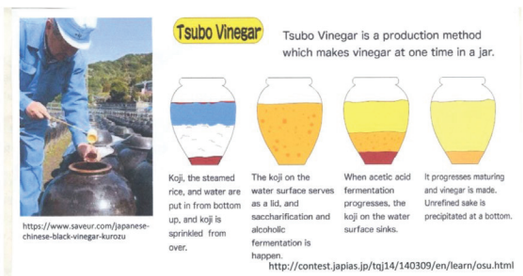

Figure 6. Kurozu (black vinegar) fermentation in Kagoshima prefecture

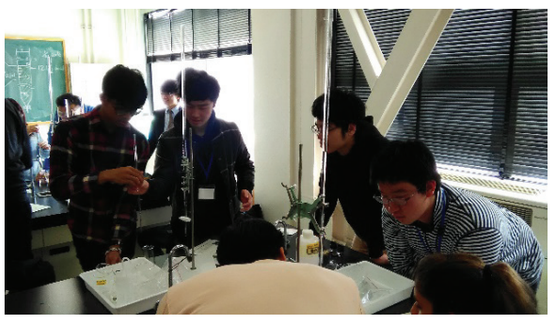

Figure 7. Snapshot of Chemical Experiment: Neutralization Titration

Table 2. Experimental Results Sheet

Results Table Date ( )

Names(,)

Exp.no.	Scale of NaOH soln (O.OO) Start(v_1)	End(v_2)	NaOH soln volume added (v_2-v_1 mL)	Volume of acid soln (mL)	Success (s) or Not(n)
1				10.0	
2				10.0	
3				10.0	
4				10.0	
5				10.0	
6				10.0	
			Ave.	10.0	

*Do not include unsuccess data to calculate the average.

① Chemical reaction formula

CH_3COOH + NaOH →

② Calculation of acetic acid concentration in the 10 fold diluted rice vinegar

Conc. of NaOH (9.73×10^{-2} mol/L), Ave. volume (mL)

(A) Substance amount of OH^- needed to neutralize the acid soln =

(B) Substance amount of H^+ in 10 mL of X mol/L acetic acid soln =

For neutralization, it becomes (A) = (B).

=

The concentration of acetic acid in the 10 fold diluted rice vinegar, x mol/L is mol/L

The concentration of acetic acid in the commercial rice vinegar, 10x mol/L is mol/L

Post-experiment review (Your impressions)

Physics Experiment: Swing of Pendulum

According to the lecture of this experiment, this physics experiment, i.e., Swing of Pendulum, is known as a way of obtaining relatively accurate value of gravity, even though the preparation for this experiment is simple: a working table, stopwatch, string, and clip which are to work as a pendulum. Students at Nagaoka KOSEN learn this experiment when they are 2nd year students. Therefore, as the Nagaoka KOSEN students have already tried the experiment in advance, little instruction was required to conduct this physics experiment together with Singaporean students.

After the experiment, namely, the measuring time of the swing with different lengths of string that each group decided for conducting this experiment, the presentation of each group's measurement results was implemented, followed by obtaining the value of gravity by calculating with the formula. (See Figure 8.)



Figure 8. Snapshot of Physics Experiment: Swing of Pendulum

Evaluation

In order to assess the effectiveness of each activity of the students receiving program at Nagaoka KOSEN, a questionnaire was given under the cooperation of the Singaporean students.

Results and Discussion

After the completion of all the activities during their stay in Nagaoka, a questionnaire was given to the twenty Singaporean students in order to obtain their frank opinions about the activities. The questionnaire asks respondents to answer in autonym. The answering form is a four-point Likert's scale i.e., Very Good, Good, Bad, Very Bad, followed by a free description writing space provided, which is to be written in two lines. The results of the questionnaire are shown in Table 3.

Table 3. Results of questionnaire

Activity	Very Good	Good	Bad	Very bad	Total
Ice-breaking (5th Mar)	10	10	0	0	20
LEGO Line-trace competition (6th Mar)	11	9	0	0	20
Math Fast Finger Quiz (7th Mar)	9	10	1	0	20
Chemistry Experiment (7th Mar)	9	7	0	0	16
Physics Experiment (7th Mar)	5	11	0	0	16

Four students could not answer to two activities due to their sickness absence in the afternoon on March 7th in which the Chemistry and Physics experiments took place. The ice-breaker on March 5th received a 100% positive answer: 50% Good and 50% Very Good. The LEGO Line-Trace Competition also received a 100% positive feedback: 45% Good and 55% Very Good. The Math Fast Finger Quiz received 5% Bad, 50% Good and 45% Very Good. Chemistry Experiment received a 100% positive answer: 44% Good and 56% Very Good. Finally, the Physics Experiment received a 100% positive feedback: 69% Good and 31% Very Good. As the results reveal, the feedbacks from the respondents were all positive except one Bad vote to the Math Quiz. Furthermore, below are the randomly extracted free-descriptions of each activity:

-*Very interesting, making new friends* (Very Good: Ice-breaker)

- *Fun and engaging* (Good: Ice-breaker)

- *Made new friends and new experience* (Good: LEGO Line-Trace)

- *Too simple* (Good: LEGO Line-Trace)

- *It was a rather cool experience but yet there are areas of improvement like allowing us to have a better understanding of the programming instead of letting us experiment.* (Good: LEGO Line-Trace)

-*Very fun and competitive* (Very Good: Fastest Finger Math Quiz)

-*Didn't really understand some questions but I had fun nonetheless.* (Good: Fastest Finger Math Quiz)

-*Bad questions were all over the place.* (Bad: Fastest Finger Math Quiz)

-*Tasted vineger.* (Very Good: Neutralization Titration)

-*It was enriching as I get to learn how the rice vinegar is made here in Japan*. (Good: Neutralization Titration)

-*The pendulum experiment was okay but the professor's voice was too soft*. (Good: Swing of Pendulum)

-*It was refreshing my memory too.* (Good: Swing of Pendulum)

As it is shown in the above free-descriptions, despite scoring positive marks in the Lickerts' scale, there are some critical feedbacks in the free-descriptions. For instance, even the respondent who marked Good in the LEGO Line Trace, he wrote *Too simple*. In addition to this exmple, the one who scored Good in the LEGO Line-Trace mentioned *It was a rather cool experience but yet there are areas of improvement like allowing us to have a better understanding of the programming instead of letting us experiment*.

In terms of the Fastest Finger Math Quiz, there is a negative feedback, namely, *Bad questions were all over the place.* To improve the quality of the questions, the following countermeasures are to be considered for the future:

・Math questions and their explanations should be checked in advance. (Note: the negative effect on the tendency of questions by examiners might be arisen in this case.)

・Collect the Math questions in advance and rank the difficulty of each and show them in order.

・As for Project Based Learning (PBL), all the Math questions should be prepared by teachers, not by students.

Conclusions

In conclusion, the idea of how teachers in the Division of General Education get involved in the international exchange program when accepting students from overseas institutes was proposed in this paper, i.e., not only applying engineering related subject like LEGO Robot programming as a standard engineering activity, but an activity like the One-Day Experience of KOSEN Classes described in this paper, which are composed of subjects taught in the Division of General Education such as Math, Chemistry, and Physics experiments can be one

possible and/or practical solution. It was also revealed that even though the classes were conducted in English, the feedback from the Singaporian students were mostly positive.

Acknowledgements

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CULTURE AS A TOOL FOR INTERNATIONALIZATION: HANDS-ON INTERNATIONAL WORKSHOP

A.P. Higashino[*, a],

[a] National Institute of Technology, Akashi College /Architecture Department, Akashi, Japan

*adriana@akashi.ac.jp

Abstract

The internationalization of the working market makes essential to train students to work with people from a different cultural background. The Japanese government has altered the education curriculum and included English language courses in the elementary school to answer to this problem. Unfortunately learning English is not enough. Lately, although Japanese students have raised their scores in languages tests and improved their English skills, they still show difficulty to express their ideas in a multicultural workshop or group discussion. In a global context, cultural identity and self-confidence are more important than foreign language skills.

The first international workshop realized at Akashi college was in 2014 when the architecture department received 16 students from Australia for one week. Now, only four years later the number of events involving short-term international students increased exponentially. At Akashi College, we believe that those events help the students to develop a global perspective. The students do not only become bilingual, but they became bi-cultural too. The short-term international workshops help the students to practice their English skills and their capacity of understanding different cultural points of view.

In this paper is described Akashi college experience with international exchange activities on campus and explain how the use of hands-on activities and Japanese traditional culture related themes helped to instigate communication between the students. At first, we describe the different workshops and events held at Akashi college, how those events were held and organized. Later using data from students' surveys of the workshops we will discuss and evaluate the educational impact of those activities on the students. Finally this paper will show that hands-on events, where the students have to build something together instigate more interaction between the students, and that the use of a theme typical of Japanese traditional culture for the workshops is not only attractive to international students but also provides self-confidence to Japanese students, improving their participation in the workshop.

Keywords: *Akashi college, international students workshop, Japanese traditional culture, students' surveys, communication*

Introduction

The Global Education Center of NITA has promoted several international workshops and cultural exchanges since it was established in 2016. The Department of Architecture has always been very active and organized several of the international workshops. This paper describes the activities and analyzes the impact of international activities in our students. At first, It will explain the long-term international activities. Here we considered as long-term workshops or programs that were longer than one day. Furthermore, we will describe the short-term workshop and based on surveys results evaluate its educational value.

Long-term International Exchange Programs

The first long-term international workshop was in 2015, with students from Australia, Griffith University. Later, in January 2016, in partnership with a university from Brazil (UFRGS), the NITA Architecture Department started to host a three weeks' program. Also, was realized in 2016 the first Summer Program, promoted by the GEC but organized and executed by Akashi students.

Griffith University students workshop 2015

The Architecture Department first international exchange program was in 2015. We were asked to host for one week 16 students from Australia. Our objective was to have the Australian students interacting with as many Akashi College students as possible. There was no time available for extra curriculum activities and the workshops needed to fit in the Akashi College Architecture Department March-August semester classes schedule. We organized the activities according to the academic years. Akashi's 5th and 4th-year students were involved in activities that required more talking, such as field trips and the tea room design workshop, while the 1st, 2nd, and 3rd-year students participate in simpler workshops, where the students had to craft something together to create situations to stimulate them to communicate. Tea architecture, because it is a topic peculiar to Traditional Japanese architecture and the

small scale of the tearoom was perfect for such a short time design workshop.

Through the one-week international exchange activities with the Australian students we learned that:

(1) It is possible to include international exchange and workshops into the courses scheduled.

(2) The tearoom is an excellent theme for international exchange workshops.

(3) Workshops with lower academic years require preparation and teacher assistance.

(4) Field trips, especially when on foot should be organized with time to spare.

(5) It is necessary to stimulate interaction and communication without forcing it.

(6) Not all students may be positively involved when the workshop was included in the required courses.

(7) Too busy schedules may turn international exchange into a negative experience.

This first experience was essential because it proved that it was possible to fit international workshops on the regular course's schedule. Having no time for international workshops have always been a problem because the National Institute of technology colleges have a hebusyctic course schedule. The colleges have classes from 9 to 4, and during the vacation periods, the students have sports activities. Therefore, it is challenging to organize any extra curriculum activity.

UFRGS Japanese Traditional and Contemporary Architectural Course

The first edition of this course was in January 2015 and had a two-week duration. From the second edition, we extended the course to 3 weeks. In January 2019, we will hold the 5th edition of the course. This course is an elective subject in UFRGS Faculty of Architecture curriculum, and each of the UFRGS students received six credits for participating in the course. The average number of participants' students from Brazil is 6. From the second edition of the course, the students stayed on campus dorm facilities. The course included the activities with Brazilian students in the Akashi College Architecture Department October-March term courses schedule. The course included lectures on Traditional Japanese Architecture, several field trips and workshops with different academic years. Here again, our goal was to maximize the interaction between students. The level of interaction of the activities was according to Akashi students' academic level. 1st, 2nd, 3rd, 4th-year students participate on field trips and simpler workshops while the 5th and Advanced Course students worked together on assignments and developed design projects with the students from UFRGS. The tearoom design workshop was the main event of the course and was included in the Architecture Planning III course, a 5th-year elective course. Since the course is elective, all students were eager to participate in the workshop.

The course has shown that experiencing international exchange activities has improved the students' communication skills. During the tea room design workshop, all groups were able to work on a concept for the design of a tea room and to finish their designs with minimum interference from the teachers. The final presentation of the Tea Room Design Workshop was in the school auditorium room, and all the students in the Architectural department watched it.

As part of the course and to extend the experience to other departments every year we organize a weekend a trip to Nara. All students from Akashi College can participate, but usually, most of the students are from the Department of Architecture.

According to the results of the course evaluation survey, most of the students enjoyed the workshop and affirmed that Tearoom as a theme was very interesting because it is a small space and unique to Japanese Culture, appropriate to such a short time design workshop. Brazilian students said the workshop not only gave them the opportunity to learn about Japanese culture but also to learn different ways of developing architectural projects. Akashi students said that since this was not their first experience working with international students, they could better communicate and enjoy the activity. Some students pointed out that communication was not about the ability to speak English, and by using drawings and body language they were perfectly able to communicate and transmit their ideas. The fact that the Brazilian students stayed on campus allowed the students to interact more.

From the Japanese Traditional Architecture course, we concluded that:

(1) International exchange experience is a cumulative process, and gradually exposing the students is more important than training their English language skills.

(2) Lodging international students inside the college campus increase interaction between students.

(3) The necessity to extend international activities to other departments in the college.

(4) Communication is more comfortable when both students are not English native speakers.

Japanese Culture Summer Program

Studies that compare the Japanese language structure with Japanese space structure (A. Berque, 1982) explained that in the Japanese language the subject is defined by the environment. Differently from English or Latin languages, which the subject is absolute, "I" is always "I," independent of the situation, in Japanese "I" changes according to the situation. For example, a teacher will refer to himself as "sensei" (teacher) while speaking with his students, and if he is at home, he will be "otosan" (father) to his children if he goes shopping he is "okyakusan" (client), etc. In the Japanese language, the subject changes according to the social environment he is involved. These studies help to understand why Japanese students have difficulty to communicate with people from different cultures when they do not understand the environment they are is more difficult to define the subject or "I." Consequently, in a multicultural context, cultural identity and self-confidence are more important than foreign language skills. The students need to learn how to be bicultural and not only bilingual. Using the principle that the best way to understand something new is by comparing with something we already understand, working with themes related to Japanese

culture, bring the students aware of their native culture and facilitate Japanese students to communicate and understand different cultural contexts. The results from the Tearoom workshops confirmed that Japanese students performed better in international activities when the theme was related to Japanese culture. Therefore, we decided to extend the experience for students other than the architecture department. We used Japanese Culture in general as the theme for a summer course, open to students from all different majors. This program developed activities involving Japanese culture where Akashi College students acted as tutors. The students organized the course under the supervision of the faculty in charge, and the college international plaza capacity limited the number of international students' participants. It was a five days' course, from Monday to Friday. The activities started with Japanese lessons, and Akashi students taught international students how to write in the Japanese alphabet (hiragana and katakana) and some basic expressions in Japanese. During lunch time the students cooked traditional Japanese food, such as Takoyaki, Somen or Okonomiyaki. The course included several activities such as Origami workshop, Ayatori play, Calligraphy (Shodo), Hana Fuda Game and visits to Himeji Castle. The participants were students from Hong Kong IVE, Philipines Della Salle University and UFRGS Bazil. The students' course evaluation survey showed that all students that participated in the course were delighted and that the program overcame their expectations. All the students said they would like to join again. The international students also highly appreciated the program, said it was well organized and more interesting than expected. Was observed by the advisor faculty that the students went out together after the activities, and the interaction between students expanded beyond the program schedule.



Figure 1: Summer Program Calligraphy lesson

The Summer Program showed that:
(1) It is possible to have international activities organized by the students and with no financial cost to the hosting institution.
(2) Japanese Culture can be used to stimulate communication between Japanese and International students.
(3) To avoid field trips during summer.

Short-term workshops

There were several short-term workshops and here we will focus on the bigger ones, realized with students from IVE Hong Kong.
The first workshop was in 2016 when 40 students from IVE Tsing Yi Department of Architecture visited Akashi college and Himeji Castle. Here again, the most challenging point when organizing the workshop was to combine Akashi courses schedules with IVE trip schedule. The second problem was to find a room big enough for a workshop of 80 students. Based on our positive experience with the tea room as workshop theme, we used the Okoshie or paper model of a tea room. The exchange activity was composed of a lecture in English about Japanese Architecture, building a paper model of a tearoom in the morning and the afternoon a visit to Himeji castle. In the morning IVE students interacted with Akashi 1rst years students. The workshop was in May, so the 1st year students were fresh, they had been studying in Akashi for about a month only. Also, in the afternoon IVE students visited Himeji castle together with the 4th years' students.
The students answered a survey and evaluated their experience in the workshop.

Table 1: 2016 Akashi 1st year and IVE workshop survey

	Akashi	IVE
Workshop in general		
easy	16%	20%
OK	56%	73%
difficult	11%	0%
very interesting	65%	60%
interesting	3%	30%
boring	0%	0%
Workshop Schedule		
too long	0%	0%
just fine	86%	93%
short, too busy	14%	7%
Communication between the students		
easy	5%	10%
OK	38%	78%
difficult	57%	12%

Even though Akashi students were at 1st year, and were experiencing international workshop, and model making for the first time, the workshop went well. Most of the students from both institutions evaluated the workshop as very interesting, the workshop schedule as fine and did feel difficulty in communicating with each other (table 1).

However, the visit to Himeji castle did not work as well as the morning workshop. The students were divided into groups to instigate communication, they left the parking lot in groups but when they arrived at the castle the groups dissolved and the IVE students gather by themselves. Akashi students complained that IVE students would not talk to them. Interesting here is that the former international exchange experience of Akashi 4th year students seems to have backfired. They had been, when they were younger, to several field trips with students from Brazil. Apparently, they got used to have a passive attitude and wait for the international students to communicate with them. Students from Brazil are never shy and very talkative, but most students from other countries, especially from Asian countries tend to be as

shy as the Japanese. Also, it was a mistake to change the interacting group, because both institutions students are shy and need time to get along.

The second short-term workshop was in 2017 with IVE Tue Mun Department of Architecture students. In these case IVE students interacted with 5th-year students and the schedule allowed to organized a full day workshop. The theme of the workshop was modern architecture, and the students worked in groups, half of the members from IVE the other half from Akashi. In the morning, there was a lecture about Hong Kong modern architecture and modern Japanese architecture. Later in groups, the students were assigned icon buildings to investigate. Each group built models and panels explaining the building they were assigned. The workshop finished with a final presentation of the buildings. In general, the workshop went well, most groups were able to finish their assignment on time, and the students enjoyed working together.



Figure 2: Modern Architecture Workshop

The last workshop was held last May with IVE Tsing Yi Architecture students. Here again, we used the tea room paper model. The IVE students interact with Akashi 4th year students. In the morning, the students had a lecture about the Hong Kong public housing project and Traditional Japanese Architecture. After the lecture, they worked on groups at the tea room paper model. Later they went on groups to lunch and explored Akashi's fish market. The activity finished with a visit to Takenaka carpenter's museum in Sannomiya.



Figure 3: 2018 Tearoom paper model workshop

Table 2: 2018 Akashi 4th year and IVE workshop survey

	Akashi	IVE
How often have you participate in international workshops		
1st time	47%	90%
2 times	26%	5%
3 times	11%	0%
4times	0%	0%
more than 4 times	3%	5%
Hong Kong Housing Lecture		
interesting	29%	32%
Ok	21%	32%
interesting but difficult	48%	5%
Not interesting	0%	32%
Japanese Architecture Lecture		
interesting	45%	47%
Ok	39%	24%
interesting but difficult	29%	16%
Not interesting	0%	0%
Paper Model Workshop		
fun and easy	47%	53%
OK	0%	0%
fun but difficult	45%	21%
very interesting	0%	0%
interesting	0%	0%
boring	8%	26%
Building paper model help communication		
yes	61%	74%
maybe	24%	5%
no	16%	21%
Would you like to participate again		
yes	61%	74%
maybe	40%	21%
No	0%	5%
How many stars to the Workshop		
5	29%	32%
4	47%	42%
3	21%	21%
2	3%	5%
1	0%	0%
0	0%	0%

Some groups got along well and went to visit Sannomiya and Harbor Land area together.

The students' surveys results (table 2) show that most of the students think that working together on the paper model activity helped to improve communication between the students.



Figure 4: Visit Takenaka Carpenters Museum

Finally, to evaluate the impact of the short-term workshop was realized a second survey with the first group of Akashi students. At the time of the workshop they were 1st-year students and now they are3rd year students (table3). The survey asked if the students remember the 1rts year workshop and if they felt influenced by it. It also inquired if the students have participated in international exchange activities such as workshops, field trips or abroad study trips.

Table 3: 2016 Akashi 1st year 2 years later survey

Participation in International Workshop	
0	42%
1	25%
2	25%
3	0%
more than 4 times	8%
Would you like to participate again	
yes	0%
maybe	86%
No	14%
Went to study abroad	
0	64%
1	25%
2	11%
Participated in field trips with international students	
Never	42%
Nara	23%
Naoshima	48%
S A Tours	14%
Other	3%
Do you remember the 1st year workshop	
yes	100%
no	0%
Do you think the 1st year international workshop influenced you?	
yes	53%
no	47%

According to the survey results, 53% of the students think that having participated in an international workshop when they were 1st year head a significant impact in their academic life. This group of students' participation in international workshops and field trips with international students is high. Also, 36% of the students went on a short study program abroad!

Conclusions

In this study, we have shown that international workshops have a positive impact on the students. We have demonstrated that we can include a Long term or short term workshops in the regular course schedule. The results also confirmed that exposing the students to international exchange is more effective than merely teaching them English. International workshops help the students to understand that communication is not only verbal and that are manners of overcoming language barriers. Moreover, workshop themes related to Japanese culture are attractive to international students and to give confidence to Japanese students. Also, students that have to participate in international workshops at an early academic stage showed to become more active and to go to study abroad.

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TEACHER AND STUDENT EXCHANGES WITH UNIVERSITIES IN THE US AND SOUTHEAST ASIA

K. Sekine*

* National Institute of Technology, Kushiro College / Department of Creative Engineering, Field of Mechanical Engineering, Kushiro, Japan

*sekine@kushiro-ct.ac.jp

Abstract

This paper reports on teacher training at the University of US and dispatching international students to Universities of Thai. Teacher training at the University of Arizona has been implemented in 2017 with the objective of improving the instruction skills for teachers to lecture the engineering fields in English. In practical training, introduction of digital books and necessity of academic vocabulary, use of non-linguistic expressions, teaching material improvement and development etc. have been lectured. Furthermore, I have visited King Mongkut's Institute of Technology Ladkrabang (Thailand) in 2017 with exchange students of Kushiro college. Then, I was able to receive some impression University of Southeast Asia. In this paper, activities of teacher training and international exchange between Kushiro college and these Universities institution are introduced.

Keywords: *Teacher and Student Exchange*, *Teacher Training*, *Material Development*

1. Introduction

This paper reports deals with teacher training at the University of US and dispatching international students to Universities of Thai. Teacher training at the University of Arizona implemented in 2017 with the objective of improving the instruction skills for teachers to lecture the engineering fields in English. As an advance training, the second language acquisition theory and evaluation method etc. were introduced using site (online learning) of the University of Arizona. Also, impressions and remark in observing the online learning were considered and a report was written to post. Practice training contents have lectured on introduction of digital books and necessity of academic vocabulary and use of non-linguistic expressions are developed as teaching material improvement and development. In addition, classroom observation and formats of observation reports were treated, and teaching demonstration were conducted based on the lesson planning sheet. Lectures using papers and boards were also included, but there were many groups discussion style in classroom. Furthermore, the instructors had attitudes of "Help" and "Support" to the students.

Secondary, I have visited King Mongkut's Institute of Technology Ladkrabang in Thailand in 2017 with exchange students of Kushiro college. The training items were orientation, research work, city tourism, contents mainly based on academic and cultural exchanges. In the campus, professors responded to classes and research, and the staff responded to the private matters of the students, that is, a clear division on works was found. As a result, students were able to receive prompt and smooth response to consultation on the college life. In addition, it was found that teachers are in an environment where they can devote themselves to preparation of classes, development of teaching material and self-reflection, etc. The educational culture experienced in the two countries is different in detail from Japan, but it turned out that it is common to conscious of the support to student in each educational institution.

2. Teacher training in University of US

In this section, contents of teacher training in the University of Arizona are described. Participants were teachers other than the English teacher of the Hachinohe college and colleges in Hokkaido.

2.1 Online course program

Participants have taken the following online learning before field training. Assignments are imposed in each item and the trainee has to submit assignments to a site due dates. In that case, the trainee can argue with instructor variously about assignments. Therefore, it is possible to deepen an understanding for assignments.

2.1.1 Observation

Trainees may choose to observe classes as online class MOOCs (Massive Open Online Course). MOOCs are online classes in a wide of field and often free. Trainee can also choose to suggest students to enrol in course related to major class. Also, participants write the responses to observation form and submit the form as assignment. Observation form has the contents about development of learning objective, instructional material, educational climate, preparation for class, instructional methods and difficulties, etc. Furthermore, the argument was deepened with instructor about the report.

2.1.2 EMI

Trainees obtained opportunity to learn the history, theory and practice of English Medium Instruction(EMI) in online course program. Participants evaluated their own and ether EMI setting, and created EMI manual for major classes. Therefore, the trainee set up a student's number, a special field of study, degree, country, level, school name and age in order to create summary form.

2.1.3 Assessment

The method and importance which are related with evaluation of a major subject were shown by this module. This course gave primarily about developing effective class assessment policies and practice. Trainees learn how to use and create the rubric for assessment in major classes. Rubric is a set of criteria for student's work that includes description of the level of performance. When evaluating a student, especially five principles (validity, reliability, practicality, washback, authenticity) in evaluation are effective, and fundamental.

2.1.4 SLA

Trainee learned about general concepts in the field of Second Language Acquisition(SLA) through the online course. Theoretical approaches and general principles of SLA are suggested in this module. How to learn language more easily, and kinds of practice helpful in language learning were introduced in this module. Also, it was very interesting that SLA can be studied from many perspectives as linguistic, psychological (or cognitive), social (interactional), neurological.



Fig.1 Campus of University of Arizona



Fig.2 Main street in vast campus



Fig.3 Center for English as a Second Language(CESL)



Fig.4 University museum in campus

2.2 Face to Face course program

Participants have taken the following Face to Face training in University of Arizona for two weeks. Lectures using papers and boards were also included, but there were many groups discussion style in classroom. As for practical training, three contents of modifying and developing materials, reflection and practicum were mainly carried out in the seminar room of University of Arizona.

2.2.1 Modifying and Developing Materials

In this module, trainees learn how to identify variety of techniques for lesson planning, modifying and developing materials. Also, sourcing materials in English is introduced here. For example, internet searching, university libraries system and e-books are shown. Difference between digital native and digital immigrants is indicated by using related paper, too.

2.2.2 Reflection

Teacher reflection gives trainees to evaluate their teaching. For example, self-assessment of instructional, self-study, audio-video recording and writing of teaching philosophy statement are useful reflection. And, differences in teaching behaviour between native and non-native teachers of English, and then specifies the causes of those differences.

2.2.3 Practicum

This module has instruction and demonstrations of teaching methods, approaches and strategy with respect to EMI (English Medium Instruction). Trainees give teaching demonstrations to colleague and observe each other's demonstration, and receive feedback from each other as well as from instructors. Outcomes of this course are that trainees can recognize and evaluate a variety of teaching methods and approaches relevant to EMI and select from those methods to effectively design lessons and class activities.

Moreover, the director and instructor of University of Arizona visited the Hachinohe college in 2018, and follow-up seminar was implemented for two days. As for the contents of training, review of EMI and demonstrations of teaching were developed. The content of the practical training was remembered and the motivation for introducing English skills into the class was improved, and it was a meaningful training for participants.

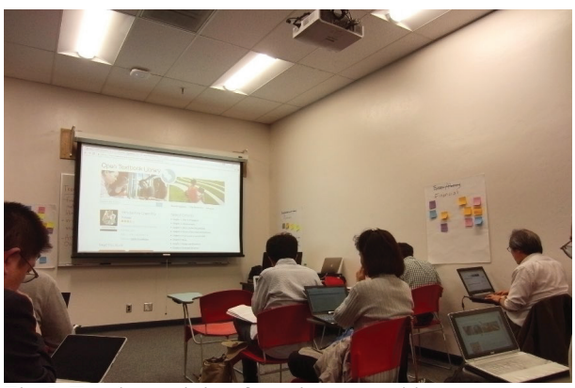

Fig.5 Teacher training for using second language



Fig.6 Observation of a class (department of civil engineering)

3. Student exchange with University of Thai

I visited King Mongkut's Institute of Technology Ladkrabang(Thai) in 2017 with short-term exchange students of Kushiro college. The regular course students participated for one week, and the advanced course students participated for one month in the exchange program. The training contents were orientation, research work and cultural exchange from a research work to sightseeing. At that time, we received helps from the division of international affairs very much. All the processes of resulting in the inside of a training term, dormitory procedure, a campus tour, the assignment procedure to a laboratory, and sightseeing were corresponded from staff of the division of international affairs. Also, about assignment in a laboratory, departments to which the students belong and field of investigation were investigated in advance. Therefore, it can be supposed that exchange students were able to experience useful research work.



Fig.7 Campus of King Mongkut's Institute of Technology Ladkrabang



Fig.8 Entrance of King Mongkut's Institute of Technology

Professors corresponded about a research work, the staff were treating about clerical matters of students, and clear "division-of-work organization" was able to see. As a result, the student could receive quick and smooth correspondence to the consultation about a various procedure and life items. Also, it is conjectured that professors have the environment that they can concentrate on preparation of the lesson, teaching materials development and self-reflection, etc.

All students were kindly, and when I asked the root, the students took me to the destination. The students of Thai have hard work, and it was seen that students can have environment for striving the study of the major field. Also, it was guessed that the student can develop a sensibility through learning activities.



Fig.9 Campus tour at King Mongkut's Institute of Technology



Fig.10 Laboratory(Electric engineering) of King Mongkut's Institute of Technology



Fig.11 Sightseeing to Wat Arun



Fig.12 Sightseeing in Bangkok city

Summary

This paper described about the exchange program of a teacher and a student. The teacher training and the lecture contents in University of Arizona were described. Also, the director and instructor of University of Arizona visited the Hachinohe college, and follow-up seminar carried out. Moreover, impression and comment at the time of visiting with exchange student to King Mongkut's Institute of Technology were expressed. Precious informations about the work contents of the international affairs division ans how to treat international student were acquired through the visit to each Universities. Moreover, the motive was acquired very much also about implementation of the class which uses English and the practical use of English.

I would like to utilize these experiences for activities of international exchange. Impressively, any Universities had the help and support to a student about various problems of study work and the college life in common.

Acknowledgements

I would like to appreciate to University of Arizona and King Mongkut's Institute of Technology Ladkrabang which gave the precious opportunity for exchange program, teacher training and inspection.

Similarly, I would like to express gratitude here to directors , coordinators, instructors and the staff of the international affairs division of the exchange program of Universities.

FRANCE – JAPAN EXCHANGE PROGRAM FOR GLOBAL TECHNOLOGY EDUCATION

K. Haddadi[*,a], A. Caillier[b] and V. Buquet[a]

[a] Institute of Technologies (IUT 'A') / Dept. of Electrical Engineering (GEII) - University of Lille
Institute of Electronics, Microelectronics and Nanotechnology (IEMN – CNRS), France
[b] Institute of Technologies (IUT A) / International Relations Office IUT 'A' - University of Lille

*kamel.haddadi@univ-lille.fr

Abstract

To foster the urban revolution in the frame of smart-cities, smart education models should be ideally defined across global institutions, industry and community partners. In particular, teacher and student international exchanges for technology through multiple institutions collaboration are beneficial for the students' degree of understanding at the international level. In this frame, a France-Japan Exchange program has been successfully established between the IUT 'A' of Lille and 8 Kosen in Japan since 2005. A thorough analysis of the Exchange program based on our experience is detailed and discussed.

Keywords: *exchange incoming students, international connectivity, global technology education*

Introduction

The 'Instituts universitaires de technologie' or IUT (translated as "University Institutes of Technology") are part of the university system in France. The IUT were created in 1966. There are 116 IUTs which are attached to 80 universities including the ones in the French Overseas Territories and Departments. The IUTs allow the preparation of a two-year undergraduate technical diploma called a "Diplôme universitaire de technologie" or DUT. After finishing their DUT, students have the option to work, do a one-year professional degree called "Licence Professionnelle" (a course also offered by IUTs), or further their studies in a university or "école".

Situated in French Flanders, near France's border with Belgium, Lille is the fifth-largest city in France. Lille is connected to the Brussels-Paris-London TGV network. The journey to Brussels takes little more than 30 minutes, to Paris about an hour, and to London about an hour and 25 minutes. IUT 'A' of Lille established in 1966, is an undergraduate college of applied sciences of the University of Lille. For 50 years, IUT 'A' has turned out more than 30,000 graduates and it has kept abreast of scientific and technological advances. This original vocational training has proved to be successful over all these years. Its permanent aim is to make young people efficient and adaptable.

IUT 'A' consists of 7 departments:

- Chemistry (Chimie)
- Biological engineering (Génie biologique)
- Electronics and automatic control engineering (GEII)
- Mechanical and production engineering (GMP)
- Business studies (GEA)
- Computer science (Informatique)
- Physics and applied sciences (Mesures physiques)

The courses consist in lectures, seminars or tutorials (TD), laboratory sessions (TP), for a weekly workload of about 50 hours (35 hours/class contact) per student. Besides, tutored projects enable students to run some work of their own on a specific subject. At the end of the second year, students have to complete an industrial placement of at least 10 weeks. The curriculum is clearly defined in a national syllabus (in French) approved by the Ministry of Education.

From the Japan side, Colleges of technology (KOSEN) were first founded in 1962, and since then, about 310,000 students have graduated during the 46 years so far. The Institute of National Colleges of Technology, Japan (INCT), which organizes 51 KOSEN (55 Campuses), was established in April 2004 as a single legal entity, and it has become a massive-scale institution which has approximately 50,000 students and 6,300 academic /administrative staff.

The mission of the KOSEN, which were established in response to a strong demand from industry, is to foster creative and practical technical engineers. In order to accomplish this aim, the KOSEN conduct practical and professional engineering education based on a five-year integrated system with general learning and specialized learning organized systematically. About 60% of students find employment after completing the five-year associate degree course, and 40% of them go on to a two-year advanced course, or transfer to a university and receive a bachelor's degree. Some of them continue their study in postgraduate schools. The variety of

career courses after graduation creates many possibilities for their careers, and leads to the production of excellent talents such as practical and creative engineers, entrepreneurs, managers, and researchers, who can be inventive and have problem-solving skills. Receiving extremely high acclaim in personnel training from industry, KOSEN are conducting positive activities in relation to technological innovation from the local community and technology with global competitiveness, and cooperating with industry and government.

France-Japan exchange program

The France-Japan Exchange program has been successfully established in 2005. A timeline of events is described is given in the following:

- 2005: bilateral agreement between Hachinohe NIT (National Institute of Technology) and IUT 'A'

- 2007: Japanese classes taught at IUT 'A'

- 2008: bilateral agreement with Akita NIT

- 2009: bilateral agreement with Sendai,Tsuruoka and Ichinoseki NITs

- 2010: MoU between Tohoku Federation of NITs and IUT'A'

- 2011: The IUTs of Lens, Béthune, Calais and Valenciennes join the programme

- 2015: The IUTs of Le Havre and Blois join the programme

- 2016: MoU between Gifu NIT and IUT'A'

- 2016: MoU between Chiba University of Commerce and IUT'A'

The establishment of a student/teacher exchange agreement is implemented to ensure optimal effectiveness.

A. Sending and receiving students

The partners have agreed to welcome students by giving them orientation of the city and university. Students will also be assigned a tutor to help them in their daily life inside and outside the school. Tutors should initiate contact with the foreign students a few weeks before their arrival in the host institution.
There will also be cultural events where the new exchange students can meet and interact with long-term foreign students.
Partners will try their best to pick students up from the nearest airport or at least train station.

On each side, there should be no more than thirty students sent to the host country at the same time. Moreover, it is our hope that students have a TOEIC score of at least 500. In cases where students somewhat lack English skills, but are extremely motivated and possess good communication skills and diligence, the teacher will advise and may permit such students to apply.

B. Research

The members of the Japanese consortium understands that providing and managing research projects is a challenge due to the short period for which Japanese students come. Using a unified English application form (including gender, and picture), when students apply, they will describe their research field, keywords, and desired project. Before Japanese students come to France, the host institution will send documents and research materials so that students can effectively prepare in order to make the most of their relatively short period of stay.

C. In the dormitory

As some dormitories in Kosen may have stricter rules compared with the French system, slight modifications may be considered (extended curfew time for instance). French students are guests of kosens, and receive ample financial and academic support, and as such, must respect their host institution, students and teachers.

D. Internship presentation in Japan

In order to alleviate the logistic and financial burden of a collective presentation by all students in one location and time, from the 2015-2016 school year the Kosens will host local events, where only students of the institution will present their internship. The presentations will take place at the end of June, near the very end of the program. Students will then be evaluated by one or two guest members on the French side, the lead teachers and other volunteer staff from the host institution.

Figures 1 and 2 illustrate the trends in outgoing and incoming students. From these data, on can note that around 10 students participate to the student exchange program since 2011. A pic of students is also denoted in 2014-2015 corresponding to new French IUTs that have joined the programme.

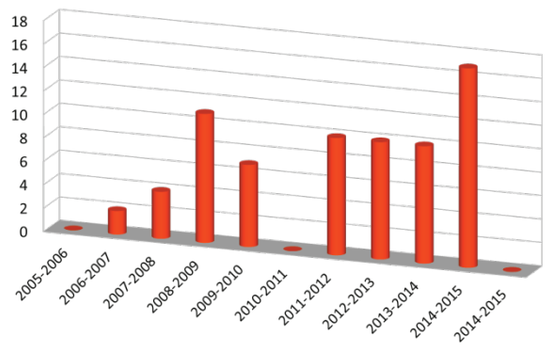

Figure 1. Number of outgoing students versus time.

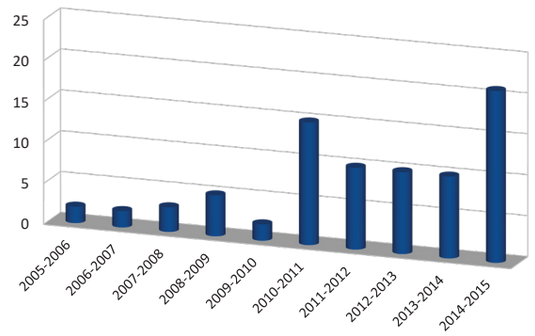

Figure 2. Number of incoming students versus time.

Results and Discussion

From a general point of view, a first foreign exchange program in France or in Japan is an unforgettable experience. In addition to theoretical and technical skills acquired during lectures and practical works, the students develop their language, whether it is French or Japanese or English and their cultural awareness. Indeed, cultural and linguistic immersions for students for both sides are a unique opportunity to bring language skills to life.

Another benefit is the possibility to add new knowledge that can be learned in the foreign course by trying new specialisations and learning in a different cultural context. Indeed, they may also be able to undertake classes that are not available at their school.

Students will experience learning in a different education system, which will expose them to a different style of teaching. Therefore, the willingness to put itself outside his comfort zone is seen as great experience to future employers.

Students will become more independent and will learn a variety of life skills while they are away from home. Although they will be boarding at a host university, they learn to think more independently and develop their problem-solving skills.

Conclusions

The experience gained from this educational system significantly enhances the student's pedagogic and professional experiences. The success of the program is demonstrated through new initiatives. Among them, UCLL (Belgium) has applied to join the programme and successfully did it in 2017. 3 more kosen from Hokkaido (Kushiro, Asahikawa and Tomakomai NITs) have joined the programme. Iwaki kosen eager to strengthen our cooperation in the field of business studies.

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UNIQUE INTERNATIONAL PROGRAMS OF NIT, TOYAMA COLLEGE (KOSEN) ACROSS GLOBAL INSTITUTIONS AND INDUSTRY

T. Homae*

Center for International Education and Research, NIT, Toyama College, Imizu, Japan

*homae@nc-toyama.ac.jp

Abstract

NIT, Toyama College provides unique international programs to the students. As Toyama College has variety of departments, namely, four engineering departments, Department of International Business, and Department of Maritime Technology, the interests of the students are very various. The author would like to share the outlines and outcomes of these programs and discuss how to modify the programs as effective as possible with global institutions and industry including ISATE attendees.

Keywords: *Internship, Research project, Foreign institutes, Foreign factory, Company*

Introduction

NIT, Toyama College provides unique international programs to the students. As Toyama College has variety of departments, namely, four engineering departments, Department of International Business, and Department of Maritime Technology, the interests of the students are very various. We provide 15 programs every year to satisfy the interests.

The author would like to share the outlines and outcomes of these programs as case study for the global education.

Programs for Advanced Course Students

We provide two kinds of oversea programs to the advanced course students. One is "Academic internship" and the other is "Company Internship".

The students, who are interested in a research project, join the former programs. We conclude agreements with five foreign universities/Research Institutes, namely, King Mongkut's Institute of Technology Ladkrabang in Thailand, Pazmany Peter Catholic University in Hungary, Budapest University of Technology and Economics in Hungary, and so on. The students stay laboratories in these institutes for a month or a couple of months, work on specific research projects, which are assigned by the supervisors in the foreign institutes.

The students, who are interested in learning advanced engineering English, join the program held in South Eastern Regional College in Northern Ireland, UK. They stay in Northern Ireland for 4 weeks and learn how to describe engineering papers and abstracts. They also join the engineering class with local students.

The students, who are interested in the internship at the companies in foreign countries, join the latter programs. Many companies, whose head office is near Toyama College, have factories in Asian countries. Three companies in these companies cooperate with us. They have factories in Thailand or Malaysia and provide the opportunity for the students to experience in the factories for two weeks. In one program in Thailand, we also collaborate with the local college near the factory (Lamphun College of Agriculture and Technology). A Japanese student and a local college student participate the internship program as a pair. The Japanese student stay in the student dormitory of the local college. They live together with the local students and can experience daily life if they work in foreign countries. In this framework, all the members have merits. The company can make a connection with the local college through this program. The company do not worry about providing accommodation. The local college make a connection with the company. The students in the college can experience the internship in the company, and touch with Japanese culture. The Advantage for Toyama College is described above. I believe that this so-called "win-win" relationship makes the program continue.

Programs for Associate Degree Course Students

We provide unique programs for the students in associate degree programs. We prepare the programs for learning foreign languages, such as Engineering English, Business English, Russian, Chinese, and Korean. They stay in Hawaii, Canada, Russia, Taiwan, and Korea, respectively, for 2 to 3 weeks. They also learn the culture, history, customs in each country, because not only the language itself but also knowledge above is important to talk with foreign people.

We also have a program for cultural exchange for maritime students. I will report this program in the other paper in this symposium.

Short-term International Students

We accept short-term international students every year. We concluded agreement with KMITL in Thailand, Nanyang Polytechnic and Temasek Polytechnic in

Singapore. 20-25 students of these institutions in a year come to Toyama College. They stay in Toyama College for two or three months. During their stay, they work on research projects assigned by supervisors of Toyama College. We ask their interest and request based on "Researchers List" of Toyama College in advance and match as possible. They work on their research projects with Japanese students, 5th grade of associate degree course or 1st or 2nd grade of advanced course. During the collaboration, Japanese students also learn a lot from the international students. At the end of the stay period, they give us presentations about their research project in English. Figure 1 shows a picture of this presentation. The Japanese students attend the presentation, and give some questions in English. They live in student dormitory. Japanese students can know the cultural background. Unfortunately, not all students can go abroad, because it costs a lot. However, if we accept international students as much as possible, all Japanese students can have the opportunity to contact them. From this point of view, we initiatively accept short-term international students.



Figure 1 Presentation by short-term international student

CAST (Conference for the Advancement of Studies in Technology)

We host CAST every year. In this conference, advanced course students of 3 or 4 Kosen give presentations in English. We use teleconference system and the 3 or 4 Kosen students can attend the presentation. We invite up to 4 professors from foreign countries to ask questions or give the speaker some comments in English. The Japanese students can know the international conference from this opportunity. Figures 2 and 3 are pictures of this conference.



Figure 2 Invited commentator from foreign institutes.



Figure 3 The conference is operated using a teleconference system.

Conclusion

These programs obviously affect the students' life plan. Some of the students choose the job as an engineer in foreign countries. We would like to modify the programs as effective as possible based on the discussions with global institutions and industry including ISATE attendees.

A KNOWLEDGE-CAPTURE REPORT ON LECTURER'S SPECIFICATION OF NATIONALINSTITUTION OF TECHNOLOGY (NIT)

S. Phiyapa*[,a], T. Matsumoto[b], A. Ratchaphon[c], J. Wajinee[d], and B. Sarocha[a]

[a] OTEPC, Ministry of Education, Rachadamnoen Nok Ave., Dusit District, Bangkok, Thailand
[b] National Institute of Technology Head Querter, Tokyo, Japan
[c] Valaya Alongkorn Rajabhat University (Under the Royal Patronage), Ministry of Education
[d] Nakhon Si Thammarat Provincial Public Health Office, Ministry of Public Health

*s_phiyapa@hotmail.com

Abstract

Teachers in vocational schools in Thailand have been found unqualified, which have affected teaching and learning quality. OECD Reviews of Tertiary Education shows that the National Institute of Technology (NIT), Japan, has operated best practices in its personnel management system, particularly on the lecturers' specification. So, the aim of this study is to conduct the knowledge-capture in order to illustrate NIT's lecturers' specification and diagnose its achievement factors in personnel management. This work consists of two parts: firstly, the documentary study; and secondly, the in-depth interview and focus group discussion. In the first part, documentary data on NIT's lecturers' specification and personnel management were collected from previous research papers, articles, reviews, reports and related institution publications. Then, the interview items on achievement factors in personnel management were set and investigated by three experts. They were applied for the in-depth interview and focus group discussion in the second procedure. Fifteen key informants in Japan, from two NIT colleges: Kumamoto and Ube; and its head quarter: Tokyo, were selected to be involved. All collected data were synthesized using data analysis method. The finding on NIT's best practices regarding lecturers' specification revealed five important qualifications, namely, skills and experiences; educational level (Ph.D.); educational background; academic and research publication; and self-reputation(attitude, vision, belief). In addition, the finding on the diagnosis of its achievement factors in personnel management revealed in two portions: external and internal. External factors found in this study were 1) NIT's educational system 2) NIT's networks among all related campuses, companies, and manufacturing 3) organization rules and regulations and 4) organization explicit roles and structures. Internal factors were 1) self-belief in their organization, system, themselves, and learners 2) value 3) discipline 4) devotion 5) willingness 6) loyalty 7) good relationship. Therefore, Thai teachers' personnel management regarding lecturers' specification should be developed by considering the application of NIT's best practices. After that, the experimental pilot project should be held in order to examine its outcomes on the teaching and learning quality in the institutions which conduct new teaching and learning system.

Keywords: *NIT, personnel management, teacher, specification, Japan, Thailand, system, factor, best practice, lecturer*

Introduction and pedagogy

The process of knowledge management (KM) by means of knowledge capturing was a method an organization used to explore the best practices from external sources. Explored knowledge gained from the collaboration with other organizations, outstanding partnerships, would benefit to its efficient and effective human resources development. (Panich, V., 2003; Nonaka, I & Takeuchi, H., 1995; Turban, E & Aronson, J., 2001) Thailand has been facing the issue on teachers' personnel management in specific vocational institutes, especially in teachers' specifications criteria. Report of the meeting between Thailand's Office of the Teacher Civil Service and Educational Personnel Commission (OTEPC) and National Institute of Technology (NIT) or KOSEN, (OTEPC, 2018) revealed an incompatibility of teachers' specification which could not serve KOSEN to recruit qualified teachers for KOSEN lecturers' specific tasks to work in Thai-Japanese Institute of Engineering and Technology. This affects the quality of teaching and learning in schools that provide new teaching system in Thailand like KOSEN. The interview of Thailand's Office of the Vocational Education Commission (OVEC) staff (Interview, April 20, 2018) also showed that Thai teachers who had been selected into the system encountered 2 crucial problems. Firstly, they lack of appropriate quality for teaching and learning. High expectation of schools executives and parents forced them to create high quality teaching and learning. Secondly, they lack of motivation which affected on their ability to improve their morale and performance.

To deal with these problems, OVEC staff suggested that the relevant educational agencies should develop appropriate teachers' specifications criteria for the schools that provide new teaching and learning or bilateral education. Thus, OTEPC as a sector responsible for Thai teachers' recruitment system development should consider and review its current policy, rules, laws, regulations, and criteria with the support of outstanding external sources like NIT best practices.

Importance of recruitment system

Barber, M., & Mourshed, M. (2007) indicated that an education system cannot exceed the quality of its teachers. Teachers' quality is one of the main factors that affect learners' quality. Therefore, recruiting the right people to become teachers and developing those people to be effective teachers is the most important aspect of the world's best performing school systems. Mathis & Jackson (2010) indicated that the most important mission for any organization's success is the human resources management of the organization through the recruitment, selection, and placement process. The report of TDRI research (2016) and Thai Publica (2014) also confirmed that standard of teacher recruitment system is important to effective teaching and learning. Orawongsuphathat, C. (2013) supported that the key to successful organization is the person who meets the needs of the organization. This will be a valuable and important asset to drive the organization to achieve its goals and objectives. Smithikrai, C. (2013) stated that each job is different. Each person has different attributes, knowledge, ability, skills, and personality. To deploy qualified person with the appropriate tasks will produce the best results for an organization. This can enable them to work effectively and satisfy to engage organizational commitment. Unqualified personnel recruitment, selection, and placement resulted in unqualified staff and organization failure eventually. (Heneman & Heneman, 1994)

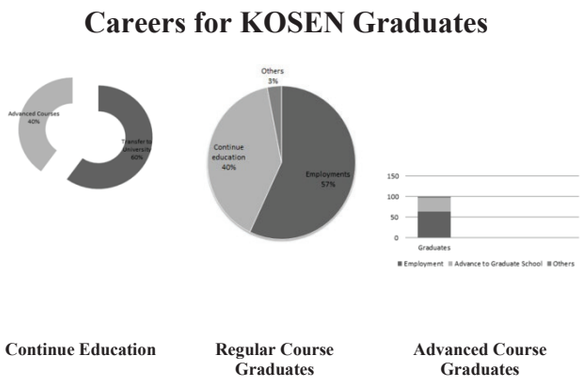
Japanese Identity

Japanese identity is very important when addressing Japan organization or institution achievement. Tsutsui (1997) stated that Japanese management developed from the cultural heritage and reflected traditional values of "groupism" - feeling of dependency and high regard for harmony". Besides, a strong sense of "we" versus "they" and emphasis of our group was strong in Japanese society. (Caudill, W., 1970) Japan society is a masculinity society which the preferences for the achievement, heroism, assertiveness, and material rewards for success are value. Japanese value more success and challenge. Khlangsuwan, Y. (2003) indicated that Japanese society is unique in terms of being a society of unity and social order which is influenced by culture and tradition inherited from the past. In addition, Japanese society is a strong society and most people value for success, courage, expression, challenge, and material rewards for concrete success. So, Japanese focus on the competition and long-term success in the future (Hofstede, 1981; Hofstede, 1991) Japanese organization culture was also influenced by national culture as could be seen from the organization management. It is a kind of father and son management – paternalism. It is a unique feature of the management of Japanese organizations that grow from cultural heritage and reflects traditional values. "Group reliance and one united." (Tsutsui, 1997) The education system in Japan themselves was influenced by traditional culture, and is recognized as a system of education that emphasizes collaborative unity and social order. Khlangsuwan, Y. (2003) summarized that after World War II, when Japan needs to recondition their economy, they aimed at recruiting and satisfying talented people to work in the organization or study and work in educational institutions. The study focuses on education for the benefit of the public and the nation not education for the benefit of an individual. Japanese people always remember that national needs come before personal needs. (Wray, H. 1999) It is concluded that Japanese society and culture have a great influence on the lives and beliefs of the people in its society as well as in its educational system.

Best practice in NIT personnel management

The 1st KOSEN was established in 1962. Now, there are 51 KOSENs 55 campuses nationwide in Japan. After World War II, there was a huge higher educational shift in Japan. It shifted from elite to mass and a trend towards more "vocational" degree program has been introduced. (Newby, H. et al., 2009) National Institute of Technology (NIT) Japan or KOSEN which offer more of a fit-for-purpose license to engage in professional practice served to this policy aim. OECD Reviews of Tertiary Education (Newby, H.et al., 2009) also showed best practices in its own individuality and distinctiveness in NIT's educational system: the co-curriculum between practice in companies and theories in class. Besides, the focus on regular production of research studies can improve the quality of both teachers and students. Accordingly, this opens the opportunities for students' success in jobs finding. 40% of graduates could take further education or advance course in famous universities and 57% could obtain job offers from well-known industries, manufacturing, maintenance service, IT, and etc. worldwide, and the rest 3% aimed for other purposes.

Figure 1 NIT students' success in jobs finding



From Introduction of KOSEN, Presentation of NIT's president: 9th October, 2017 Bangkok, Thailand

To successfully run this newly trend of education system, NIT has to meet the challenge of international competition in research. Therefore, NIT must be internationally competitive with respect to the recruitment and retention of high-impact researchers. Focusing on NIT's policy of lecturer recruitment, most of NIT's lecturers or academic staff must hold Ph.D. degree due to NIT mission and the value of the country. Its mission is to produce research paper and create innovation while the value of the country is to maintain the quality and standards of education in order to develop industrial workforce. Thus, it is a common belief that one of the best practices leaded to NIT success is its lecturer's quality and specification.

Based on the above reviews, the study on NIT lecturers' specification had been conducted. OTEPC, an office responsible for the establishing of teachers' specification, raised a collaborative project with the National Institute of Technology (NIT) to study NIT lecturers' specification. It aimed to illustrate the results of knowledge-capture on lecturers' specification of National Institution of Technology and diagnose its achievement factors in personnel management.

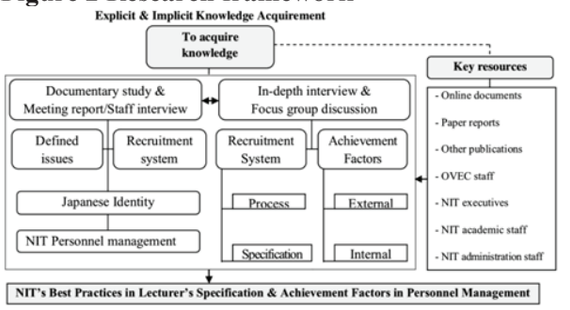
Materials and Methods

This qualitative research divided into 2 sessions: the documentary study session and the in-depth interview and focus group session. Materials and methods of each session were as follows.

Material Firstly, documentary study and meeting report forms, investigating by three OTEPC and NIT experts, were used to explore the issues on teachers' personnel management, the importance of recruitment system, best practice in NIT personnel management and Japanese identity. Secondly, a semi-structured interview items, investigating by three OTEPC and NIT experts, was designed regarding NIT's structure and context and the best practices of its recruitment system and lecturers' specification.

Methods Firstly, data were collected from previous studies, articles, report, reviews and related institution publications both in paper and online. In addition, three meetings between OTEPC and NIT were set for the discussion regarding the overview of personnel management. The reports of the three meetings were reviewed, then, all data were analyzed. Secondly, data were collected via in-depth interview and focus group discussion. Purposive sampling with snowball method was used to select the key informants. Fifteen key informants: executives; academic staff; and administration staff from Kumamoto and Ube colleges (25th Feb.-2nd Mar, 2018) including one executive at NIT head quarter in Tokyo were involved. Focus group discussion, interview, and campus context were observed and noted. All data collected were analyzed using content analysis method. (See Figure 2)

Figure 2 Research framework



Results and Discussion

The findings of this knowledge-capture report reveled 2 parts: lecturers' specification and NIT achievement factors in personnel management.

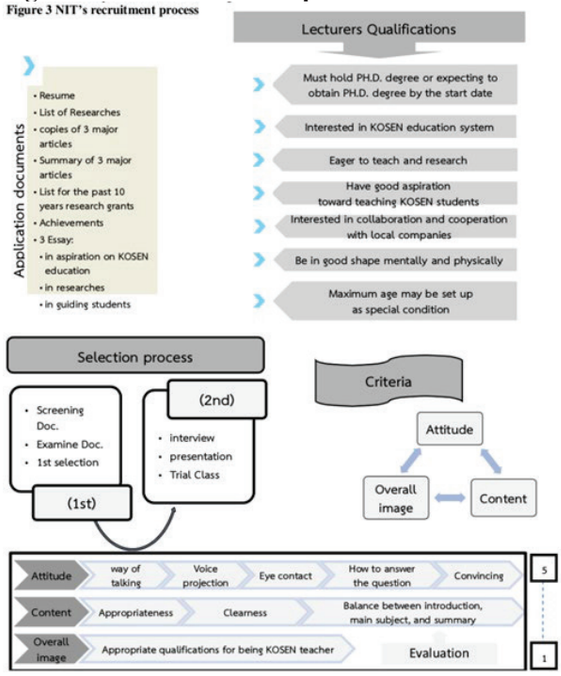
NIT's lecturers' specification

NIT lecturers' selection has been done by the committee, namely, "Personal committee" which is the main committee appointing to select new academic staff in a transparent and independent manner. The lecturer applicants need to hand in their outstanding documents such as resume, list of articles, books, patents, conference presentation, the summary of 3 major articles, list for the past 10 years research grants, their achievements record, and 3 essay about the aspiration on KOSEN's education, researches, and students guiding. Their resume and documentations will be screened, examined, and reviewed by the judges. The selected applicants will be interviewed and they have to make a presentation and the trial class in front of the judges. Three criteria were set with equal weight: attitude was 15; content was 15; and overall rating was 15, so total were 45. Applicants' way of talking, voice projection, eye contact, way to answer the question, and way of convincing people will be evaluated for their attitude. The appropriateness, clearness, balance of the applicants' essay, presentation, trial class, and interview will be evaluated for the content. Applicants' appropriate qualifications for being KOSEN teacher will be evaluated for their overall image. After all, the final selection will be made. The transparency of NIT lecturers' selection is known as one of NIT outstanding reputation.

NIT lecturers' specification consisted of 5 core criteria. The first core criterion was lecturers' educational background. They must hold Ph.D. due to NIT mission to produce research paper and create innovation and the values of the country to maintain the quality and standards of education in order to develop industrial workforce. Therefore, Ph. D. is required. The second core criterion was applicants' interests. The applicants must hold an interest in NIT education system, eager to teach and research, have good aspiration toward teaching NIT students, interest in a collaboration and cooperation with local companies to make the contribution due to the college duty, and be ready, willing, and able to support the community which is a key mission of NIT College. The third core criterion was applicants' skills. The application must

hold all required essential skills and other specialized skills are preferable. The fourth core criterion was applicants' publication. The applicants must have articles published in domestic and international peer-review journals, books, patents of products' innovation and design, conference presentation, other reputation. In addition, the applicants must be in good shape mentally and physically and be ready to perform all NIT teacher duties. Beside, maximum age may be set but not fixed or subject to special conditions. (See Figure 3)

Figure 3 NIT's recruitment process



The excerpts from in-depth interview and focus group discussion of NIT members in Kumamoto and Ube colleges regarding NIT's lecturers' specification were as follows.

Excerpt 1 Lecturers' educational background

"One of the most important requirements is having PhD degree. This is a very important requirement."
"Teacher must have the PhD. because they must do the research"
"We expected for PhD. holder because the Japan society is expect and want the quality of education"
"I think why KOSEN teacher is Ph.D. because teachers must instruct students in graduation research so teacher must have Ph.D."

In-depth interview and discussion, 25th Feb.-2nd Mar, 2018

Excerpt 2 Applicants' interests

"Teacher could interest in collaboration with local companies because one task of the college is to serve the local development"
"Main task of the KOSEN is to support the communities, therefore, our teacher or our staff must have the qualification in willing to support the communities"

In-depth interview and discussion, 25thFeb.-2nd Mar, 2018

Excerpt 3 Applicants' skills

"Skill of the teachers important to us and we prefer testimonial from applicant's supervisor or professor to prove it"

In-depth interview and discussion, 25thFeb.-2nd Mar, 2018

Excerpt 4 Applicants' publication

"Publication is require for the teacher who want to be a teacher at the college"
"Applicant should have the publication in journal both domestic or international, book or others"

In-depth interview and discussion, 25thFeb.-2nd Mar, 2018

Excerpt 5 Others

"The issue of age, it depends on the position. We are not fixed."

In-depth interview and discussion, 25thFeb.-2nd Mar, 2018

NIT achievement factors in personnel management

Important factors behind NIT personnel management achievement have been revealed in terms of external and internal factors. *External factors* that influence the achievement of NIT's personnel management were NIT's education system, the invaluable networks, the explicit and transparent organization structure and rules, and the clear staff roles and responsibilities. Firstly, NIT's education system was geared to teaching both theoretical and practical in the same weight. Besides, the focus on its research process is a main key in NIT teaching and learning which contributes to learners' potential to create innovation. Secondly, the invaluable networks both inside and outside the country such as network of NIT colleges', network of NIT alumni, and network of companies' or enterprises' have strongly been woven and tied. Thirdly, the explicit and transparent organization structure and rules and, lastly, the clear staff roles and responsibilities also influence the achievement of NIT's personnel management. NIT structure and rules as well as staff roles and responsibilities were well-constructed. In addition, all the details of these crucial information have been shared and conveyed to all staff by NIT prior to and throughout the period they has been working in NIT. All staff received, understood, and accepted the same value since they applied and entered into NIT. Their authorization has been operated in terms of committee. NIT stakeholders, former staff, or companies could not intervene the committee operation.

The excerpts from in-depth interview and focus group discussion of NIT members in Kumamoto and Ube colleges regarding external factors were as follows.

Excerpt 6 NIT's education system

"Engineers need both knowledge and practice skill. So KOSEN produce such students"
"We share for practice and theory as half and half because after the WWII Japan need high school on technology and engineering"

In-depth interview and discussion, 25th Feb.-2nd Mar, 2018

Excerpt 7 Invaluable networks

"The KOSEN has various partners including universities, national research institute, private enterprises and so on".
"Our style and teaching ideology is lead by the problem base learning so that style make us can make the network with many local community, companies, enterprise and alumni is also"

In-depth interview and discussion, 25th Feb.-2nd Mar, 2018

Excerpt 8 Explicit and transparent organization structure and rules

> *"The executive committee is one of which discussed various issue in the school management and decide the school policy. And this committee work like a control tower of the KOSEN."*
> *"We have clear role and rule, for instance, in the recruitment and selection. No one can involve or dominate the Personal Committee to select someone that they know."*
>
> In-depth interview and discussion, 25th Feb.-2nd Mar, 2018

Excerpt 9 Clear staff roles and responsibilities.

> *"The teacher's tasks at KOSEN are classified into three large groups. They are lecture, research and management."*
> *"Mainly is to do the research, teaching, engine the community and consult for the student"*
>
> In-depth interview and discussion, 25th Feb.-2nd Mar, 2018

Internal factors that enhanced the achievement of NIT's personnel management were NIT staff's belief (1) in organization (2) in system (3) in oneself and (4) in students; value; loyalty; devotion; willingness; discipline; relationship; and attitude toward problems solving. These internal factors have been observed by the researchers during the conversation of the interview, discussion, and campus tour. To the question *"With the decreasing budgets and work overload you still have good attitude toward your work. They can motivate themselves under this circumstance well. What do you think? Can they accept that? Or may be how do you deal with that problem?"*, one of the key informant replied that *"I think this is a Japanese character, may be culture."* And, *"I work for Tokyo KOSEN for 31 years; I have met the very nice and very good students. It's my pleasure in my life. KOSEN has a big special structure between students and teachers. They have much closer relationship. It's not only a class and teachers teach. They are more involved in each other."*

Excerpt 10 Staff's belief, value, loyalty, devotion, willingness, discipline, relationship, and attitude toward problems solving.

Belief
"The students are very serious and have a good attitude to study."
"Number of teachers, all branches 79 including 66 Ph.D. holders graduated by two institutions, both names are too long so that are called NIAD and JABEE for short."
Value
"Our teachers are willing to serve the community and teach and also all of them are highly in performance"
Loyalty
"Many student apply to master degree and higher level and after they finished doctoral they come back to college"
"In Japanese society, remain the way of thinking, life and employment. If you get employ company, you keep work in the company for retirement."
Devotion
"If you don't gave me more salary I'll be stay here because I think here is suit for me and enough"
Willingness
"I love to be a teacher and when I finish I come back to teach at KOSEN, I willing to teach"
Discipline
"The professor's policy was 'Do it yourself'. So we decided all things ourselves and we made the machine ourselves, repeating the failure. And finally we complete the machine and did the fatigue test and analyzed the data."
Relationship
"Also we have a homeroom teacher. So teachers have sort of feelings seeing students growing up. It's more emotion."
Attitude toward problems solving
"I can say the diversity some problem have some opinion. Some person tries to communicate to young person, young boy and young girl."
In-depth interview and discussion, 25th Feb.-2nd Mar, 2018

Discussion on NIT's lecturers' specification

Why do educational background and interests of NIT applicants that was set up as main specification of NIT's lecturers' influence NIT personnel management achievement? The answer related to many previous studies on Japan identity and importance of recruitment system. Japanese society values achievement and success and expect the quality of education (Hofstede, 1981; Hofstede, 1991; Bond M. H., 1991) while NIT has to meet the challenge of domestic and international competition in research. Thus, to successfully run NIT's new trend of education system which emphasize on quality research works, NIT needs to recruit qualified people into its system. Ph.D. is the right answer for setting up lecturers' specification on NIT lecturers' educational background. Qualified lecturers with Ph.D. could serve those values and challenge as well as serve the students success both in furthering their education and job finding. This phenomenon confirmed by the statement of Barber, M., & Mourshed, M. (2007) that teachers' quality is one of the main factors that affect learners' quality. Japanese society at large is more competitive. (Hofstede, 1981; Hofstede, 1991; Bond M. H., 1991) Thus, unity of organization is dramatically important. Setting up lecturers' interest as one of the main specification is a must. NIT right person must first hold the same interest in NIT education system, eager to teach and research, in good aspiration toward teaching NIT students, in a collaboration and cooperation with local companies to make the contribution due to the college duty, as well as be ready, willing, and able to support the community which is a key mission of NIT College. In addition, with the support of a strong society in Japanese characteristic and Japanese shared value in unity and future-oriented (Khlangsuwan, Y., 2003), a strong NIT community will eventually be created by these qualified lecturers. Accordingly, this phenomenon will enhance organization long-term success. This was confirmed by Orawongsuphathat, C. (2013) who indicated that the key to successful organization is the person who meets the needs of the organization. This will be a valuable and important asset to drive the organization to achieve its goals and objectives. Unqualified personnel recruitment, selection, and placement resulted in unqualified staff and organization failure eventually. (Heneman & Heneman, 1994)

Discussion on NIT achievement factors in personnel management

Internal factors that influenced NIT achievement in personnel management had been revealed during the staff discussion and interview. They were staff's belief, value, loyalty, devotion, willingness, discipline, relationship, and attitude toward problems solving. Reviews on Japanese identity could explain this phenomenon. All these factors found to serve better NIT organization culture influenced by national culture inheriting from Japanese culture and tradition in the past. They were formed inside their mind during the

upbringing period. This was confirmed by the studies on Japanese cultures, social order, tradition, and society (Khlangsuwan, Y., 2003; Wray, H., 1999; Hofstede, 1981; Tsutsui, 1997; Bond M. H., 1991; Hofstede, 1991) Japanese NIT staff's belief, value, and loyalty may influence by organization culture. The thinking of most Japanese tends to be intuitive and emotional. (Nakamura, 1964) So NIT set up its shared motto, core values, and mission statements for their staff to hold on. When staff shared the same value and belief, they hold the unity of their NIT society. The more they maintain the unity, the more the society united and their loyalty was built. This strong sense of loyalty finally builds a strong society and vice versa. Consequently, strong society served their courage and challenged them to compete with all tasks and focus on long-term success. Since Japanese society is defined as a society of unity. Staff's devotion, willingness, and discipline occurred. They work to serve the organization and the nation. They devote themselves willingly and disciplinary focusing on the benefit of the public not the benefit of an individual. (Wray, H. 1999) Japanese people praise the strength of patience and perseverance, not from cleverness or deceit. In Japanese society, full action toward everything they do is the pride of the family. (Tuntiruttanasoontorn, B., 2015) In addition, most Japanese have a willingness to work hard and to persevere toward long-range goals. If a person is treated well, he works willingly and hard. (Caudill, W., 1970) The culture of Japanese organization is a kind of father and son management – paternalism. (Tsutsui, 1997) Close relationship between NIT staff was seen as a very distinctive and unique feature of Japanese organization management. It reflected traditional values of "groupism". So, their attitude toward problems solving influenced by Japanese social order, the feeling of dependency, and high regard for harmony emphasizing collaborative unity and social order. (Tsutsui, 1997)

Conclusions

This report revealed very useful NIT best practices for OTEPC to deal with the issues of inappropriateness of Thai teachers' specification in the schools that provide new teaching system in Thailand. Collaborations between OTEPC, OVEC, and NIT is in need for appropriate teachers' specification and selection criteria renewing. The teachers' specification and selection criteria must be reviewed and developed. In order to sustainably create high teaching and learning quality as well as high quality of Thai students, achievement factors both external and internal are applicable to Thai teachers' personnel management. All external factors should be reviewed by Thai institutions prior to apply to their institutions development. However, national identity has to be educated since young. Therefore, internal factors application toward Thai staff may take times and need the involvement of the Office of the Basic Education Commission (OBEC). Due to the differences between Japanese and Thai cultures and educational system, the comparative study should be made.

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LESSONS FROM THE TRADITION - JAPAN MARITIME COLLEGE (KOSEN) STUDENTS EXPERIENCE POLYNESIAN TRADITIONAL VOYAGING THROUGH GLOBAL PARTNERSHIP -

T. Homae*,[a], T. Oku[b], D. Chun[c], K.Ikeda Chun[c], B.T. Yamamoto[c], N. Hashizume[d], T. Murakami[e], K. Ishida[f] and M. Endo[a]

[a] Department of Maritime Technology, NIT, Toyama College, Imizu, Japan
[b] Japan Agency of Maritime Education and Training for Seafarers, Yokohama, Japan
[c] Kauai Community College, University of Hawaii, Lihue, USA
[d] General Education, NIT, Toba College, Toba, Japan
[e] Maritime Technology Department, NIT, Yuge College, Kamishima, Japan
[f] Maritime Technology Department, NIT, Toba College, Toba, Japan

*homae@nc-toyama.ac.jp

Abstract

Japan maritime colleges (Kosen) and Kauai Community College (KCC) co-execute a three-week cultural exchange program, specially designed for Japan maritime college students, every March on Kauai Island. The main topic of the program is Polynesian traditional voyaging. As the first program was held in 2010, 10th program is going to be held in next March. In this paper, the authors would like to share our experiences in these programs.

Keywords: *Polynesian voyaging, voyaging canoe, maritime students, hands on activities, practical communication skills*

Introduction

Japan maritime colleges (Kosen) and Kauai Community College (KCC) co-execute a three-week cultural exchange program, specially designed for Japan maritime college students, every March. As the first program was held in 2010, 10th program is going to be held in next March. In this paper, the authors would like to share our experiences in these programs.

History

One of the traditional voyaging canoe, "Hokulea", sailed from Hawaii to Japan in 2007. As Hokulea is a symbol of Polynesian traditional voyaging, her visiting to Japan was a big news. Many Japanese people related with her voyage. In this circumstance, the authors, namely, Mr. Chun, Mr. Oku, Ms. Ikeda knew each other on the canoe. They discussed how to educate maritime students. One idea was a program related with Polynesian traditional voyaging on Kauai. Although there were many kinds of barriers, the related people solved the problem one by one, and the idea was finally implemented. The first program was carried out on March 2010. Only Toyama College students participated in the first program. As the first program was a great success, the program expanded for all Japan maritime college students. Since then, 8 to 16 students of Japan maritime college join the program every year.

Volunteers in Kauai built their own voyaging canoe, named "Namahoe". Figure 1 is a picture of Namahoe, taken during the program. It took more than about 15 years for completion. She was launched in 2016. During her building, Japan maritime college students got opportunities to build her as a part of this program. They sanded, varnished, and tied lashing. Hawaiian people believe the power of "mana" or sincere heart. If many people relate with building the canoe with sincere heart, it strengthens the canoe. From this point of view, the maritime students played important roles.



Figure 1 A traditional voyaging canoe, Namahoe.

Program Outline

The program is entitled "Ikena Kahua" in Hawaiian language. It means "Seek your foundation". Through lessens from traditions, the students are expected to find the foundation of their life.

The main topic of the program is Polynesian traditional voyaging, namely, way finding without modern navigation instruments. They know the direction and their position from everything in nature, such as the sun, stars, waves, clouds, birds, and so on. Kyselka (1987) published a book about the Polynesian traditional voyaging and Hokulea. The technique made the Polynesian people possible to voyage on the Pacific Ocean in ancient times. As Japan maritime colleges (Kosen) educate the students who will be a captain or a chief engineer of ocean-going large vessels, it is important for the students to learn how to have good relationships with the ocean. The program focuses not only on the technical aspect of the traditional voyaging but also on the good relationship between the people, who related with the traditional voyaging, and the ocean.

The period of the program is about 20 days. The students learn about Polynesian traditional voyaging in KCC on Kauai Island in Hawaii for first two weeks. They learn the fundamental theory and practical procedure for traditional way finding with KCC students in the KCC classrooms in the morning. Figure 2 shows a picture of the class. They also learn the Hawaiian traditional culture, the history of Japanese immigrant on Kauai.



Figure 2 Japanese students and KCC students discuss how to find the way from stars at night.

They also participate in Japanese class of KCC. In this class, KCC students and Japan maritime college students teach their own language each other. Japanese students are motivated to learn English by communicating with KCC students who learn Japanese as a foreign language. In addition to that, as the KCC students who take Japanese class are interested in Japanese culture in general, the students can make KCC friends easily.

The students work on off-campus activities in the afternoon. They build/maintain the voyaging canoe, Namahoe, learn how to swim or float if they fall overboard from the canoe as ocean training, and so on.

The accommodation has a kitchen in each room. During the program, they cook dinner by themselves and eat together in the escorting teacher's room. After the dinner, they reflect the things on the day together, facilitated by the escorting teacher. All elements in daily life is a part of the program.

The motto is "Help each other." A student who are good at English, he/she should shear his understanding to the other students. A student who are good at cooking, he/she should guide the other students in preparing dinner. A student who swim well, he/she should support the instructor of the ocean training, and so on. As the program includes great variety of elements, we expect all the students make use of his/her advantage and learn as much as possible as a group.

The students participate in a special program of crew training for the traditional voyaging canoe in the third week. The people who relates with the Polynesian voyaging join the training from all over Hawaiian Islands. The number of people depends on the year, but it can be up to 80. They camp together like on a voyaging canoe. The attendees are divided into 3 or 4 groups, so called "watch". They go along as a group in the program. Three or four students belong to each watch. The students are surrounded by the Hawaiian people who are interested in voyaging canoe. Figure 3 shows a picture taken in the training. They simulate the life on the voyaging canoe and experience/learn more about the Polynesian voyaging and relationship with the ocean.



Figure 3 Japanese and Hawaiian people learn how to use stars for way finding together in the special program of crew training for the traditional voyaging canoe.

Results and Discussion

All the students, who completed this program, find something important for his/her life. Some students reconfirm that they have had a good relationship with the ocean. Some students find how to communicate with a person who has different cultural background. Some students start studying English more zealously. As a result, most of the graduates are hired as an officer or an engineer of large vessels or went on to universities or advanced course of Kosen.

Conclusions

The authors report the cultural exchange program, specially designed for Japan maritime college students to share our experience. We hope many attendees are interested in this program through this paper.

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FOSTERING PRACTICAL AND GLOBAL ENGINEERS BY PARTNERSHIPS WITH THE REGIONAL COMMUNITY

Yoshiaki Suda*[a], Tatsuo Nishizawa[a], Satoru Seto[a],
Kiyoshi Hatta[a] , Hirofumi Kuroda[a], and Keiko Dochi[a]

[a] National College of Technology, Ishikawa College, Ishikawa, Japan

*y-suda@ishikawa-nct.ac.jp

Abstract

National Institute of Technology, Ishikawa College (NIT-IC) has started an educational program since 2017, "Fostering Practical and Global Engineers by Partnerships with the Regional Community - Career Design Education through Collaboration with Local Companies ", which was adopted in FY2017 by the Ministry of Education, Culture, Sports, Science and Technology as a "KOSEN 4.0" Initiative. The aim of this program is to encourage young KOSEN students to acquire and develop knowledge, skills and mind-set of the next-generation technology. The project is systematically organized as a career design program through collaboration with local communities and companies.

This education program motivates and encourages the lower grade students to be leading engineers with lectures of experienced engineers and visits to actual production sites and working places. For the upper grade students, it provides seminars for the students to study what local companies and municipalities are working on. After the students learn the activities of the companies and municipalities, they take two weeks internship to experience actual jobs in development and production sites of the companies. Also, all fourth-grade students visit overseas factories in Southeast Asian countries, where the local companies have their production branches and interact with the students of these countries.

In the advanced course, the students take three months internship, where they try to find various problems that local companies or communities face and tackle the problems for themselves. Furthermore, some of them participate in an overseas internship for a couple of months to become a global engineer with a financial support by the Japanese government (e.g., Tobitate! (Leap for Tomorrow) Study Abroad Initiative).

The students document every event provided in the program on a portfolio with self-evaluation. The portfolio records not only engineering knowledge and skill development but also professional sense development.

This paper reports the specific contents and outcomes of the educational program.

Keywords: *career design, international internship, engineering education, regional community, portfolio*

Introduction

Japanese local societies like Ishikawa Prefecture are facing several serious issues, e.g. depopulation, globalization and climate change. The depopulation of the region leads to shortage of local engineers as well as shrinking of local markets. This would hinder development of advanced productions and make it difficult to maintain old infrastructures in this area.

The globalization forces the local industries to transfer their production departments overseas like Southeast Asian countries to complete with global companies and expand new markets. The climate change urges the industries to produce environmentally friendly products with a reasonable cost. KOSEN needs to not only teach technical skill and knowledge but also educate young engineers to contribute to the sustainable development of regional communities.

Under such circumstances, National Institute of Technology, Ishikawa College (NIT-IC) has started an educational program since 2017, "Fostering Practical and Global Engineers by Partnerships with the Regional Community - Career Design Education through Collaboration with Local Communities", adopted in FY2017 by the Ministry of Education, Culture, Sports, Science and Technology as the "KOSEN 4.0" Initiative.

The project is systematically organized as a career design program through collaboration with local companies. This paper reports the specific aims, contents and outcomes of the educational program.

Aim and System of the Educational Program

The aim of this program is to encourage young KOSEN students to acquire and develop technical skills, knowledge and mindset of a global engineer. The project is systematically designed as "Career Design Program" through collaboration with the regional communities.

The program is consisted of following four subprograms:

1. "**Career literacy**" **for lower grade students**
   The subprogram motivates and encourages the lower grade students to be leading engineers through lectures by professional engineers and

visits to actual production sectors and working places.

2. "**Career Workshop**" **for upper grade students**
   It provides seminars for the students to study what local companies and municipalities are working on. After learning the activities of the companies and municipalities, the students participate in a two-week internship to experience actual jobs in development and production sites of the companies. Also, all fourth grade students visit overseas factories of Japanese companies in Southeast Asian countries and interact with local students of these countries.
3. "**Career Challenge**" **for advanced course students**
   The students take three month internship working at local companies as the normal employees to find what they can do and what they lack in an actual working environment.
4. "**Global Career Challenge ” for all students**
   Some of the students go on an overseas internship for a couple of months to prepare to become a global engineer with a financial support from the college and Japanese government, e.g., Tobitate! (Leap for Tomorrow) Study Abroad Initiative (Ministry of Education, Culture, Sports, Science and Technology, 2018).

The program overview is shown in Figure 1. Expected specific outcomes from this program are an increase in the number of students who participate in an international internship and get a job at the local companies.

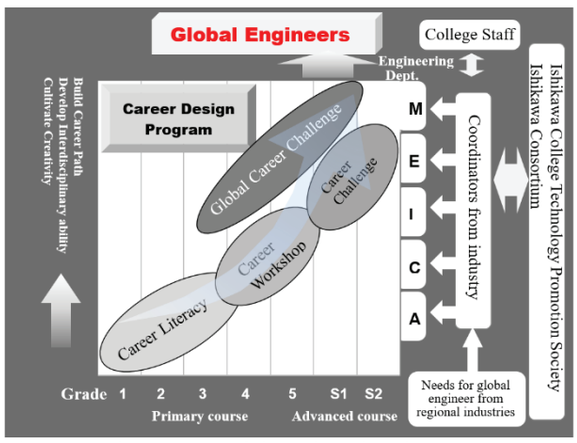


Figure 1. The System of the Educational Program

Implementation and Support of the Project

The program is implemented by whole college staff under the leadership of the president. In this program, colaborations with regional communities are indispensable. For that, we have supports from two local organizations: Ishikawa College Technology Promotion Society (ICTPS) and Ishikawa Consortium of Higher Educational Institutions (ICHEI).

ICTPS is an organization with 220 members from local companies, municipal governments and industrial societies. Its activities are to support educational and research activities of the college and connects the members with students and faculty members of the college. In this project, the members accept the students for an internship, provide information of the companies and arrange production sites and working places for the students to visit.

ICHEI is an organization comprising of 21 higher educational institutions of Ishikawa prefecture. The mission is to enhance and develop the regional higher education, culture, research and industry with colaborations among the member institutions and regional communities. The activities include sharing education programs between the member institutions and promoting collaborative educations with regional communities. In this project, ICHEI provides coordination and financial support for students who participate in an oversea internship.

The college employs two coordinators who used to be professional engineers and have experiences in industrial worlds. Their roles are to connect the students with local companies and teach business manner, culture and safety management to the students.

Career literacy

There are three fundamental components in the career design (Tazawa, 2018): ***Will*** (hope, dream and determination), ***Can*** (ability) and ***Must*** (requirement from societies) as shown in Figure 2. In the career design, students have to find what they really want to do, which motivates them to move forward (Super, 1957).

However, the students sometimes feel anxious or dissatisfied due to lack of skills and abilities, and mismatching between current study and future career. Analyzing their current situations in terms of the three components and recognizing overlapping area of the components change these negative feelings to “Hope” and “Fulfillment”. This process prompts the students to analyze their dreams and abilities as a self analysis, and study business outlines of companies as an exterior analysis. Those actions encourage them to make positive actions for realizing their dreams.

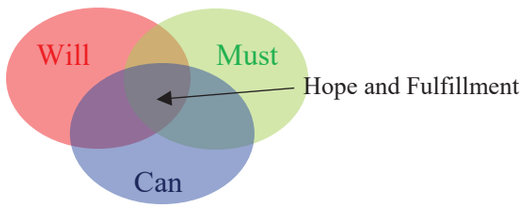
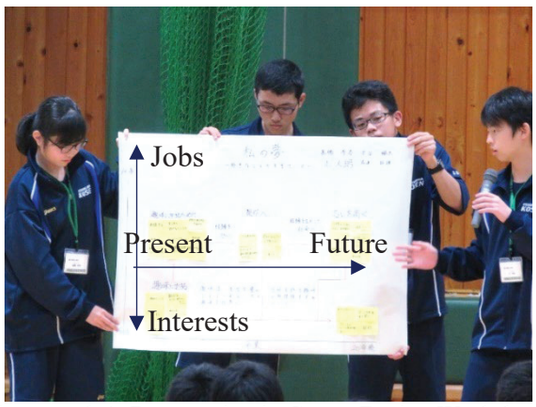


Figure 2. Three Fundamental Components in Career Design

Lower grade students tend to have very little concerns on their own career. This program provides them an opportunity to learn basics of career design. Soon after new students enter college, the students participate in a workshop of career design to acquire the basics and find what they have and do not have for achieving their career goals. In the workshop, the students think about and list up what they want to do in a future career. They put the

listed items on a matrix form with a vertical axis of present to future and a horizontal axis of interests to job as shown in Photograph 1. This process gives them an opportunity to connect their present with their future and recognize the relationship between their interests (*Will*) and jobs (*Must*).



Photograph 1. Presentation in Career Design Workshop

The students train and repeat this process continuously and record the results of the process on a portfolio, which will be explained later in this report.

In a class of orientation for each engineering department, students learn about what their career and jobs as an engineer will be in each engineering field. Also, they have lectures from graduates how they build their own career as an engineer, and they visit factories and construction site to learn what are actual works and what engineers really have to do.

The third grade students visit a production sites and working places for two days outside of Ishikawa prefecture to see jobs of big global companies. Also, they have lectures from the leading engineers of the companies to learn the state of art of their engineering field and build their own career images.

For the third and fourth students, ICTPS holds a job fair in the college gymnasiums, where member companies are able to explain their own technologies and business outlines directly to the students. The college gives the students a booklet, which introduces these companies to the students for studying the companies before the fair. All the students visit at least four company booths and contact company engineers. This is the first opportunity for the third grade students to know what kind of companies are located in Ishikawa prefecture. This fair motivates the students, who were very little concerned their career, to explore their future and prepare a short period internship provided in their fourth grade curriculum.

According to the result of the survey, more than 70 % of the students who attended the job fair expressed that the fair was very helpful to think about their future. We also asked the companies participating in the fair about impression of the students. They answered that the students very seriously listened to the company presentations and they had very positive impressions on the student's attitude. 95.6% of the companies very eager to participate in the fair again.

Career Workshop

The fourth grade students have to start to think about what kind of job they are going to obtain after they graduate the college. The college provides them information on their career paths and local companies as much as possible.



Photograph 2. Job Fair Held by ICTPS in College Gymnasiums

The students take a two-week internship in a company selected based on the knowledge obtained from the job fair and graduate lectures. In the internship, they experience actual activities in the factories or government offices. Since they realize that their engineering knowledge and skills are still insufficient, they find out what they need to take up the profession, and what they would actually do at work.

After experiencing the short internship, they have ICTPS job fair again. Since this is the second time for them to participate in the fair and they have to determine and find employment in several months, they take this opportunity much more serious than in the previous one. They visit company booths that would be related to their future career. In this fair, many local companies, which are unfamiliar to the students but have great technologies, are able to present and appeal their business to the students. Therefore, this is a good opportunity for the students to broaden their perspectives of own future careers in the local companies.

In the meetings of ICTPS, we found that even local companies have a strong incentive to transfer production bases and expand new markets abroad such as Southeast Asian countries because these countries are developing their economic powers and becoming great markets for Japanese industrial productions.

Sometimes, our college graduates are in charge of the oversea operations. Since young people these days do not want to go working out of home country, the companies have difficulties to find a staff member who are able to work abroad. ICTPS requests the college to let the students have more international experiences and broaden their job perspectives to worldwide.

Considering the situations, the college takes all fourth grade students to Southeast Asian countries and let them have international experiences exposed to other cultures and customs.

Each engineering department chooses a country to visit and gives the students opportunities to meet the same age local college students and look at working environment of Japanese companies operating in the countries. Although the trip is very short, it is a first trip abroad for most students and gives a strong impression to them. Through the trip, the students open their eyes to outside of home country and understand the meaning of working abroad. Table 1 shows an example of schedule of the short trip abroad.

Table 1, An Example Schedule of Oversea Excursion for Civil & Environmental Department

The first day	Move to the country to visit
The second day	AM: Meet with local students
	PM: Sightseeing
The third day	AM: Visit a construction site of subway station
	PM: Shopping on their own
The fourth day	Back to home

The result of a survey to the students after the trip revealed that more than 90% students realize the lack of English communication skills. But, at the same time, they do not hesitate to work abroad any more.

Career Challenge

The curriculum of the advanced course includes three month internship to a local company, which is worth ten credits. The students have to take orientations and lectures about basics of internship before the internship.

In the orientation, the students learn business manners, cultures and safety management. The host companies are responsible to determine what the students are going to do during the internship, and set a goal of the student.

The students are trained by the host company as a normal employee. Some of them are involved in a research and development activities. They submit a daily report to supervisors who are in charge of looking after the interns and checking their daily activities. They also report their monthly activities to teachers in the college. The teachers and coordinators in the college visit the host companies to see how the students work. Moreover, they talk with the surpervisors in the company about student's activities as well as issues or problems if they have.

After the internship, the students make a report about their activities and self evaluation including whether they attained their goals that they set beforehand, what they accomplished and what they lack. The students hold a presentation of the report to the coordinators, teachers and host companies. The students are graded according to the evaluations of teachers and host companies based on a daily report, working attitude, the final report and presentation.

The three month internship is a big challenge for the students and help them to establish their realistic and specific future plan as an engineer. Even students who had not confidence in themselves before the internship have changed to young engineers with confidence after the internship.

The host companies deal with the student as a normal employee and strictly point them out what they lack for the job assigned. This experience motivates them to study harder after coming back to the college. Some of them determine and choose the host companies as a place of employment. Although the three month internship generally is the burden of responsibility for the host companies, they understand the importance to educate young engineering students in collaboration with colleges. It is because the internship would be long term benefits for the companies who are struggling to find young employees. We also have continuously been improving the three month internship program based on the feedbacks and constructive opinions from the host companies.

Global Career Challenge

The local companies in the HOKURIKU region comprised of three prefectures: Toyama, Ishikawa and Fukui have a strong incentive to transfer production bases abroad such as Southeast Asian countries. Many graduates are employed by those companies and some of them work an overseas branch. Therefore, those companies are looking for young engineers who are able to work in oversea environments.

Several international programs are available for our students. As we have explained in the previous part, the advanced course students are required to participate in three month internship either in Japan or abroad. ICHEI provides a competitive fund to support college students. Students propose a plan of various international activities including internship abroad for more than one month. Few of the plans are accepted and have the financial support after a rigorous screening. This support program is called “Tobitate! (Leap for Tomorrow) Study Abroad Initiative “, which is sponsored by Ministry of Education, Culture, Sports, Science and Technology. We also recommend our students to apply other programs sponsored by Ishikawa prefecture and National Institute of Technology. The students who have studied abroad and attended oversea internship share their experiences with other students through the reports and presentations. Table 2 indicates the numbers of students who participated in these kinds of international programs.

Table 2, Numbers of Students Who Attended International Internship. Short: Less than one month, Long: More than one month

Year	Long	Short	Subtotal
2015	0	6	6
2016	2	8	10
2017	2	5	7
Total	4	19	23

The numbers of students who had international experiences as presented in Table 2 do not seem enough considering the total number of students in the college of 1100. The reasons of these small numbers are:

1. The financial burden of international programs is a serious problem for the sututdents and their family.
2. Very few local companies that have oversea branches are able to accept the interns, because the most of local companies are small or middle-seized and do not have staff taking care of the interns.

The college set up a fund to support the students, who want to have international experiences, by collecting donations from local companies, college graduates and parents. Also, we strongly recommend the students to apply international programs sponsored by Japanese government, municipalities, industries and other various agencies.

The college has been trying to expand the international networks by attending relevant international conferences and visiting oversea branches of Japanese companies and international colleges with supports from ICTPS and ICHEI.

Career Portfolio

As mentioned earlier, it is required for a student to analyze three components and overlap them for building up his/her career. The portfolio is designed to help the student to practice this analyzing process. The structure of portfolio consists of the following steps:

1. ***Will***: A student imagines his/her future as a professional engineer of around 30 years old (long-term goal).
2. ***Will*** and ***Must***: The student looks at overlapping area of ***Will*** and ***Must*** to set a short-term goal based on the long-term goal as described in Step 1.
3. ***Can*** at present: The student analyses what he/she can do at this present to attain the goal of Step 2.
4. Extend present ***Can***: The student makes a specific action plan of what to do, when to do and how to do.
5. Change of ***Can***: The student evaluates the difference in ***Can*** between past and present.

The students repeat this process and record them on the portfolio every half school year. They are able to examine and recognize the change in the future image and growth in the engineering abilities from the portfolios. This enhances the self-efficacy (Deci, et al., 1985; Bandura, 1977), which will be the strong motivation for the students to challenge the next stages.

This type of portfolio is designed for the first, second and third grade students. The fourth grade students add sheets including company research results and self introduction to previously accumulated portfolios to raise their social consciousness. Such self analysis on ***Will*** and ***Can*** and external analysis of ***Must*** are continued for all years to give the students new goals and stimulate them to prepare new challenges. These analyses make students set specific goals up before an internship and evaluate themselves based on what they accomplish in the internship.

Conclusions

NIT-IC has started a specially designed program since 2017, “Fostering Practical and Global Engineers by Partnerships with the Regional Community - Career Design Education through Collaboration with Local Communities “. The aim of this program is to encourage the young KOSEN students to acquire and develop knowledge, skills and mind-set of global engineer to the next-generation. The project developed a career design program through collaboration with local companies. The program consists of five processes: career literacy (lower grade students), career workshop (upper grade students), career challenge (advance course students) and global career challenge (all students) and portfolios that visualizes the change future career image and development in engineering abilities and global mind. Through all activities provided in this program and recorded in the portfolios, students realize the growth of themselves, of which process itself is the career design for the students to become a global engineer.

One of issues raised up in this project is lack of fund to support students to attend international conferences. Another one is a small number of host companies that are able to accept international internship. We are expecting that these issues could be resolved in cooperation with local companies and municipalities who understand the importance of engineering education for sustainable development of the local communities.

Acknowledgements

We are grateful to the students who allowed to be interviewed for this study. We would like to acknowledge the Ministry of Education, Culture, Sports, Science and Technology as the “KOSEN 4.0” Initiative for sponsoring the project of ‘Fostering Practical and Global Engineers by Partnerships with the Regional Community’.

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A CASE STUDY OF CROSS-BORDER EXCHANGE PROGRAMME IN ENVIRONMENTAL PROTECTION EDUCATION

Ka Po, NGAI*

Department of Applied Science, Hong Kong Institute of Vocational Education (Sha Tin), Hong Kong

*kpngai@vtc.edu.hk

Abstract

International exchange programme can serve as an effective tool to enhance personal growth and acquisition of subject knowledge. Visiting places away from home town provides a chance to refresh the mind, and usually lead to a better learning atmosphere. As an international city, Hong Kong always look for opportunities to exchange innovative ideas with other places. Considering a wide-range of environmental technologies being adopted all over the world, it is particularly important for incorporating international exchange in environmental education to enrich students' learning experience. Year one students from the Higher Diploma of Environmental Protection and Management, Applied Science Discipline, IVE have participated in an exchange programme held from 26 to 29 March 2018 at the Shenzhen Polytechnic. Through the collaboration between the two institutes, students are expected to learn about the environmental protection issues and management strategies being adopted in Shenzhen. This programme has been held since year 2016. There are two kinds of delivery mode, which includes student projects and exchange tour. Based on the suggestions and feedbacks from the students and teaching staff, improvements have been implemented incrementally throughout the years. Owing to the tight schedule, arranging exchange activities requires good planning in advance to ensure archeiving the educational goals. This paper aims to share the engaged educational activities during the programme, and the challenges involved in the planning and delivery stages. We reviewed the activities held during the exchange programme, which includes lecture, site visits and student presentation. The value of fun as well as the educational value of each activity were described. The main contribution of this paper is to review the characteristics of the exchange activities from an international connectivity perspective, and their relationship with learning and teaching.

Keywords: *cross-border exchange programme, exchange activities, environmental protection, educational value, learning and teaching*

Introduction

Enhancing the curriculum with international content is always an important strategy to cope with the global academic environment. Cross-border collaboration such as exchange programme has long been considered an initiative to motivate knowledge acquisition (Altbach & Knight, 2007). It is not just the technical knowledge but also the behavioural changes that play a key role in environmental education (Valderrama-Hernández, Alcántara, & Limón, 2017; Varela-Candamio, Novo-Corti, & García-Álvarez, 2018). Engaging students in exchange programme has been proposed as an indicator to reflect the achievement of an environmental higher education programme (De Andrade Guerra et al., 2018). However, the success in bilateral exchange of environmental protection ideas depends on the design of the exchange activities. In view of the time management and logistics support, there can be various mode of delivery for the exchange programme. Our collaboration with the Shenzhen Polytechnic in organizing an exchange programme under the "Ten Thousand Student Interflow Programme of the Ministry of Education", Ministry of Education of the People's Republic of China (hereafter referred to as the exchange programme) started in year 2016. It aims at organizing technology and cultural exchange activities among students from the two institutes. This paper provides an overview on the design and delivery of the exchange programme focusing on environmental protection education.

Methodology

The design of the exchange programme has been reviewed in relation to the types of exchange activities, time management and the learning outcomes. The experience in fine-tuning the design over the past three years are summarized, and the impact of introducing new designs on the fun element and educational values of the programme would be discussed.

Roles of regional exchange activities in environmental protection education

Environmental protection has been known to be a cross-border issue. Regional cooperation are necessary to tackle green issues such as air and water quality monitoring and management. The policies and technologies adopted by nearby regions are good references for local discussion and subsequent decision-making to formulate appropriate strategies. Exchange activities shall offer opportunities for the participants to broaden their horizon.

Mode of delivery

The exchange programme has been delivered in two different modes: student project and exchange tour. Student project mode engaged year 2 students from the Higher Diploma programme studying environmental protection and management. Students from both institutes would teamed up in groups to conduct the project in both Hong Kong and Shenzhen. Numbers of project titles would be selected with agreement among the teaching staff from both institutes. The project would last for three months, and with four full days in total for the field work. Working days are scattered over the whole period, and with a final student presentation for reporting the results. This mode of delivery usually involves three groups of students, and with around five students as well as one teaching staff from each institute in a group.

Exchange tour served as another mode of delivery, which engaged year 1 students and all of our programme team teaching staff. The tour could last for 4 – 7 consecutive days, and covered a range of activities including technical visits and lectures. Students were asked to give a presentation on the last day of the tour sharing about the acquired subject content. Figure 1 and 2 summarized the time allocation of the exchange activities for the two mode of delivery.

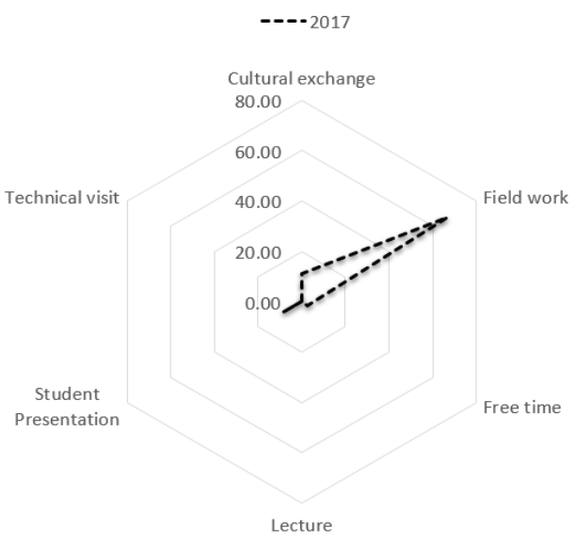

Figure 1. Time allocation of the exchange activities (student project mode)

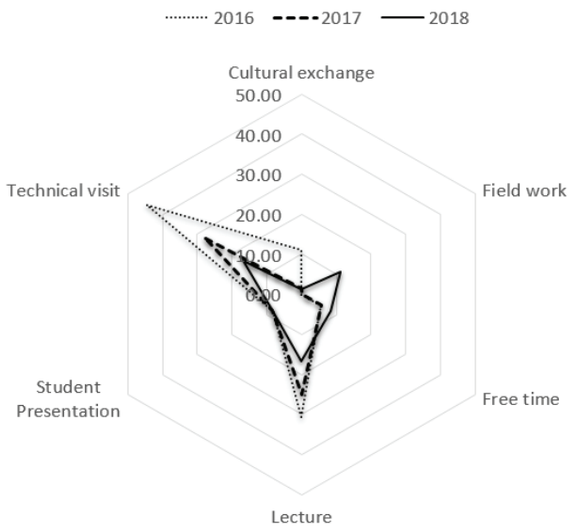

Figure 2. Time allocation of the exchange activities (exchange tour mode)

Learning outcome – fun and educational value

The exchange activities in two different modes of delivery varies, but serve the same purpose of enriching the learning experience of the students. The activities are expected to be with high uniqueness and offering new experience to the participants.

Considering the time constrain and the differences in the learning outcome in the curriculum between the two institutes, the investigation topic of the student projects focused on conventional environmental studies. Projects related to river water quality, roadside air quality and monitoring of water quality of sewage treatment work have been carried out in Hong Kong and Shenzhen. Students learnt the differences in the environmental regulatory standards and testing procedures among different administrative entities. Sharing the findings from the cross-border studies allow students to get familiar with thinking environmental protection in a global perspective.

The exchange tour, on the other hand, provides a larger flexibility in the design of learning activities. Table 1 summarized the activities that had been included over the last three years. At the planning stage, we considered the fun element as well as the educational value of the proposed activities. Some visits are more technically-oriented, while some of them taking an implicit learning approach. One should notice that striking the balance between having fun and rich in educational value is always difficult, and it is a progressive improvement process over the past three years. There are teaching team meetings reviewing the activities after each exchange tour. Visits organized in year 2016 mainly focused on technical know-how with numerous hard facts. Students had been hard to learn efficiently as they are in a relax state in a foreign place. This year we firstly included the visits to the Shenzhen Safari Park and the Waste-to-Energy Incineration facilities.

Table 1. Fun element and educational value of the exchange activities.

Exchange tour Mode	Fun element	Educational value	Student Project Mode	Fun element	Educational value
Cultural exchange			**Cultural exchange**		
**Campus tour*	✓	✓	**Lunch gathering*	✓	
**Cycling*	✓				
**History museum*	✓	✓			
Field work [(a)]			**Field work**		
**Air & Water sampling / measurement*	✓	✓	**Air & Water sampling / measurement*	✓	✓
Lecture			**Lecture**	N.A.	N.A.
**Regulatory standards*		✓			
**Water / Wastewater treatment*		✓			
**Sustainable urban planning*		✓			
Student Presentation		✓	**Student Presentation**		✓
Technical Visit			**Technical Visit** [(a)]		
**Landfill site*		✓	**Air monitoring stations*	✓	✓
**Safari Park* [(a)]	✓	✓			
**Water supply systems*		✓			
**Water treatment plant*		✓			
**Wastewater treatment plant*		✓			
**Waste-to-Energy Incineration facilities* [(a)]	✓	✓			

(a) Activities newly introduced in 2018.

Visiting the Safari Park served as an implicit learning to raise the student awareness in nature conservation, while the MSW incineration plant echo the increasing local concern on the environmental impact of adopting such MSW treatment technology. Both site visits have fun element and high education values due to the uniqueness of the facilities.

Another new trial being taken this year is to deliver teaching content of the Higher Diploma module during the exchange tour. Laboratory session with field practical work has been chosen to be delivered during the tour. Air and water sampling and on-site measurement have been conducted. Teaching staff noticed a strong learning motivation among students. The application of field practical techniques in a foreign place is a refreshing experience for the students.

Cultural exchange

Cultivating mutual understanding has always been one of the major objectives of any exchange programme. For the project-based mode, there has been lots of conversation among the exchange students. Students from both institutes built a close collaboration during the field work and lunch time. Mutual assistance has been common in such an alternate host-guest relationship. Jang, D. and Kim, D.-Y. (2010) suggested that adhering to the host cultural norms and values is a crucial factor for the acculturation of exchange students. We observed such phenomenon during the exchange programme, in which there were raised awareness in self-initiated food waste collection by our students. This is mainly due to the cultural norms at the campus of the Shenzhen Polytechnic. The closely engaged project groups guaranteed an exchange in various depth.

It has always been a challenge to arrange cultural exchange activities between students from different institutes (Rohrbaugh, 2016). Numbers of approaches have been tried out in the exchange tour: (i) common lecture; (ii) leisure group activities; (iii) common site visits. We observed the common lecture and site visits approach have limited impact on promoting cultural exchange. Blanchet-Cohen and Reilly (2013) noticed the challenges including value clashes and lack of common lived experiences in environmental education within a multiculturally-diverse classroom setup. Conventional lecture is an undesired scenario for sharing opinions among students. While leisure group activities are usually considered as an effective approach to cultivate culture exchange, it may suffer from constrains in time management and logistics supports. To encourage students discovering the cultural characteristics, we arranged some free time slot for the students and adopted a nearly complete laissez-faire approach. Regular checking on students' status have been done only for safety and security reasons.

Conclusions

Environment education is an inter-disciplinary subject requiring students to apply the acquired skills in different time and space. The exchange program provided an opportunity for students to practice the generic and technically-specific knowlegde in an unfamiliar situation. We demonstrated an exchange program, with a continuous review on the exchange activties, could boost the learning motivation and encourage positive acculturation on environmentally friendly behaviour.

We noticed this study is subject to several limitations. First, there are only descriptive assessment on the learning outcome for the exchange activities. There is lack of empirical analysis on the instructional sensitivity, which could be critical in evaluating the vocational educational training (Carleton-Hug & Hug, 2010; Deutscher & Winther, 2018). Second, the language issue occuring in similar exchange programmes is not a concern in this case and not being discussed. There is also a limited understanding in the appropriate incorpration of implicit learning throughout the programme. Future work on implementing a variety of exchange activities would be crucial for continuous improvement of the exchange programme.

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CAN JAPANESE EXTRACURRICULAR ACTIVITIES IMPROVE ENGINEERING STUDENTS' GENERIC SKILLS?

Y. OMINATO*,a

[a] Division of General Education, National Institute of Technology, Nagaoka College, Niigata, Japan

*ominato@nagaoka-ct.ac.jp

Abstract

Generic skill is not a very new aspect to look at students' abilities in educational fields; however, not a sufficient number of studies has reported specific methodology to train students' generic skills. Moore (2011) calls it "transferable [skill] to a multiplicity of situations" which students can apply in their next level schools or their professional working fields, such as creativity, teamwork, leadership, communication skill, time management skill, critical thinking, and so forth. Hamana (2010) mentioned it is essential for teachers to implement some educational methodologies "both inside and outside of the classroom." School teachers spend most of their time on preparing lessons for "inside the classroom." Nevertheless, Mizokami (2009) pointed out that students who can successfully combine their management in learning in their regular classrooms and their extracurricular activities showed higher improvement in their generic skills. Therefore, in some extent it is difficult to just ignore students' extracurricular activities. This study focuses on the implementation of "outside classroom" extracurricular activities and how it works in a setting of National Institute of Technology [Kosen]. Based on the Mizokami's (2015) questionnaire on Japanese high school students, the author arranged it for the Kosen students. The number of participants was 101. The questionnaire asks how they spend their daily lives, (whether they have breakfast every day, read newspapers, read books, and etc.) and their typical school lives on weekdays and weekends. The purpose is to figure out what type of students can improve what specific generic skills. Moreover, the questionnaire was also conducted on the members of the author's swimming team. This club is one of the extracurricular activities in Nagaoka Kosen and the members practice competitive swimming six days a week. This study also reveals whether the members could improve their generic skills through their school lives and how they are different from the others, because they have participated Uitemate project which the Society of Water Rescue and Survival Research conduct in ASEAN countries in order to prevent Asian children from drowning. In this way, it might be possible to suggest that one of the methodologies to improve students' generic skill is to participate in an extracurricular activity and to get involved in an international activity.

Keywords: *extracurricular activity, generic skill, swimming, UITEMATE*

Introduction

Things are getting really complicated for teachers who are in charge of club activities at their extracurricular activities in Japanese junior high and high schools. Traditionally, Japanese school teachers are assigned to coach some sports or cultural activities after school. Large amounts of teachers spend their valuable preparation time for their lessons for coaching his/her club team in their schools. Kosen in Japan also has club activities and most of the Kosens in Japan have club activities, but Kosen teachers have choises whether they take care of those club activities or now, bucause club activities are not officially considered as an educational task for teachers like junior high and high schools in Japan. However, Japanese Kosen has a common standards for teacher to teach at their Kosens called Core Curriculum, and it requires us to improve students' generic skills such as communication skills, leadership, problem-solving skills, and so forth.

Literature Review

The questionnaire was created by Mizokami (2015) and he conducted his research on 165,687 Japanese high school students (sixteen to seventeen years old: 21,238 boys, 22,588 girls, and 1,485 unknown) in 2013, and 16,829 (37.1%) responded his questionnaire. Conducting some cluster analysis on his data, his research figured out that there were seven different types of high school students among his participants such as (1) Study Type, (2) So-so-Study Type, (3) Club Activity Type, (4) Playing with Friends & SNS Type, (5) Reading & Manga Type, (6) Game Type, and (7) Less Participation in School Event Type. Regarding club activity, his finding was that the students who were categorized in Study Type and who could spend both their study and club activities compatibly showed the highest score in their improvement on their generic skills compared to the other types of students. Here, the "generic skills" indicate eighteen different students'

skills and attitudes. For instance students are able to (1) plan a schedule, (2) analyse problems in society, (3) have strong leadership, (4) search information in libraries and on the Internet, (5) discuss with others, (6)write in their own words, (7) make presentations in front of people, (8) cooperate with others, (9) use computers and the Internet, (10) use time efficiently, (11) create new ideas, (12) challenge difficulties, (13) listen to others, (14) respect opinions from others, (15) concern others, (16) work on tasks patiently, (17) be interested in different cultures from different countries, and (18) understand themselves objectively. He asked those questions above in five point Likert. The details how he conducted research will be mention in the Method section in this research.

Methods

In order to figure out what types of students can improve what kind of skills and attitude throughout their Kosen lives, the author has arranged his questionnaire for specifically for Kosen students based on Mizokami's (2015) study. The questions used on the questionnaire are as below;

Q1-1: Sex
Q1-2: Major
Q1-3: What type of Entrance Exam did you take (paper test or recommendation from his/her junior high school?)

Q2: Daily Activities <4 point Likert> 1: all of the time, 2: some of the time, 3 hardly ever 4:never
Q2-1: I take breakfast every day
Q2-3: I read newspaper every day
Q2-4: I read news on the Internet
Q2-5: I have regular habits on everyday life
Q2-6: I am late for school
Q2-7: I understand what I learn in school
Q2-8: I have high motivation toward learning
Q2-9: I make plans for learning
Q2-10: I solve any problems while studying
Q2-11: I seldom study if it is nothing to do with university entrance examinations
Q2-12: I participate actively in school events (e.g. school festival, sports day, etc.)
Q2-13: I often participate in volunteer activities
Q2-14: I have joined internship programs
Q2-15: I would like to study abroad
Q2-16: I would like to work abroad in the future

Q3-1: Is your study and club activity compatible?
1: yes, 2: so so, 3: not really, 4: no, 5: I do not belong to any club
Q3-2: Do you often involved in discussions and presentations?
1: all the time, 2: some of the time, 3: hardly ever, 4: never, 5: no opportunity in my Kosen
Q3-3: Do you participate in comprehensive schools hours or homeroom activities
1: all the time, 2: some of the time, 3: hardly ever, 4: never, 5: no opportunity in my Kosen
Q3-4: Are you satisfied with your Kosen life?
1: strongly agree, 2: agree a little, 3: neither agree or disagree, 4: disagree a little, 5: strongly disagree

Q4: Daily activities: Write how many hours you spend for the following activities. The total should not exceed 24 hours including 7 to 8 school hours.
*write hours for weekday and weekend separately
Q4-1: Club Activity
Q4-2: Study (other than classes in school)
Q4-3: Play with friends
Q4-4: Watch TV
Q4-5: Exchange messages on mails, LINE, or SNS (twitter) etc.
Q4-6: Play games
Q4-7: Reading (other than mangas nor magazines)
Q4-8: Read mangas and magazines
Q4-9: Sleep
Q-10: Other

Q5: Relationship with their friends <5 point Likert> 1: strongly disagree, 2: disagree a little, 3: neither agree or disagree, 4: agree a little, 5: strongly agree
Q5-1: I am trying to make more friends
Q5-2: I can make friends with people whom I meet for the first time
Q5-3: It is comfortable to be alone rather than to be with friends
Q5-4: If I have a different opinion from others, I can discuss it until it is solved
Q5-5: I feel anxious if I cannot make contact with my friends
Q5-6: I try not to have deep relationship with friends
Q5-7: I have friends to study with
Q5-8: I have friends who can give me advices
Q5-9: I have many friends online

Q6: Generic Skills and their Attitude <5 point Likert> 1.not improved, 2: not improved that much, 3: neither improved nor not, 4: improved a littler, 5: improved
"Students are able to…"
Q6-1: plan a schedule
Q6-2: analyse problems in society
Q6-3: have strong leadership
Q6-4: search information in libraries and on the Internet
Q6-5: discuss with others
Q6-6: write in my own words
Q6-7: make presentations in front of people
Q6-8: cooperate with others
Q6-9: use computers and the Internet
Q6-10: use time efficiently
Q6-11: create new ideas
Q6-12: challenge difficulties
Q6-13: listen to others
Q6-14: respect opinions from others
Q6-15: concern others
Q6-16: work on tasks patiently
Q6-17: be interested in different cultures from different countries
Q6-18: understand themselves objectively

Q7: Self-esteem <5 point Likert> 1: strongly disagree, 2: disagree, 3: agree, 4: strongly disagree
Q7-1: I am satisfied with my self
Q7-2: I have good points about myself
Q7-3: I can achieve things to the extent that most people can do
Q7-4: I am not good at anything
Q7-5: I want to respect myself more
Q7-6: I show a positive attitude toward myself

The number of participants in this study was 101 students (80 boys, 19 girls, and two N/A) in Nagaoka Kosen. They were all the fourth graders, 19 to 20 years old, majoring in three different engineering departments; Electrical and Electronical Systems, Materials, and Civil Engineering. The author adopted 76 out of Mizokami's 88 questions, and the questionnaire was conducted during the author's English classes in February, 2018.

First of all, 19 out of the total 101 questionnaire (18.8%) were excluded from the analysis due to missing data. So as to sort out the data, the author focused on their total hours of their daily activities (Q4). If the total amount of hours is too big or no hours are provided on their questionnaire, they are excluded from the analysis. However, it is better to keep as many data as possible; therefore, we left the data according to the following two conditions.

(1) Total Hours: 5.5 hours to 20.0 hours on weekdays, and 5.5 hours to 25.0 hours on weekend.
(2) Sleep hour should be more than 3 hours.

As a result, four data were excluded from the analysis. The total number of data analyzed was 78. The total hours of their daily activity and its average is shown as below in Table 1.

Table 1. total hours of their daily activity (weekdays and weekend) and its average

hour	weekday		weekend	
0.0	0	0.0%	0	0.0%
0.5–5.0	0	0.0%	0	0.0%
5.5–10.0	128.2	13.3%	29.5	2.2%
10.5–15.0	736	76.2%	257.2	19.5%
15.5–20.0	101.5	10.5%	764	57.9%
20.5–30.0	0	0.0%	268.5	20.4%
30.5–35.0	0	0.0%	0	0.0%
35.5–40.0	0	0.0%	0	0.0%
Total	965.7	100.0%	1319	100.0%
Ave. h. (SD)	14.2	2.5	19.4	3.1

Using those 78 data, the author also looked at students' self-esteem (Q7), and their relationship with their friends (Q5). Especially Q7-2, Q5-2, and Q5-8 were used to categorize student types. Q2-5, Q2-7, Q2-12, Q2-13, and Q-15 were also considered to be effective to describe students-types, so they were included as categorizing factors. In Mizokami's (2015) study, he mentioned that students' consciousness about their carrier path is one of the most important factors, nevertheless, in this study the author focused on students' generic skills and their club activities, so they were excluded from the analysis this time.

On the questionnaire, the scales were different depending on questions; therefore, all the data was standardized at first, then cluster analysis was conducted. IBM® SPSS® Statistics 19 was used to group the students into four to eight clusters, and looked at characteristics of each cluster. Mizokami (2015) checked his cluster as its independent variable and its scales as dependent variable and conducted ANOVA on his gained clusters; however, this study did not go through the same statistical process. However, seven clusters produced by this cluster analysis explained well about the students' types of this group; consequently, this seven clusters were adopted as clusters to describe these seven student-types (Table 2).

Table 2. The number of cases for each cluster

cluster	1	5.00
	2	1.00
	3	16.00
	4	2.00
	5	15.00
	6	26.00
	7	13.00
Valid		78.00
Missing		0.00

Judging from the characteristics of each cluster, the author named them as following types; (see Figure 1 at the end of this paper for this cluster analysis)

(1) SNS Type (cluster 1)

They spend more time online like SNS compared to the other types (average SNS hours on weekdays: 5.40h, weekend: 6.20h). The score on "Playing games" is the lowest of all. The score on "Club & studying are compatible" and "be satisfied with Kosen life" are the highest. (average study hours on weekdays: 0.80h, weekend: 1.20h)

(2) Reading Type (cluster 2)

They spend more time on reading books excluding manga and magazines. (average reading hours on weekdays: 4.00h, weekend: 8.00h) The hours they spend on club activities, studying playing with friends, using SNS, reading manga and magazines, are the lowest. They tend not to have friends to get advices from.

(3) Club Activity Type (cluster 3)

They have the highest score on club activities (average club hours on weekdays: 3.22h, weekend: 4.31h) They tend to spend their times on volunteer and school events, but they tend to feel comfortable when they are alone.

(4) Manga Reading Type (cluster 4)

Manga Type students spend more time on reading manga and magazine of all. (average manga reading time on weekdays: 3.00h, weekend: 6.00h) Compared to the other types of students, they are hoping to study abroad in the future. They tend not to read books, which is the lowest score of all.

(5) Game (& Less Participation in School Events) Type (cluster 5)

They spent more time on playing games. (average game playing hours on weekdays: 3.43h, weekend:

5.00h) They tend not to participate in school activities, even though they participate in discussions and homeroom activities. They cannot get along with people easily and tend to have weak self-esteem.

(6) Studying Type (cluster 6)

They spend the longest hours on studying. (average study hours on weekdays: 1.17h, weekend: 1.62h) They tend to have more regular habits in their everyday lives than others.

(7) Playing with Friends Type (cluster 7)

They use more time on playing with friends (average playing hours with friend on weekdays: 1.85h, weekend: 5.00h) This type of students spend the second longest time on studying. (average study hours on weekdays: 1.12h, weekend: 1.46) They also participate in school activities and volunteer activities often, and have friends to get some advices. However, they are not satisfied with their Kosen lives, and do not participate in discussion and presentation activities in school.

Results and Discussion

The next step is to figure out which types of students above improved what kind of skills and attitude (generic skills) through their Kosen lives (see Figure 2). Playing with Friends Type, SNS Type, Club Activity Type, and Studying Type show high score on improving their generic skills. In contrast, Game Type shows the lowest score on their generic skill improvement.

Since they are all engineering students, the skills in searching for information in libraries and on the Internet, and the ability to use computers and the Internet are improved in every Type. Manga Reading, SNS, and Game Type students did not improve their skills in using their time efficiently.

Playing with Friends Type shows the biggest improvement in generic skills, such as skills in discussing with others, making presentation in front of people, cooperating with others, concerning others, working on tasks patiently, and understanding themselves objectively. Club Activity Type and Studying Type students made the next biggest improvement, and they are high on average. They both can cooperate with others and seems to be good at keeping good relationship with others.

The result of the Game Type indicates that they are avoiding contacting with other people, because their scores on discussing with others and making presentations in front of people are the lowest. They also do not challenge difficult tasks and work on tasks less patiently; therefore, they tend to rely on other people.

Mizokami (2015) indicated in his research that Study Type students who belong to club activities showed the biggest improvement in their generic skills; however, in this research at Japanese Kosen, the consequence is different. Students in Playing with Friends Type showed the biggest improvement. This result points out that students with communication skills have more opportunities to improve themselves in Kosen. In other words, in order to improve Kosen students' generic skills, we, teachers, are required to step in a little bit deeper to improve their interpersonal skills so that they can attain better generic skills in the future.

What club activities have to do with these generic skills? The author also extracted the data from Q3-1: Is your study and club activity compatible? (1: yes, 2: so so, 3: not really, 4: no, 5: I do not belong to any club). 1 and 2 means study and club are compatible for students, 3 and 4 means students cannot do both club and study at the same time, and 5 means he/she does not belong to any club activity. These three kinds of compatibility and seven student-types make new 21 compatibility types of students to be analyzed. (See Table 3)

Table 3. Creating Compatibility Types of Students' Club Activities & Studying

Student Type	Compatibility w/ study & club	Compatibility type	the number of students (%)	Types Analized (more than 5%)	Studying Time (weekdays)	Studying Time (weekend)	TOEIC Score
SNS Type	Compatible	1	0 (0.0%)		-	-	-
SNS Type	Not Compatibel	2	0 (0.0%)		-	-	-
SNS Type	no club activity	3	5 (5.7%)	★	0.80	1.20	358.0
Reading Type	Compatible	4	1 (1.1%)		0.00	0.00	450.0
Reading Type	Not Compatibel	5	0 (0.0%)		-	-	-
Reading Type	no club activity	6	0 (0.0%)		-	-	-
Club Activity Type	Compatible	7	13 (14.8%)	★	0.96	1.35	401.9
Club Activity Type	Not Compatibel	8	2 (2.3%)		0.75	0.75	360.0
Club Activity Type	no club activity	9	1 (1.1%)		-	-	-
Manga Reading Type	Compatible	10	1 (1.1%)		1.00	1.00	325.0
Manga Reading Type	Not Compatibel	11	1 (1.1%)		0.00	0.00	350.0
Manga Reading Type	no club activity	12	0 (0.0%)		-	-	-
Game	Compatible	13	2 (2.3%)		0.25	0.50	440.0
Game	Not Compatibel	14	6 (6.8%)	★	0.67	1.00	365.8
Game	no club activity	15	7 (8.0%)	★	0.21	0.00	429.3
Studying Stype	Compatible	16	8 (9.1%)	★	1.50	1.94	437.5
Studying Stype	Not Compatibel	17	4 (4.5%)		1.00	1.38	415.0
Studying Stype	no club activity	18	14 (15.9%)	★	1.04	1.50	405.7
Playing with friends Type	Compatible	19	5 (5.7%)	★	1.20	0.80	428.0
Playing with friends Type	Not Compatibel	20	1 (1.1%)		1.00	0.00	400.0
Playing with friends Type	no club activity	21	7 (8.0%)	★	1.07	2.14	458.6
Swimming Club	Compatible	22	9 (10.2%)	★	2.56	0.83	498.9
Swimming Club	Not Compatibel	23	1 (1.1%)		3.00	0.00	570.0
Swimming Club	no club activity	24	0 (0.0%)		-	-	-
			88 100.0%				

There is one student in Club Activity Type and answered "no club activity," so this student was excluded from the analysis. The compatibility types which have more than 5% of the total students were chosen to be analyzed. They are star-marked in Table 3. So Compatibility Type 3, 7, 14, 15, 16, 18, 19, and 21 were selected. Plus the data from the author's swimming club was added as Compatibility Type 22 and 23.

As a result, Compatibility Type 19 and 21 showed the highest score on improving their generic skills (see figure 3). Although the average score of Type 19 (compatible) is slightly higher than Type 21 (no club activity), Playing with Friends factor seems more influential on this matter. Again, Compatibility Type 14 and 15 (both Game Type) showed the lowest result. The author's swimming club data is similar to Compatibility

Type 3 (SNS + no club) and 7 (Club Activity + compatible).

Conclusions

This study revealed not only the influence of club activities but also what teacher for engineering are required now in Japan. Even though the number of participants is limited, it is sufficient to grasp the current state of Kosen in Japan. Many of the engineering students in Kosen are not very good at communicating with others; however, this study found out that how important it is to increase their chances to interact with other people (not on the Web) in order to improve their generic skills.

Acknowledgements

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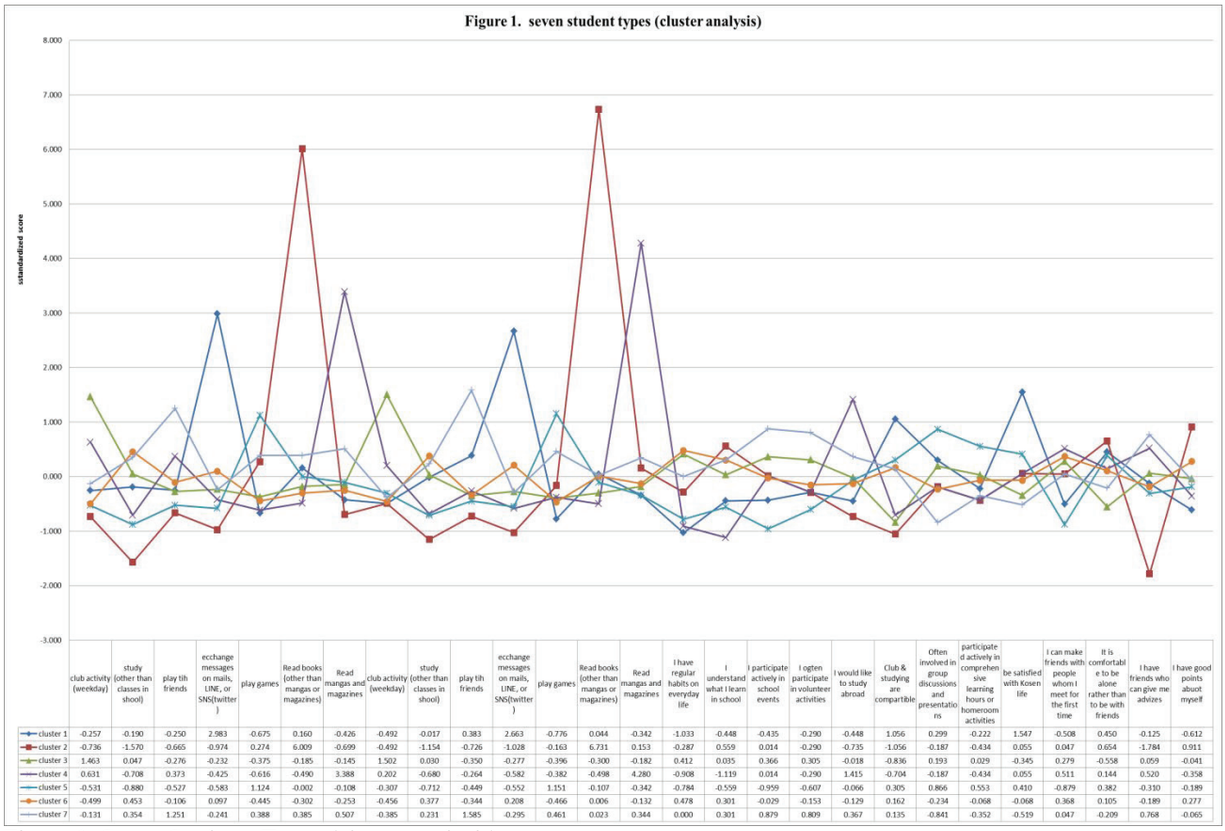

Figure 1. Seven Students Types (cluster analysis)



	plan a schedule	analize problems in society	have strong leadership	search info in libraries and on the Internet	discuss with others	wtrite in their own words	make presentation in front of people	coperate with others	use computer and Internet	use time efficiently	create new ideas	challenge dificulties	listen to others	respect opinions from others	concern others	work on tasks patiently	be interested in cultures in different countries	understand themselves objecctively
SNS Type	2.60	3.40	3.40	3.60	3.60	4.40	3.80	3.80	4.80	2.40	3.20	4.20	4.40	4.60	3.60	3.00	3.60	3.60
Reading Type	3.00	4.00	2.00	3.00	4.00	4.00	4.00	2.00	5.00	4.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00
Club Activity Type	3.13	3.81	3.00	4.25	3.81	3.81	3.19	4.13	4.38	3.13	3.38	3.69	4.19	4.50	4.25	3.69	4.44	3.88
Manga Reading Type	2.00	4.00	3.00	4.00	3.50	2.50	3.00	3.50	4.00	2.00	3.00	3.00	2.50	3.50	3.00	4.00	4.50	3.00
Game	2.20	2.87	2.07	4.13	3.07	3.20	2.53	2.80	3.73	2.40	2.53	2.53	3.13	3.53	3.00	2.47	3.20	2.87
Studying Stype	3.15	3.46	3.12	4.15	3.81	3.88	3.73	4.00	4.38	3.42	3.38	3.35	3.96	3.96	3.69	3.65	4.00	3.73
Playing with friends Type	3.62	3.46	3.85	4.54	4.31	3.92	4.15	4.54	4.54	3.15	3.54	3.92	4.15	4.46	4.31	4.15	4.23	4.00
Swimming Club	3.7	3.8	4	3.7	3.8	4.2	3.2	2.6	3.4	3.6	3.9	4	4.1	3.6	3.9	2	1.9	2.5

Figure 2. Improved skills and attitude (generic skills) throughout Kosen lives



	plan a schedule	analize problems in society	have strong leadership	search info in libraries and on the Internet	discuss with others	wtrite in their own words	make presentation in front of people	coperate with others	use computer and Internet	use time efficiently	create new ideas	challenge dificulties	listen to others	respect opinions from others	concern others	work on tasks patiently	be interested in cultures in different countries	understand themselves objecctively
C_Type 3	2.60	3.40	3.40	3.60	3.60	4.40	3.80	3.80	4.80	2.40	3.20	4.20	4.40	4.60	3.60	3.00	3.60	3.60
C_Type_7	3.31	3.85	3.00	4.23	3.77	3.85	3.08	4.08	4.31	3.15	3.38	3.62	4.08	4.46	4.15	3.62	4.38	3.85
C_Type_14	2.00	2.75	1.50	4.13	2.88	3.13	1.88	2.50	3.63	2.63	2.75	2.38	3.00	3.25	3.00	2.50	2.63	3.13
C_Type_15	2.43	3.00	2.71	4.14	3.29	3.29	3.29	3.14	3.86	2.14	2.29	2.71	3.29	3.86	3.00	2.43	3.86	2.57
C_Type_16	3.13	4.00	3.50	4.38	3.75	4.25	3.63	4.13	4.50	3.25	3.88	3.63	4.13	4.25	4.13	4.00	4.25	4.00
C_Type_18	3.14	3.21	2.86	4.29	3.79	3.71	3.79	3.93	4.43	3.64	3.14	3.21	3.86	3.79	3.43	3.50	3.86	3.79
C_Type_19	3.80	3.60	4.00	4.40	4.20	4.40	4.20	4.60	4.40	3.00	3.20	4.00	4.00	4.40	4.40	4.40	4.60	3.80
C_Type_21	3.50	3.38	3.75	4.63	4.38	3.63	4.13	4.50	4.63	3.25	3.75	3.88	4.25	4.50	4.25	4.00	4.00	4.13
C_Type_22	4.00	3.78	4.00	4.00	4.11	4.56	3.44	2.78	3.67	3.89	4.22	4.00	4.44	3.89	3.89	2.11	2.00	2.67

Figure 3. Relationship between Students' Compatibility Type and Their Generic Skills

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GLOBAL EDUCATION BASED ON INTERNATIONAL EXCHANGE IN NITKIT

Masahiro Wakiyama*, Akira Miyamoto*, Yukiharu Yamauchi*, Yasunobu Hitaka*, JIANG Xin* and Naruki Shirahama*

* National Institute of Technology, Kitakyushu College
Department of Creative Engineering,
Robot and Mechatronics Course, Fukuoka, Japan

*E-Mail wakiyama@kct.ac.jp

Abstract

In a rapidly globalizing modern society, we need to promote global education based on international exchange that grows internationally competitive students for education and research. We try to develop our exchange programs to accept an increasing number of foreign students to Japan (inbound) and Japanese students to foreign countries for studying abroad (outbound). Furthermore, we foster talented students capable of working in the international community. The international students are increasing in National Institute of Technology, Kitakyushu College. (abbreviated by NITKIT) The International exchange education needs to be collaborated with Memorandum of Understanding (MOU). The philosophy of education in NITKIT is to foster pioneer-oriented engineers in the international community. We need to improve the international existence in NITKIT which will proceed global manufacturing education. We seek to stimulate international exchange between motivated outstanding foreign students and Japanese students and to construct a school for nurturing international professionals and creating connections, as well as for initiating education to promote intercultural understanding.

In this paper, we will report the international exchange program in NITKIT. We state about overseas affiliated universities. When the foreign students come to the NITKIT, the NITKIT students can get the international perspective by concerning about the international exchange in education contents at present. Through international exchange and cultural experience abroad, the Japanese students can improve learning motivation and get the ability that they have not had so far. They can improve the technical skills which are useful for cultural negotiations, leaderships, communication skills and job hunting. The foreign students and Japanese students can enjoy and practice the good international exchange activities together. NITKIT offers their Internship programs which enable students to gain work experience at either Japanese or foreign companies. This helps students to develop an understanding of work and gain skills for integrating themselves actively into our society.

The NITKIT students face various realistic problems in the world with independence, cooperation and creative attitudes when contacting with foreign students. They have acquired scientific thinking, professional and practical knowledge and world technology. We are practicing global education by accepting both short-term and long-term inbound students. Finally, we discuss that we are able to develop a comprehensively enhancing project and trusted processes to build inbound-outbound relationships in future.

Keywords: *International Exchange, Global Education, Internship program, Inbound Exchange, Outbound exchange*

1. Introduction

NITKIT philosophy of education is to foster pioneer-oriented engineers. One of the objectives is to acquire international awareness to gain trust and respect in the international community. The international students are increasing in NITKIT. It is important that NITKIT which offers global manufacturing education, need to enhance the position in the international community.

It's necessary that we help the student to get the international perspective by experiencing the international exchange. The students with international exchange and cultural experience abroad, improve learning motivation and get the international empowerment. They can improve various kinds of skills, which are useful for cultural negotiations, leaderships and communication skills and job hunting. There are many foreign students in NITKIT and they help each other to study. The foreign students and Japanese students can enjoy the studying process together and practice the good international exchange activities.

There are many educational environments to study abroad(outbound) among agreement schools (cf. chapter 2) and experience student exchange(inbound) with foreign students in NITKIT. (chapter 4.2) By cooperating with domestic and overseas institutions or organizations, NITKIT can provide international education.

2. Agreement schools

2.1 Overseas Affiliated Universities

It is indispensable to comply with MOU (Memorandum Of Understanding) for ensuring the safety and agreements of students and teachers in another countries. NITKIT has cooperative agreements with overseas affiliated Universities in the world. (cf. Table 2.1)
A number of students go abroad every year to make research and pursue active academic exchanges.

Table 2.1 Academic exchange agreements

Year	Country	School
2017	Germany	Hochschule Esslingen
2016	Singapore	Nanyang Polytechnic
2015	Thailand	King Mongkut's Institute of Technology Ladkraban
2010	Korea	Chonbuk National Mechanical Technical High School
2010	Korea	Chonbuk National University
1994	China	Yangzhou University

2.2 9 Kosen collaboration Project

In a Project with collaboration with 9 Colleges of National Institute of Technology in Kyushu-Okinawa National institute of technology of Nine colleges (Kitakyushu, Kurume, Ariake, Sasebo, Kumamoto, Oita, Miyakonojo, Kagoshima and Okinawa), we developed a lot of international exchange activities through internship, overseas training. (cf. Table 2.2)

Table 2.2 Overseas affiliated University (9 NIT)

Year	Country	Partner University
2015	Taiwan	National Taipei University of Technology
2014	Mongolia	The Mongolian University of Science and Technology
2014	China	Xiamen University of Technology
2014	Viet Nam	Hanoi University
2017	Viet Nam	University of Danang
2016	Thailand	King Mongkut's University of Technology Thonburi
2014	Thailand	King Mongkut's University of Technology North Bangkok
2014	Thailand	Kasetsart University
2014	Indonesia	Vocational College Universitas Gadjahmada
2014	Indonesia	Universitas Gadjahmada
2014	Malaysia	Institute of Technology Petronas SDN BHD

2.3 NITKIT long-term Foreign student

NITKIT accepts foreign students in the 3rd grade every year. The students enroll in 3rd grade in NITKIT after they study Japanese at Japan language schools. (cf. Table 2.3) They live in NITKIT dormitory for three years. They are given Japanese lectures together with Japanese students.

Table 2.3 Number of Overseas students

Year	Country	Gender	Engineering Course
2017	Malaysia	Male	Robotics and Mechtronics
2017	Laos	Male	Material Chemistry
2016	Indonesia	Female	Material Chemistry
2015	Mongolia	Male	Information and Systems
2015	Madagascar	Female	Material Chemistry

2.4 Research abroad of NITKIT teacher

The teachers of NITKIT go abroad for research activities. (cf. Table 2.4)

Table 2.4 Number of Overseas Teacher

Period	Country	Engineering Course
2016.5.1-2017.3.31	America	The University of Massachusetts Amherst
2015.4.1-2016.3.31	HongKong	Hong Kong Vocational Training Council
2015.8.14-2016.8.7	America	College of William & Mary
2014.9.21-2015.3.22	Singapore	Republic Polytechnic
2014.7.1-2015.9.30	America	State University of New York

3. NITKIT student study abroad

3.1 NITKIT Collaboration Project

NITKIT students go abroad for the following study program in Table 3.1

Table 3.1 Student exchange

Period	Number	School
2018.3.16-3.21 Study Program	18	Chonbuk National University, Chonbuk National Mechanical Technical High School (Korea)
2017.3.19-3.24 Study Program	11	Chonbuk National University, Chonbuk National Mechanical Technical High School (Korea)
2016.9.1-9.7 Study Program	5	Chonbuk National University (Korea)
2016.3.20-3.25 Spring Program	8	Chonbuk National University (Korea)
English language Training (2016.8.30-9.20)	13	University of Oxford University of Bath (England)
English language Training (2015.8.17-9.7)	11	University of Oxford University of Bath (England)

3.2 Tobitate! (Leap for Tomorrow) Study Abroad Initiative JAPAN (Outbound)

Ministry of Education, Culture, Sports, Science and Technology (abbreviated by MEXT) started the program called "Tobitate! Study Abroad Initiative JAPAN" for the purpose of breeding Japanese youths who are willing to study overseas by themselves in 2014. The study abroad system offered supports such as the scholarship program by collaboration of government and commercial corporation. (cf. Table 3.2)

Table 3.2. Tobitate! Study Abroad Initiative (Outbound)

Period	Outbound School
2016.8.19-2017.5.21	Wabash Valley College (America)
2016.4.11-2017.3.10	Institute of Chemical Research of Catalonia (Spain)
2015.4.1-2016.2.29	Chonbuk National University (Korea)
2015.8.22-2015.9.25	Queens College of The City University of New York (America)

3.3 Japan Student Services Organization (Outbound)

Japan Student Services Organization (JASSO) is an independent administrative institution established under the MEXT. JASSO administers scholarship supports programs for students. Our NITKIT students use this program as shown in the following Table.3.3.

Table 3.3 JASSO (Outbound)

Period	Number	School
2017.10.1-2018.2.28	1	Reutlingen University
2017.09.6-2018.2.28	1	Esslingen University
2018.3.09-3.30	15	Nanyang Polytechnic (Singapore)
2017.8.20-9.18	7	
2017.3.02-3.31	4	Nanyang Polytechnic (Singapore)
2016.8.23-9.23	4	

3.4 9 Kosen Collaboration Project (cf. chapter 3.2)

Table 3.4 9 Kosen Collaboration Project

Period	Number	School
English Program 2017.9.17-9.27	1	Hanoi University (Viet nam)
Learn Technology in English Program 2017.8.21-9.2	1	Kasetsart University (Thailand)
Technical Challenge (2017.8.21-8.29)	1	Hong Kong Vocational Training Council (China)
English Camp (2017.8.13-8.27)	1	Singapore Polytechnic (Singapore)
Summer Program (2016.8.15-8.24)	1	National Taipei University of Technology (Taiwan)
Spring Program (2016.3.16-3.27)	1	National Taipei University of Technology (Taiwan)
2017.1.16-1.20 UTP International Symposium	4	Institute of Technology Petronas SDN BHD (Malaysia)
2016.9.6-9.25 UTP Student exchange	1	Institute of Technology Petronas SDN BHD (Malaysia)
2015.9.8-9.16 UTP Student exchange	3	Institute of Technology Petronas SDN BHD (Malaysia)
English training and Technical project (2016.12.19-12.23)	1	Hanoi University of technology (Vietnam)
English training and Technical project (2016.3.22-3.29)	1	Hanoi University of technology (Vietnam)
Summer Program (2015.8.16-8.30)	1	Hanoi University of technology (Vietnam)
English Camp (2015.8.22-9.5)	2	Ngee Ann Polytechnic (Singapore)
2015.9.20-9.29 Global Engineering Foster Program	3	Temasek Polytechnic (Singapore)
English Camp (2015.8.22-9.5)	2	Ngee Ann Polytechnic (Singapore)
Student Exchange (2015.10.12-10.30)	2	Xiamen University of Technology (China)
2015.8.16-8.30 Student Exchange	1	King Mongkut's University of Technology Ladkrabang , Kasetsart University (Thailand)

3.5 International Symposium

The objective of International Seminar on Technology for Sustainability is to foster the global engineers with the leadership.

Table 3.5 International Seminar

Period	School
2017.8.20-8.27 ISTS2017	Turku University of Applied Sciences (Finland)
2016.10.5-10.12 ISTS2016	Vocational College Universitas Gadjahmada (Malaysia)
2015.8.4-8.6 ISTS2015	Universiti Teknologi MARA (Malaysia)

3.6 Another Collaboration Project

Table 3.6 Another Collaboration Project

Period	Numbe	School
Workshop (2017.8.7-8.22)	1	Yangzhou University (China)
KitakyushuWaterWorks(2017.8.7-8.22)	1	Phnom Penh Capital Hall (Cambodia)
Summer School (2017.8.25-8.28)	1	University of California, Berkeley etc. (USA)
Global Engineering Foster Program 2017.8.28-9.1	1	Toyohashi University Sains MalaysiaTechnology Collaborat.etc. (Malaysia)
2017.3.5-3.9 Student Exchange	2	Chulalongkorn University, King Mongkut's University Khon Kaen University, etc (Thailand)

4. Foreign Student Exchange by Inbound

4.1 Japan Student Services Organization (Inbound)

Table 4.1 Japan Student Services Organization

Period	Number	School
2016.9.19-2017.1.20	1	Nanyang Polytechnic (Singapore)
2016.9.16-12.14	2	

4.2 Short-term inbound international exchange

Table 4.2 Short-term inbound international exchange

Period	Number	School
2016.9.18-9.24 Hong Kong	9	Vocational Training Council, Hong Kong
2016.10.16-10.25 Indonesia	6	Vocational College Universitas Gadjahmada
2016.1.18-2.27 Indonesia	3	Universitas Gadjah Mada
2017.3.5-3.12 Thailand	4	King Mongkut's Institute of Technology Ladkrabang
2016.10.16-10.25 Thailand	2	King Mongkut's Institute of Technology Ladkrabang
2017.3.5-3.12 Thailand	4	Kasetsart University
2017.3.5-3.12 Singapore	5	Nanyang Polytechnic

Table 4.3 Short-term international exchange

Period	Number	School
2016.4.10-7.10 Singapore	2	Nanyang Polytechnic
2015.9.29-12.18 Singapore	4	Nanyang Polytechnic
2015.8.22-11.30 Singapore	1	Nanyang Polytechnic
2015.4.13-7.2 Singapore	4	Nanyang Polytechnic
2017.1.16-2017.3.10 Singapore	2	Temasek Polytechnic
2015.9.28-2016.12.20 Singapore	2	Temasek Polytechnic
2015.9.22-2016.2.6 Singapore	2	Republic Polytechnic
2016.6.1-8.1 Thailand	3	King Mongkut's University of Technology Ladkrabang , Kasetsart University
2015.6.1-7.31 Thailand	8	King Mongkut's University of Technology Ladkrabang , Kasetsart University
2016.10.16-12.10 Thailand	6	Kasetsart University
2016.6.1-8.1 Thailand	6	Kasetsart University
2015.6.1-8.1 Thailand	3	Kasetsart University
2016.7.28-8.20 America	1	Queens College of The City University of New York
2015.6.25-8.4 America	1	Liberty High School

5. Internship (9 Kosen Collaboration Project)

The number of the students per technical college is about 1000. In the internship, we cooperate with the Kyushu Economic Federation with about 900 member companies. In the overseas training program, the school has acceptable companies of the overseas internship. (cf. Table 5.1) Through the international exchanges and overseas training, we will strengthen the relationships with Asian countries by utilizing the results of exchanges between 9 colleges and higher education institutions in Asian countries.

It is important to experience real training techniques based on a basic theory and knowledge,

The international internship study gives the youths extremely effective techniques. The students acquire all of these valuable skills such as intercultural competency, multicultural work, working experience, independence, flexibility and more.

Table 5.1 9 Kosen Collaboration Internship

Period	Number	School
2017.8.21-9.2 Thailand	2	Maxis(Thailand)Co.Ltd.
2017.8.21-9.1 Thailand	2	RPCL
2017.9.4-9.14 Philippines	1	Chiyoda Philippines Corporation
2017.9.4-9.14 Malaysia	1	NGK ELECTRONICS DEVICES (M) SDN. BHD.
2017.8.21-9.1 VietNam	1	TOTO VIETNAM CO., LTD
2016.8.22-9.2 Thailand	3	Maxis(Thailand)Co.,Ltd.
2016.8.21-9.17 Thailand	1	Kasetsart University
2016.8.22-9.3 Vietnam	1	SANMATSU CO., LTD. HANOI-VIETNAM
2015.9.5-9.18 Vietnam	1	TOTO VIETNAM CO., LTD.
2016.9.3-9.16 Malaysia	2	NGK ELECTRONICS DEVICES (M) SDN. BHD.
2016.9.5-9.9 China	3	YASKAWA (CHINA) ROBOTICS CO., LTD.

6. Long-Term Factory Visit of our course class

For the purpose of understanding different cultures, our students in NITKIT interexchange with the overseas schools in September every year. It is a golden opportunity that the Japanese students visit the foreign country, and interchange with the foreign students, and visit to facilities and make presentation about NITKIT, and experience the different cultures, and grow up by themselves.

Table6.1 Long-Term Factory Visit

Year	Number	Visiting Place
2017.9.26-9.29 Hong Kong	39	The Hong Kong Institute of Vocational Education etc.
2017.9.26-9.30 Singapore	38	Temasek Polytechnic, The NEWater Visitor Centre, Marina Barrage
2016.9.27-10.1 Singapore	41	Temasek Polytechnic, The NEWater Visitor Centre, Marina Barrage
2015.10.27-10.31 Taiwan	45	National Taipei University of Technology,Taiwan Hirata Corporation
2015.10.27-10.30 Taiwan	39	National Taipei University of Technology, Taiwan TAKISAWA Technology Co., Ltd.

7 OUR TP internship

We have started a cultural exchange plan by the students for the NITKIT and Polytechnic Schools in Singapore since 2006. We have developed a higher exchange level.

1) The students in Singapore study Japanese in our NITKIT and understand advanced techniques such as information security.
2) They study a research technology such as steganography.
3) They make cultural exchange with Japanese students.
4) They acquire the communication skills in Japanese and English with Japanese students.
5) They visit various factories in Kitakyushu.

We accepted two students in Temasek polytechnic from 2016 through 2018. Advanced course students of NITKIT supported the foreign students. They have had poster presentations in their research fields in the international conference.

8. Our Sakura Science Project 2017

We had an exchange program with 10 students in Temasek Polytechnic school by Sakura science project.

Kitakyushu has a long history of industry which is representative of Japan. There are industries that utilize advanced technologies such as IoT (Internet of Things) / M2M (Machine to Machine), robotic new strategy, the fourth industrial revolution (Industrie 4.0), FinTech and etc. The students from Singapore can learn about research results at NITKIT and universities, advanced technologies and companies and factories, and understand how Japanese technology contributes to the development of local communities.

The objective of this program is that the Foreign students and NITKIT students aquire the Robot skills, and Echology skills, and international communication skills. The participating TP students study some computer knowledge in school of Informatics & IT and then take part in a workshop with familiar contents. The TP and NITKIT students speak English in the workshop. (cf. Fig8.1) The students visited research equipments and NITKIT facilities. The students had technical exchanges by using their research presentation. The NITKIT students and TP students understood the academic research and got interested in the problem. They also learn about their educations and the cultures each other.



Fig8.1 Technical workshop

The students visited Yawata Works (Nippon Steel & Sumitomo Metal). They observed a blast furnace factory, the hot rolling factory and learned about the process of the history and the iron manufacture
They could deepen the understanding of the industrial area in Kitakyushu. (cf. Fig 8.2)



Fig 8.2 Factory visit

They had Japanese traditional cultural exchange. They played Japanese traditional musical instruments such as Koto and shakuhachi (PVC pipe). They weared Japanese traditional dress such as yukata. They enjoyed Japanese traditional cultural exchange. (cf. Fig8.3)



Fig 8.3 Japanese Koto training

They had cultural exchange. They did sightseeing at Mojiko Retro district. They were able to learn about the history of Moji Port which opened in the early Meiji era, the building which was built from the Meiji to the Taisho era by observing the strait dramaship, old monarchy customs, old gate Mitsui club, Idemitsu Museum etc.

9. Discussions

Living in the world with the social change such as declining birthrate and intensifying competition with foreign countries, it is essential for National Institute of Technology KOSEN to develop global and innovational engineers who are responsible for reforming social change.

It is necessary for the KOSEN to foster engineers who are practical, creative with international perspective and responsible for the enterprises and social community.

It is necessary to advance globalization with international community and overseas support in cooperation with society and companies.

In future international collaborative exchanges, engineer's education with global partnership, in addition to developmental relations such as international students' acceptance, exchange process, overseas relationship is required.

10. Conclusions

We have reported the international Exchange programs in the NITKIT. International exchange education needs to comply with Memorandum of Understanding (MOU) and collaborating with overseas schools and companies.

Through the international exchange programs, NITKIT fostered a lot of international engineers with globa minds, creative thinking, high communication and cooperation abilities. These international talents are competent for the rapid development of our society.

NITKIT is considering the construction of global center, aiming to train more and more practical talents of advanced technologies. In the near future, we are able to develop a comprehensively enhancing project and trusted processes to build inbound-outbound relationships.

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A STUDY OF STUDENT EXCHANGE PROGRAMMES BETWEEN SINGAPORE & JAPAN

Megumi Abe, Ph.Dr[*,a], and Amy Amrita Daga[b]

[a] Department of General Science and Education,
National Institute of Technology, Hachinohe College, Hachinohe, Japan
[b] Centre for TransCultural Studies, Department of International Relations,
Temasek Polytechnic, Singapore

*abe-g@hachinohe-ct.ac.jp
** amydaga@tp.edu.sg

Abstract

In this era of globalization, it has become imperative for exposure beyond national boundaries. Student Exchange Programmes have gained much popularity of late, and in order for the workforce to have an international outlook, the learning must start, preferably during impressionable student years. This study examined the effect of Student Exchange Programmes on the participants' personal growth from participants' perspectives. Moreover, this study examined factors that affected their perspectives on their personal growth through Students Exchange Programs. This research utilized quantitative research in order to get generalized data across groups of the participants, then utilized qualitative research, in order to get in-depth information at the micro level, closely focusing on individual exchange programme experience. Data was collected through survey questionnaires that were distributed to the participants of three such programmes: (1) 30 students on the Student Exchange Programme from National Institute of Technology, Hachinohe College, Japan, to Temasek Polytechnic, Singapore, in Fall 2017, (2) 20 students on the Student Exchange Programme from Temasek Polytechnic, Singapore, to National Institute of Technology, Tsuruoka College, Japan, in Fall 2017 and (3) 18 students on the Student Exchange Programme from Temasek Polytechnic, Singapore, to Ishikawa Prefecture, Japan, in Spring 2018. The qualitative data comes from interviews of these participants on their expectations and experiences in Singapore and Japan respectively.

The data revealed that Student Exchange Programmes may be one of the most beneficial experiences for the students in their late teens and early twenties (high school, college level and polytechnic students): (1) Global and cultural awareness: after the programme, the participants have a deeper awareness of global issues & trends, and greater sensitization towards understanding of different cultures and various world views. This exposure has a dual positive impact – it not only enhances their knowledge of cross-cultural values through interaction with foreign counterparts, but also increases awareness their own cultural values, as they compare and contrast the differences, (2) Intercultural communication skills: they are motivated and provided the opportunity to improve intercultural communication skills such as foreign language proficiency, (3) Personal Growth: they perceive their own personal growth such as self-confidence, responsibility, independence, a spirit of curiosity & challenge, of taking leadership, problem-solving skills and the ability to take action, and (4) Professional Development (future career) in the long-term goals: they perceive future career in the world setting, expanding their geographies from the familiarity of only their own town / city / country , to an international arena across political boundaries. They view their career and their life with a broader vision, and beyond the immediate, many are encouraged and inspired to look at their medium to longer-term goals. In addition, this study found that Peer Interaction in the counterpart country, during these exchange programmes, is an important factor that encourages students of that impressionable age, to review themselves in their own cultural setting, and compare & contrast it with world settings in a positive way for a richer outcome. The findings suggest that International Student Exchange Programmes have an overall positive effect on young students' growth – personally and professionally – and promote Global Citizenry for the immediate and foreseeable future.

Keywords: *Student Exchange Programmes, Global exposure, Global Citizen, Cross Cultural Communication.*

Introduction

Japan and Singapore established formal bilateral G2G relations in 1966, 52 years ago, and have steadily worked towards collateral exchanges in multiple areas

over the years. This is further expounded by various sources of funding provided by agencies in both these countries to encourage the same. Student Exchange Programmes are one such area. The JET (Japan Exchange and Teaching Programme) offered by the Japan Government states that it "seeks to enhance internationalization in Japan by promoting mutual understanding….through fostering of ties between Japanese youth and foreign youths alike". The JENESYS Programme established in 2007 subsidizes Singaporean students to tour Japan and "aims to further engage in and diversify…and eventually to deepen friendship and understanding…" between Japan and Singapore. National Institute of Technology and has signed an MOU with five Polytechnics in Singapore in 2011. National Institute of Technology, Hachinohe College and Temasek Polytechnic started exchange programs every year after that. A few years later, National Institute of Technology, Tsuruoka College, as well as Ishikawa Prefecture, Japan, also started student programmes with Temasek Polytechnic. Many Japanese and Singaporean students have participated in these particular student exchange programs over the years.

Other Student Exchange Programmes, between Singapore and Japan, have taken place across various institutions through the last many years. Though many people have been involved in creating these programmes and numerous students have participated in these, there is little research available to date that explores learning outcomes and experiences from the Japanese & Singaporean participants' own perspective. This study seeks to investigate the initial perspectives of Japanese and Singaporean students going on these Student Exchange Programmes, and how these perspectives get modified or change as a result of the exchange, interaction and exposure. This study also highlights expectations of the students when embarking on these programmes, and explores similarities as well as differences in responses between the Japanese and Singapore participants.

In this study, we do not intend to carry out a cross-cultural comparison, nor impose sweeping generalizations about Japanese and Singaporean students' perceptions of their expectations and personal growth through such Student Exchange Programmes. Rather, it is to investigate and take into account the participant perspectives and learning on these particular three programmes, by examining their preconceptions, attitudes, beliefs, and focusing on their experiences during the exchange.

The purpose of this study is two-fold. The first is to examine the various responses of the participants regarding the learning outcomes. The second is to determine the factors that influence these responses. Based on these responses, some suggestions are also made on what must be retained / modified / added in order for these programmes to enhance participant learning in a holistic and engaging way, without compromising on institutional objectives.

Methodology

This study is a combination of quantitative and qualitative insights into the reasons for the participants choosing Japan or Singapore respectively, as a choice destination for Student Exchange Programmes; the opportunities and challenges they perceive of study trips to these destinations; and the learning gained through the cross-country exposure. In addition to areas mentioned above, they were also surveyed and interviewed about pre-trip and post-trip knowledge and preparedness status, perceived advantages and disadvantages, and change in outlook (if any) towards consequent and potential future interaction with the counterparts.

The sample pool for this study is currently restricted to those students from the National Institute of Technology, Hachinohe College, in Japan, and Temasek Polytechnic in Singapore, who went on these three specific exchange programmes over Fall 2017 and Spring 2018. They age between 15 – 19 year old Japanese students and 17 – 22 year old students from Singapore. They include both male and female students for a more balanced study.

The sample size of this study was a total of 30 Japanese students from the National Institute of Technology, Hachinohe College, in Japan, and 38 students from Singapore, studying various courses at Temasek Polytechnic.

There are several reasons for choosing participants of these exchange programmes for this study. They came from diverse backgrounds in terms of area of study as well as professional and personal aspirations. They had different levels of prior global exposure, as well as varied depth of knowledge and experience of Singapore and Japan. This gave us a more generic and holistic view of participant responses, without biases that could potentially stem from singularity of area of study and exposure. Another reason for selecting this sample pool was due to the observation over time and multiple runs, that these particular programmes are over-subscribed and where possible, have grown in numbers. This observation does not suggestion that other such programmes have not seen similar enthusiasm and participation growth.

In terms of location, this study was conducted in both Japan and Singapore. It was carried out in the home-country after the students had returned from the trip and after giving them time to settle from the initial exuberant emotions that may cloud judgment and may result in bias in responses.

The data collection was carried out from the following sources: (1) A questionnaire for all the Japanese and Singaporean students who participated in three different Student Exchange Programmes: English and Cultural Exchange Programme for Japanese students held at Temasek Polytechnic in Singapore; Global Citizenship trip for Singapore students held at National Institute of Technology, Tsuruoka College, Japan; and Ishikawa Japanese Study Programme for Singapore students held at Ishikawa Prefecture in Japan, to glean their perspectives on the learning outcomes of the various programmes; and (2) Interviews (open-ended interviews and semi-structured interviews), in order to examine the

factors that affected their perspectives on their growth, with six Japanese and six Singapore students selected from the sample pool. The combination of data collection methods is important in order to understand deeper perspectives from the participants' viewpoint and in order to enhance verification of the findings. This study explores the viability and usefulness of such exchange programmes from the learner-participants' perspectives, and hopes to makes suggestions for enhancing these programmes. It also hopes to justify the rationale for continuing such positive exchange programmes in the future.

Results & Discussions

The participants' perspectives on their personal and professional advancement through the intended learning outcomes for these Student Exchange Programmes was studied via a Survey Questionnaire.

Survey Question 1a (to Japanese students): Highlight 2 main reasons that encouraged / attracted you to participate in the Student Exchange Programme to Singapore.

- ➔ To improve their English Language & Communication skills - 87% of the participants
- ➔ To learn more about Singapore Culture, Lifestyle & Cuisines - 50% of the participants
- ➔ To make friends with Singapore peers and fellow students - 59% of the participants
- ➔ Others / Undetermined – 4% of the participants

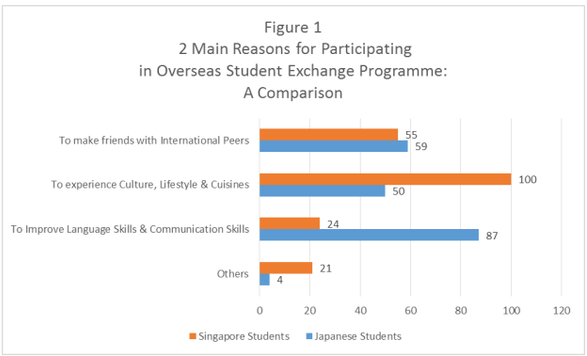
Survey Question 1b (to Singapore students): Highlight 2 reasons that encouraged / attracted you to participate in the Student Exchange Programme to Japan.

- ➔ To improve their Japanese Language & Communication skills - 24% of the participants
- ➔ To learn more about Japanese Culture, Lifestyle & Cuisines - 100% of the participants
- ➔ To make friends with Singapore peers and fellow students - 55% of the participants
- ➔ Others / Undetermined – 21% of the participants

Discussion:

It is interesting to note that whilst 87% of the Japanese students see Singapore as a destination for improving (English) Language and Communication Skills, only 24% of the Singapore students choose to go on these Student Exchange Programmes with improving (Japanese) Language and Communication Skills as their goal. There were responses like *"As I don't like English, I'd like to conquer it," "I would like to see and understand different cultures that I cannot experience in Japan," "I would like to make foreign friends and establish friendship".*

The large number of Others / Undetermined Singaporean participants – 21% - are attracted to Japan to experience her varied Nature, Cool Temperatures and Small City Destinations and Countryside. These are not available in Singapore, and are thus fascinating for the Singapore students. 100% of the Singapore participants want to go to Japan because of the Japanese Culture, Lifestyle and Cuisine that they have been introduced to in Singapore itself, because of the popularity of J-Pop, Manga, Anime and Japanese cuisine in Singapore.

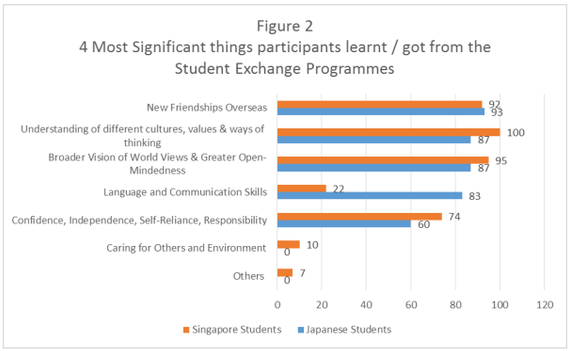


Survey Question 2a (to Japanese students): What were most significant things that you learnt or got from this student exchange programme to Singapore?

- ➔ New Friendships from Singapore - 93% of participants
- ➔ Understanding of different cultures, values & ways of thinking - 87% of participants
- ➔ Broader Vision of World Views and greater Open-Mindedness - 87% of participants
- ➔ English Communication Skills – 80%
- ➔ Confidence, Independence, Self-Reliance, Responsibility – 60%
- ➔ Caring for Others & Environment – 2%
- ➔ Others – 4%

Survey Question 2b (to Singapore students): What were 4 most significant things that you learnt or got from this student exchange programmes to Japan?

- ➔ New Friendships from Japan - 92% of participants
- ➔ Understanding of different cultures, values & ways of thinking - 100% of participants
- ➔ Broader Vision of World Views and greater Open-Mindedness - 95% of participants
- ➔ Japanese Communication Skills – 22%
- ➔ Confidence, Independence, Self-Reliance, Responsibility – 74%
- ➔ Caring for Others & Environment– 10%
- ➔ Others – 7%



Discussion:

Singaporean students commented that they felt that the exposure to a new culture and surroundings helped them push their boundaries, become much more confident and find solutions to challenging situations. The concept of Punctuality and appreciation of Time within the Japanese culture was an eye-opener for them. The Onsen experience, though intimidating initially, helped them overcome their inhibitions and become much more open-minded. Interaction with students or even host families in Japan found them new friends for the long run. Some are even hosting their friends and host families from Japan, in Singapore. Independence and self-reliance were big learning areas for Singapore students, especially for students staying with host families for the IJSP. They had to learn to communicate without proficient Japanese language skills. *"I learnt that the world is a bigger place than I had thought earlier. It has broadened my mind and encouraged me to be open-minded". "During my homestay, I experienced Japanese hospitality and saw how caring they are.. I learnt that I must care for others too, for a better society."*

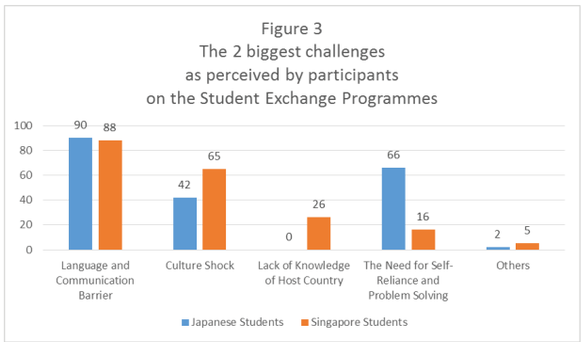
For the Japanese students who had essentially wanted improvement in English language skills and Cross-Cultural exposure as their main take-aways, found that they achieved those goals. In addition, there was personal development and self-reflection throughout the exchange programme. The growth in their confidence, self-reliance and independence spilled over to other tasks they consequently undertook, even after the return to Japan. *"I would like to broader my values, and integrate good points of Singaporeans into my life".* The fear of unknown situations and new surroundings was much reduced due to these Student Exchange Programmes.

Survey Question 3a (to Japanese students): What were your 2 biggest challenges on this student exchange programme to Singapore?

- ➔ Language and Communication Barrier - 90% of participants
- ➔ Culture Shock - 42% of participants
- ➔ Lack of Knowledge of Host Country – 0%
- ➔ The need for Positivity, Self-Reliance and Problem Solving – 66%
- ➔ Others – 2%

Survey Question 3b (to Singapore students): What were your 2 biggest challenges on the student exchange programme to Japan?

- ➔ Language and Communication Barrier - 88% of participants
- ➔ Culture Shock - 65% of participants
- ➔ Lack of Knowledge of Host Country – 26%
- ➔ The need for Self-Reliance and Problem Solving – 16%
- ➔ Others – 5 %



Discussion:

It cannot be denied that the students face challenges of different types and intensity whilst on these Student Exchange Programmes overseas. The primary challenge that can be seen is that of Language and Communication. What is interesting is that despite the setback, they learnt to communicate much better with each other as time progresses, by picking up a few words and terms in the foreign language, gestures and expressions. The second biggest challenge for Singapore students is the Culture Shock they face. In the survey answers they mention issues like not being used to the Japanese level of Punctuality, Politeness, Humility and Hospitality '*back home*'. One of the big reasons for any sort of Culture Shock could be the lack of experience, knowledge and preparedness for such an exchange programme in Japan. The need to do things on your own also made them realize how dependent they are on others in Singapore. Some mentioned experiencing loneliness due to language barriers and communication gaps.

For Japanese students, one of the biggest challenges was also Language and Communication. Even those more fluent in English may struggle initially with the accent, as they are used to the American accent. In addition, Singlish, with various local expressions and terminology from dialects, is popular in Singapore and spoken by most of the Singapore poly students. These could be further distractions in the communication. Another challenge that was evident from the study, was for participants to remain positive and gung-ho despite struggling with the weather in Singapore and the Culture Shock.

Survey Question 4a (to Japanese students): Has this student exchange trip encouraged you to interact more with Singapore students / people post programme?

➔ "Yes" – 90 %

Japanese students shared that the trip had certainly encouraged them to interact more with Singapore students and they kept in touch via social media app - Line. They also expressed that the programme had encouraged them to visit Singapore again and to interact with friends made here.

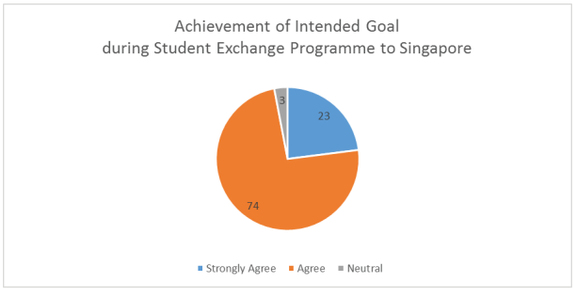
Survey Question 4b (to Singapore students): Has this student exchange trip encouraged you to interact more with Japanese students / people post programme?

➔ "Yes" – 95 %

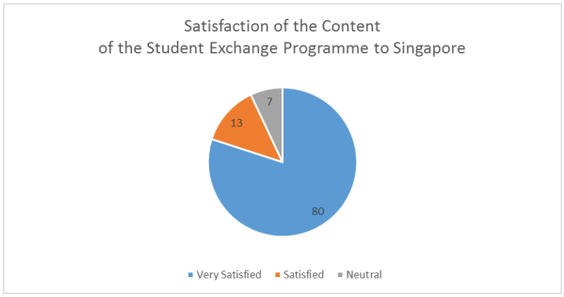
Singapore students shared via the survey answers that they continued to keep in touch with their peers / counterparts and host families even months after the programme, mainly via social media like Line. Apart from people they already had interacted with in Japan, they also shared that their overall inhibition in communicating with the Japanese had gone down. Japanese language skills had improved thanks to the programmes. That aside, they felt confident overall, in communicating with the Japanese, even if their Japanese Language skills were entry level. In fact several had helped in the hosting of other Japanese Student Exchange Programmes and felt much more confident when interacting with the Japanese students in these programmes than before they had embarked on their own exchange programme.

Post-Trip Evaluation for Japanese students:

Achievement of intended outcomes for Student Exchange Programme: 97% of the participants said that they were successful – (23% Strongly Agree & 74% Agree), whilst 3% were Neutral.

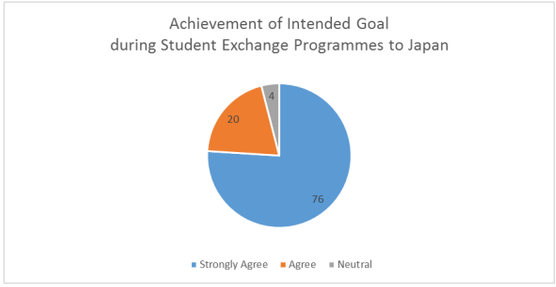


➔ Satisfaction of the Content of the Students Exchange Program to Singapore: 80% of the students answered Very Satisfied, 13% Satisfied, 7% Neutral.

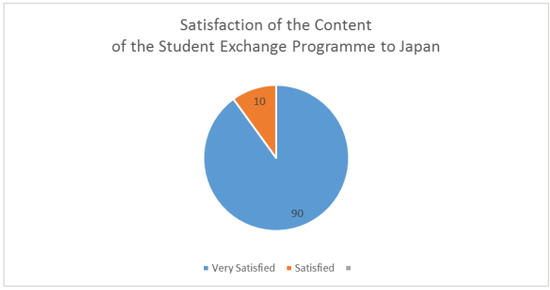


Post-Trip Evaluation for Singapore students:

➔ Achievement of intended outcomes for Student Exchange Programme: 96% of the participants said that they were successful – (76% Strongly Agree & 20% Agree), whilst 4% were Neutral.



➔ Satisfaction of the Content of the Students Exchange Program to Japan: 90% of the students answered Very Satisfied, 10% Satisfied.



Discussion

Factors affecting participant perspectives on the learning outcomes of student exchange programmes were examined through interviews that were held separately with 6 Hachinohe students and 6 Singapore students.

The data revealed that Student Exchange Programmes are probably one of the most beneficial experiences students in their late teens to early twenties could have, when they are at high school, college or polytechnic.

(1) **Global Citizenry and Cross-cultural Awareness:** the participants have a deeper global and cultural awareness and understanding of different cultures and different views after the student exchange programme. As they are exposed to behaviours, norms and values different to theirs, they gain better understanding of their own preferences, and thus can respond more appropriately in cross-cultural settings. It was evident from the survey findings of this study that Cross-Cultural Exposure and Competence was high on the goals as intended outcome for the programmes, as determined by the participants. This goal was successfully achieved through the programmes.

This development of Global Citizenship amongst the participants, sensitizes them more to environmental responsibility and enhanced awareness of Global Issues.

Some Singapore participants felt that they were much more competent in understanding Japanese culture and thus consequently 4 participants wanted to do their internship in Japan and 3 have also expressed the desire to work there in the future.

(2) **Intercultural Communication Skills:** One of the major goals for Japanese students on these exchange programmes is to learn English leading to more effective cross-cultural communication. For the Singapore students it is not only about understanding the Japanese language, but also understanding the unsaid and unspoken nuances, below-the-surface messages.

(3) **Personal Growth:** These overseas Student Exchange Programmes see tremendous contribution in this area - participants perceive their own personal growth such as self-confidence, responsibility, a spirit of challenge and problem solving, leadership and teamwork, ability to take action and feeling empowered. Singapore students commented that they would like to imbibe qualities like humility, hospitality, generosity and caring as they had witnessed from their Japanese peers and hosts. Japanese students admired the independence and assertiveness they had seen amongst the Singaporean students and wanted to adopt it for their future personal growth.

(4) **Professional development (future career) and long-term goals:** Participants perceive future careers in the world setting, expanding the working location from their own country to foreign countries, and view their career and their life with a broader vision. This then encourages them to think about their longer term goals as well. They start with participative opportunities in more such Student Exchange Programmes and also look for Internship opportunities overseas. The unknown does not appear as daunting as they have progressed in Self-Reliance and Independence.

Conclusion

Student Exchange Programmes have gained much popularity in recent years with more student participants than ever before. Endorsement by various agencies and institutions via funding granted also helps students undertake these overseas trips. This encourages young adults to leave their comfort zone and acquaint themselves with cultures beyond their own. The knowledge gained, creates a sense of familiarity, reduces the fear of the unknown and thus paves the way for opening up minds to further exploration. This in turn instils in them a sense of adventure and encourages them to be willing, and more able, to take seemingly perceived risks in order to accomplish cross-border connections.

Japan and Singapore are natural counterparts for such student exchanges. Common factors like safety, efficient infrastructure, long-standing connections and a mutual fascination with the other are reasons participants are eager to go on these programmes.

This study has highlighted the numerous benefits of such overseas programmes for the participants – both personally and professionally. Participant perspectives in this study have validated the success of the intended learning outcomes for these Student Exchange Programmes. Whilst the challenges faced by them initially, build grit, determination, a spirit of adventure, calculated risk-taking and problem solving skills, there is the potential of further training for preparedness prior to these trips.

Acknowledgements

We sincerely appreciate for faculty and staff members who have been involved in these students exchange programmes, both in Japan and Singapore. They have been wonderful mentors and support for students as they go through their learning journeys. These programmes would not be able to continue without their buy-in and belief on the positive impact these have on the students' personal & professional growth.

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INTERNATIONAL COOPERATIVE ENGINEERING EDUCATION BETWEEN JAPANESE AND MONGOLIAN KOSENS IN ELECTRICAL AND ELECTRONIC ENGINEERING

Susumu Nakamura*[a], Masaaki Yoshida [b], Takanobu Maeda [c]

[a] Department of Electrical and Electronic Systems Engineering, NIT, Nagaoka College, Nagaoka, Japan
[b] Department of Liberal Arts and Engineering Sciences, NIT, Hachinohe College, Hachinohe, Japan
[c] Department of Control Engineering, NIT, Sasebo College, Sasebo, Japan

* Email: snaka@nagaoka-ct.ac.jp

Abstract

Among about 150 Mongolian people who had studied at the KOSEN colleges in Japan for the past 20 years, there was an increasing strong aspiration to set up Japanese-style KOSEN Colleges in Mongolia. Receiving strong backing from former Minister of Education and Science of Mongolia, Mr. Luvsannyam Gantumur, who studied abroad at Sendai KOSEN in Japan, they established Japanese-style KOSEN Colleges, "Institute of Engineering and Technology (IET), Mongol KOSEN College of Technology" in 2013, followed by "Mongolian University of Science and Technology (MUST) KOSEN College of Technology" and "New Mongol College of Technology" in 2014. To extend Japanese-style KOSEN education further throughout Mongolia, it seems to be critical to raise up level of education of the present KOSEN Colleges in Mongolia. This paper reports a project to improve the education level in the Department of Electrical and Electronic Engineering at the KOSEN Colleges in Mongolia. From 14th January to 18th January 2018, eight teachers who belong to the Department of Electrical and Electronic Engineering at the KOSEN Colleges in Mongolia visited Japan for a training workshop at Nagaoka KOSEN. This training workshop aimed to deepen their understanding about research facilities, practical education using experiments, and education system of Japanese KOSEN. From 4th March to 11th March 2018, Professor Susumu Nakamura at Nagaoka KOSEN, Associate Professor Masaaki Yoshida at Hachinohe KOSEN and Associated Professor Takanobu Maeda at Sasebo KOSEN were dispatched to MUST KOSEN College of Technology in Mongolia. Two students who are majoring electrical and electronic systems engineering at Nagaoka KOSEN were also dispatched to MUST KOSEN College of Technology as teaching assistants. During their stay in Mongolia, they taught how to use an electronic circuit simulator, kits of electric circuits and an operational amplifier, and a single-chip microcontroller to Mongolian teachers.

Keywords: *International Cooperation, Engineering Education, Electrical and Electronic Engineering, Japanese KOSEN, Mongolian KOSEN*

1. Introduction

The number of students in higher educational institutes in Mongolia is increasing based on the needs of higher education since 2000. The number of students in the academic year 2015 to 2016 has increased to about 65% from the academic year 2002 to 2003. The proportion of the students who have entered universities to all graduates from full-time senior high schools in the academic year 2016 to 2017 was 75.6%. The proportions of the students who have chosen science or engineering majors were about 5% or 16.3% respectively, which shows just a small increase compared with data in 2012.

On the other hand, there is a gap between the types of human resources required by companies in industrial area in Mongolia and the graduates educated by Mongolian present higher education institutes. This is due to the situation such that current educational programs focus on theoretical learning mainly through lectures and most students start working without adequate ability of application or problem solving which are supposed to be fostered through experiment or laboratory work.

Among about 150 Mongolian people who had studied at the KOSEN colleges in Japan for the past 20 years, there was an increasing strong aspiration to set up Japanese-style KOSEN Colleges in Mongolia. In 2009, they formed a general incorporated association "Society for Establishment of Mongolia KOSEN" in cooperation with people who are involved in KOSEN education in Japan. Later, receiving strong backing from former Minister of Education and Science of Mongolia, Mr.

Luvsannyam Gantumur, who studied abroad at Sendai KOSEN in Japan, they established "Institute of Engineering and Technology (IET), Mongol KOSEN College of Technology" in 2013, followed by "Mongolian University of Science and Technology (MUST) KOSEN College of Technology" and "New Mongol College of Technology" in 2014.

In 2013, IET, Mongol KOSEN College of Technology, also known as "Mongol KOSEN", was established as a school of IET. This college is managed under Mr. Munkh-Ochir Sergelen, Principal of Mongol College of Technology and President of IET, who have experience of studying in Japan. IET, Mongol KOSEN College of Technology has four departments: Construction Engineering, Mechanical Engineering, Electrical and Electronic Engineering, and Biological Engineering.

In 2014, MUST KOSEN College of Technology was established under supervision of Mr. Ganbayar Aleksei, who has previous experience of studying abroad at Tokyo KOSEN in Japan, as ninth school belonging to MUST. MUST KOSEN College of Technology has three departments: Electrical and Electronic Engineering, Civil and Architecture Engineering, and Mechanical Engineering.

A private school corporation, the New Mongol College of Technology was founded in 2014. The New Mongolian Institute is composed of elementary school to university. New Mongol College of Technology was operated under Principal Buyangalgar who studied abroad at Sasebo KOSEN in Japan. New Mongol College of Technology has four departments: Civil Engineering and Architecture, Electrical and Electronics Engineering, Mechanical Engineering, and Chemical Engineering.

National Institute of Technology (NIT), Nagaoka College and Sasebo College were established in 1962, followed by Hachinohe College in 1963, under the Ministry of Education (current Ministry of Education, Culture, Sports, Science and Technology). Based on the Japanese Government's policy, all 51 National Colleges (55 Campuses) including Nagaoka, Sasebo and Hachinohe Colleges were incorporated as a new single legal entity in 2004 and are now under the umbrella of the National Institute of Technology, Japan. However, each college maintains its independent authority. College of Technology under the National Institute of Technology is popularly called KOSEN.

2. International Cooperative Engineering Education

In order to improve the education level of the present three KOSEN colleges in Mongolia, international cooperative engineering education between Japanese and Mongolian KOSENs was conducted. In this paper, we report the educational training workshops in the Department of Electrical and Electronic Engineering at the KOSEN Colleges in Mongolia.

2.1 Outgoing Program from 25th December to 28th December 2017

From 25th December to 28th December 2017, Dr. Susumu Nakamura, a professor of the Department of Electrical and Electronic Systems Engineering at Nagaoka KOSEN, was dispatched to MUST KOSEN College of Technology in Mongolia. During his stay in Mongolia, he taught how to assemble electric circuits using digital ICs and a breadboard to the Mongolian teachers who belong to the Department of Electrical and Electronic Engineering at the KOSEN Colleges in Mongolia. Figure 1 shows the Mongolian teachers who participated in the circuit assembly workshop.



Figure 1 Mongolian teachers who participated in the circuit assembly workshop.

As teaching material for a course of workshop, "Have Fun with Kits! Electric Circuits, Digital Circuits Edition Vol.1 and Vol.2" produced by ADWIN Corporation were used. These electric kits are designed to be provided to students studying electronics and having interest to electronics, so that they can recognize by themselves through hands-on exercise what they need to learn and understand. These electric kits are useful for science teachers. Teachers are easy to think how to teach electronics to their students effectively using these kits. For this reason, these electric kits were chosen as the teaching material. For assembling the digital circuits, at first, trainees should draw wires to make some connections between each components and/or devices in the drawing of breadboard according to the schematic diagram. Then the trainees start assembly of the circuit, and after that, they confirm its function. As shown in Figure 2, the Mongolian teachers were seriously working on the electronic circuit assembly. The following digital circuits were assembled:

(ⅰ) NOT logic circuit
(ⅱ) NOT logic circuit using a variable resistor
(ⅲ) Multivibrator circuit using NOT logic gates
(ⅳ) Logic circuit using NAND gates
(ⅴ) Logic circuit using NOR gates
(ⅵ) SR Flip-Flop circuit
(ⅶ) Counter circuit using D-Flip-Flop devices
(ⅷ) 1-digit BCD Counter
(ⅸ) A circuit to blink an LED using an NE555



Figure 2 Assembly of the electronic circuits using digital ICs and a breadboard.

2.2 Incoming Program from 14th January to 18th January 2018

From 14th January to 18th January 2018, eight Mongolian teachers who belong to the Department of Electrical and Electronic Engineering at the KOSEN Colleges in Mongolia visited Japan for a training workshop at Nagaoka KOSEN. This training workshop aimed to deepen their understanding about research facilities, practical education using experiments, and education system of Japanese KOSEN. During their stay in Nagaoka, they got the following experiments on power electronics:

(i) Control of DC motor
(ii) Control of squirrel-cage induction motor
(iii) Experiment on solar power generation
(iv) Discharge phenomenon in air
(v) Frequency control by three-phase inverter
(vi) AC control by SCR

The power electronics is the application of solid-state electronics to the control and conversion of electric power. In modern systems, the conversion is performed with semiconductor switching devices such as diodes, thyristors and transistors. AC/DC converter (rectifier) is the most typical power electronics device found in many consumer electronic devices. As mentioned above, the power electronics play an important role in modern power and energy control technologies. Therefore, the power electronics needs to be taught in Mongolian KOSEN. Figure 3 shows a lecture on the control of DC motor and Figure 4 shows experiment on the solar power generation.



Figure 3 Lecture on the control of DC motor.



Figure 4 Experiment on the solar power generation.



Figure 5 Factory tour at WEST Co., Ltd.

During the Mongolian teachers stayed in Nagaoka, they visited a company, WEST Co., Ltd., to understand the industry of Nagaoka area. West Co., Ltd. is a small company, but has unique technology to make fine powder from cereals such as rice and buckwheat. WEST Co., Ltd. produced world's first water cooled stone milling machine. Figure 5 shows factory tour at WEST Co., Ltd.

2.3 Outgoing program from 4th March to 11th March 2018

From 4th March to 11th March 2018, Dr. Susumu Nakamura, a professor of the Department of Electrical and Electronic Systems Engineering at Nagaoka KOSEN, Dr. Masaaki Yoshida, an Associate Professor of the Department of Liberal Arts and Engineering Sciences at Hachinohe KOSEN and Mr. Takanobu Maeda, an Associate Professor of the Department of

Control Engineering at Sasebo KOSEN were dispatched to MUST KOSEN College of Technology in Mongolia. Two students who are majoring electrical and electronic systems engineering at Nagaoka KOSEN were also dispatched to MUST KOSEN College of Technology as teaching assistants. The teaching materials they brought were an electronic circuit simulator, kits of electric circuits and an operational amplifier, and a single-chip microcontroller of ATmega328.

The training workshop on the electronic circuit simulator was a request from the Mongolian teachers. LTspice XVII was chosen as the electronic circuit simulator. LTspice XVII is node-unlimited and third-party models can be imported. Circuit simulations based on transient, AC, noise and DC analysis can be plotted as well as Fourier analysis. LTspice XVII also supports simple logic gate simulation. As shown in Figure 6, the Mongolian teachers discussed about how to use the electronic circuit simulator. During this workshop, the following simulations on the electronic circuits were conducted:

(i) RC low pass filter
- Drawing the circuit diagram with the editor
- Changing part values
- Time domain simulation
- Frequency domain simulation

(ii) Rectifier
- Simple rectifier without transformer
- One pulse rectifier with transformer
- Two pulse rectifier with transformer

(iii) Transistor circuit
- One stage amplifier
- Two stage broadband amplifier with feedback

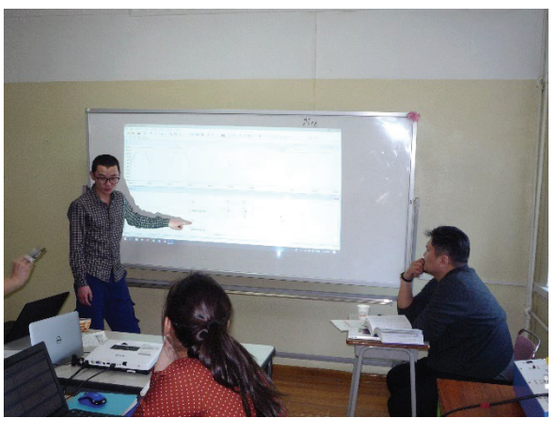

Figure 6 Discussion about the electronic circuit using the circuit simulator, LTspice XVII.

After LTspice XVII training workshop, "Have Fun with Kits! Electric Circuits, Basic Edition Vol.1 and Vol.2" produced by ADWIN Corporation were used as the teaching material. Assembling electric circuits using these kits were as follows:

(i) Make LED light ON
(ii) Change connection of LED reverse
(iii) Use variable resistors
(iv) Parallel connection circuit
(v) Diode circuit; rectification circuit
(vi) Use transistors; DC motor control 1, 2, 3

As mentioned previously, two students who are majoring electrical and electronic systems engineering at Nagaoka KOSEN were dispatched to MUST KOSEN College of Technology as teaching assistants. They made presentations on their graduation researches to Mongolian students during the workshop break time as shown in Figure 7. Mongolian students will be fifth-year class in next academic year and they will conduct final year research. Therefore, the Mongolian students were seriously listening to the presentations of Nagaoka KOSEN students.



Figure 7 Advanced course student's presentation on graduation research.

After assembling the Electric Circuits, Basic Edition Vol.1 and Vol.2, "Have Fun with Kits! Op-amp Introductory Edition" produced by ADWIN Corporation were used as the teaching material. The Op-amp means a word "operational amplifier". The word "operational" in the name refers to mathematical operations such as addition, subtraction, differentiation, integration, etc., since Op-amps are direct current amplifiers capable of performing such tasks. Although Op-amps are not normally seen, they are actually widely used in appliances with analog circuits that everybody should have. They can be found, for example, in mobile telephones, personal computers, audio players, headphone amplifiers, sensor circuits, and measuring devices. Figure 8 shows that the Mongolian teachers observed signals from the Op-amp circuit using analog oscilloscope. During this training workshop, assembling circuits using Op-amp kits were as follows:

(i) Inverting amplifier circuit
(ii) Non-inverting amplifier circuit
(iii) Adder circuit
(iv) Subtractor circuit
(v) Voltage follower circuit
(vi) Comparator circuit
(vii) Hysteresis comparator circuit
(viii) Differentiator circuit
(ix) Integrator circuit



Figure 8 Observation of signals from the Op-amp circuit using analog oscilloscope.



Figure 10 Japanese and Mongolian KOSENs teachers and Nagaoka KOSEN students.

As the last training workshop, the Mongolian teachers tried to modify "Bontenmaru" robot using the single-chip microcontroller, ATmega328. Bontenmaru is an autonomous two-wheel drive robot that can be run with a simple program for elementary and junior high school students. Although the original Bontenmaru uses a PIC microcontroller as a computing device, the Mongolian teachers tried to replace the PIC microcontroller with the ATmega328 microcontroller. Because most of the Mongolian teachers who participated in this training workshop serve as robot club advisors, they were interested in using the ATmega328 microcontroller. Figure 9 shows control of "Bontenmaru" using the ATmega328 microcontroller.

At the meeting of exchange ideas after the training workshops, the Mongolian teachers mentioned that the cooperative engineering training program gave them a rare opportunity to interact with Japanese KOSEN teachers and to obtain very significant educational benefits, such as improving communications skills and stimulating motivation for learning new technology. Figure 10 shows Japanese and Mongolian KOSENs teachers and Nagaoka KOSEN students who participated in the training workshops.

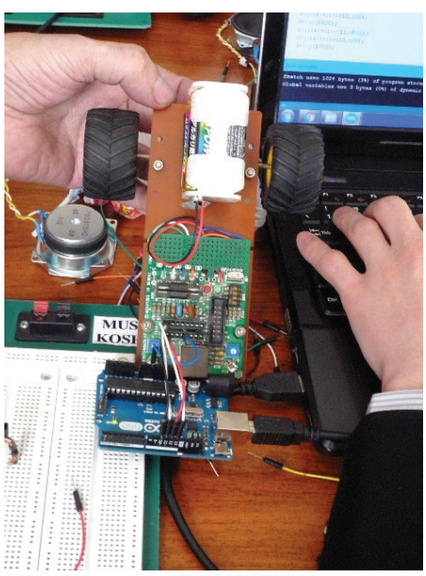

Figure 9 Control of "Bontenmaru" using the ATmega328 microcontroller.

3. Conclusions

In this project, the workshops for implementing the Japanese KOSEN educational system in Mongolian KOSEN were conducted. It is confirmed that fostering engineers in both Japanese and Mongolian KOSENs are very meaningful and KOSEN students will bridge two countries.

Acknowledgements

We sincerely appreciate the headquarter of National Institute of Technology, Japan and the Institute of Engineering and Technology Education of KOSEN Japan & Mongolia for giving us the opportunity to conduct international cooperation education.

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PRODUCTION OF SOLAR CAR BY STUDENTS PROJECT

S. Watanabe*,a, M. Furukawa[a] and K. Ohsawa [a]

[a] NIT, Nagano College / Department of Electrical and Electronic Engineering, Nagano, Japan

*E-Mail watanabe@nagano-nct.ac.jp

Abstract

The students of the National Institute of Technology (NIT), Nagano College have been taking the initiative to produce solar cars since 1992. Ten student volunteers produced a solar car using solar cells and a brushless DC motor, and participated in the competition held in Ishikawa Prefecture.

In 1993, they participated in the competition held in Akita Prefecture as a solar car team, which was launched in the same year as an extracurricular activity at the college. This competition was approximately a round course of about 30 km (currently 25 km round trip), and participants could compete for 25 h in an endurance race lasting three days. Nagano College took part in the competition for 22 consecutive years until 2014. Its team achieved 844 km as its longest running distance and won the class title in the preceding seven competitions.

In 2015, the team began to participate in another competition held in Mie Prefecture. In this competition, a 3-h endurance race of 5.807 km per lap was held. This circuit is uneven and therefore requires solar cars to have stable running capability. Because of the lack of experience in this competition, the longest running distance record for the team remains at 162.596 km, and its highest average speed is 57.2 km/h.

Approximately 20 students produce solar cars after school currently. Students are classified into three groups: the Mechanical Group, which is responsible for the design and creation of car bodies; the Electricity Group, which is responsible for working on the design and production of electrical systems; and the Cowl Group, which is involved in the production of car bodies. The students conceive an idea for new cars almost every year, make a design, and implement it for operation. The students have been making efforts to improve their skills by obtaining technical information from the top teams and by starting to socialize with the Hong Kong IVE in since 2015. Some students have found employment at auto companies, while others have participated in the competition by establishing a team consisting of volunteers. The students' knowledge is growing significantly through the production of solar cars.

Keywords: *Solar cars, extracurricular activities, solar cells, motor, racing*

Introduction

Recently, energy problems have become worse worldwide. In the automotive industry, much progress has been made in hybrid cars powered by gasoline engines coupled with motors, as well as in electric vehicles and fuel cell cars.

Solar cars are automobiles that are driven by motors powered by electric energy that has been created by solar cells from sunlight, charged, and stored in batteries (For example, Kimura et al. (2000), Taha et al. (2010), Singh et al. (2013)). These cars are noted for cleanliness, in that they take advantage of solar energy without relying on fossil fuels. Because of cost issues, however, they have yet to be adopted in commercial cars.

In Japan, auto makers and power companies, as well as students in universities and industrial high schools, tackled manufacturing solar cars in the 1990s (Kimura (2011)). Conventions are held, both in Japan and abroad. For example, the World Solar Challenge (WSC) to be held in Australia is a famous competition (For example, Ozawa et al. (1998), Elshafei et al. (2016)). At the National Institute of Technology, Nagano College, students started solar car production in 1992 and made entries in competitions to verify the performance of the car. In this research, how the solar car manufacturing proceeded at the NIT, Nagano College is described.

Manufacturing solar cars for racing competitions

Figure 1 shows the electrical system architecture of solar cars. Electricity generated by solar cells is supplied to motors and batteries by way of a buck-boost converter or charging controller. In case sufficient electric power generation is secured, the motor is driven by electricity supplied by solar cells; however, if such generation is deficient because of cloudy weather, power is supplied by the batteries to the motor. Effective utilization of batteries holds the key to winning or losing in the race.

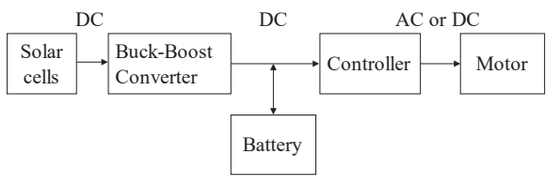


Figure 1. Construction of electrical system architecture of solar cars

(1) First participation in solar car race

Ten volunteers of fifth graders in the department of electric engineering, who aspired to participate in Japan's first solar car rally to be held in Noto Peninsula, Ishikawa Prefecture, initiated the manufacturing of solar cars and motors. Because the rally was held on the Chirihama Nagisa Driveway, a sightseeing road running on a sandy beach, they adopted front-wheel drive to simplify the drive system.

Figure 2 shows the exterior appearance of the solar car manufactured. It had one wheel on the front and two wheels on the rear. The car used the solar panels for power generation (Kyocera Corp., LA361J48, 48 W × 10 sheets), and the motors used an industrial DC servo motor donated by the manufacturers (Sanyo Denki Co. Ltd., F1470). More than 100 cars entered the rally from auto makers, power companies, universities, technical colleges, and so on. At the competition, it was notable how solar cars attracted interest in terms of the effective use of solar energy.



Figure 2. External appearance of the solar car The Wind from the Sun produced in 1997 (Solar car rally in Noto, Rank: 27th place)

(2) Production of solar car by extracurricular activities

In 1993, a circle of like-minded solar car researchers was founded on campus, and they worked on producing solar cars as an extracurricular activity. The produced solar car was entered at the World Solar-Car Rally (WSR) held on the village road (solar sports line since 1994) in Ogata-mura, Akita Prefecture. In this competition, we used a round course of about 30 km (currently 25 km round trip) and competed for the distance we ran between 25 h in 3 days. Since 1999, the All-Japan Intercollege Solar Car Championship (JISC) has joined for university students, and the All-Japan Intercollege Solar & Fuel Cells Car Championship (JISFC) was added for simultaneous competition in 2006. In 2011, JISFC merged into the World Green Challenge Solar & Fuel Cells Car Rally (WGC), which has remained to this day.

The circle was promoted to a club in 1997, and its activity grew to be able to manufacture vehicles, with subsidies from student bodies and technology promotion associations. Solar cars are designed every year for manufacturing to participate in the rally.

Figure 3 shows the exterior appearance of the solar car manufactured in 1997. It used 12 solar panels (Showa Shell Sekiyu Co., Ltd. / KIS Co., Ltd., FT132-E) for solar car racing, with the total electric power generation rated at 480 W. For the motor, it used a brushless DC motor (Honda Motor Co., Ltd., DDW4060) of 600-W output. Batteries were sealed in lead storage batteries. Solar cells were positioned in the rear, lowering the car body's center of gravity. Further, considering the driver's long hours of driving, air intake vents were installed. At this rally, the running distance was 558 km, winning the second place in the WSR fresh category.



Figure 3. External appearance of the solar car OLYMTECH 48 produced in 1997 (1997 WSR, Rank: 2nd place in fresh category)

Figure 4 shows the exterior appearance of the solar car manufactured in 2000. The solar panels and the motor were of the same specifications as those of the 1997 vehicle. For the first time this year, adjustable panels were adopted so that the solar panels could be oriented toward the sun (adjustable panels were banned later). At this rally, the running distance was 593 km, winning the 4th place in the JISC half-size category.



Figure 4. External appearance of the solar car Shining the Sun produced in 2000 (2nd JISC, Rank: 4th place in half-size category)

Figure 5 shows the exterior appearance of the solar car manufactured in 2001. The solar panels and motor used were of the same specifications as those of the 1997 vehicle. It used four sealed lead storage batteries (GS Yuasa Corp., NP24-12B). A canopy was installed in the center of the solar cell module, thereby allowing for a

smaller, lighter, lower-gravity vehicle. Furthermore, the space accommodating the driver has been made as minimal as possible and thinner in size to lessen specific air resistance. As a result, the running distance at the rally increased to 844 km, a record distance for the school, winning third place in the JISC half-size category. In addition, as a result of letting another solar car participate, we ran the 4th place by running 656 km.



Figure 5. External appearance of the solar car BIJIN produced in 2001 (3rd JISC, Rank: 3rd place in half-size category)

Figure 6 shows the exterior appearance of the solar car made in 2006. The solar panels and motor were of the same specifications as those of the 1997 vehicle. It used four sealed lead storage batteries (Furukawa Battery Co., Ltd., FPX12240H). For the past five years, vehicles of thinner types were manufactured, but, to reduce air resistance further, full cowl bodies were also made. Further, efforts for suppressing the power consumption of electric components were made by employing LEDs in winkers. Because of failure to use materials like lighter-in-weight carbon fibers, the gross weight of the vehicle increased and compromised the driving performance. However, thanks in part to good weather, the running distance grew to 600 km, winning first place in the JISFC half-size category.



Figure 6. External appearance of the solar car Hopeless Inverse produced in 2006 (8th JISFC, Rank: Winner in half-size category)

Figure 7 shows an exterior appearance of the solar car made in 2013. The solar panels and motor used were of the same specifications as those of the 1997 vehicle. Two motors were installed to beef up the output to 1.2 kW, and the solar cells were increased to 16 panels to generate a gross power of 623 W. For the battery, one lithium iron phosphate battery (Shenzhen O'CELL Technology Co., Ltd., IFM48-300E2) was used. To make the vehicle lower in cost and lighter in weight, the students used residential heat insulation material (Sekisui Chemical Co., Ltd., Zettoron) in manufacturing the streamlined cowl. As a result, the running distance turned out to be 475 km, finishing in victory in the WGC solar car sector of the challenge class.

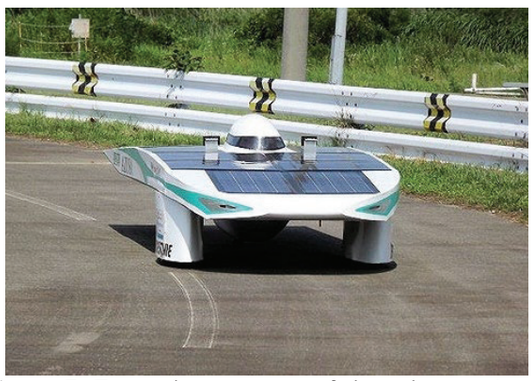


Figure 7. External appearance of the solar car Azusa produced in 2013 (2013 WGC Solar car Rally, Rank: Winner in challenge class)

Figure 8 shows a scene at the students' camping event. Students stayed at the camping spot near the rally site. It was considered that the students gained life experience from both entering the race and also from living with their peers. In addition, some of the students experienced volunteering of the rally.



Figure 8. Camp life by students in 2004

(3) Entry in solar car race at Suzuka

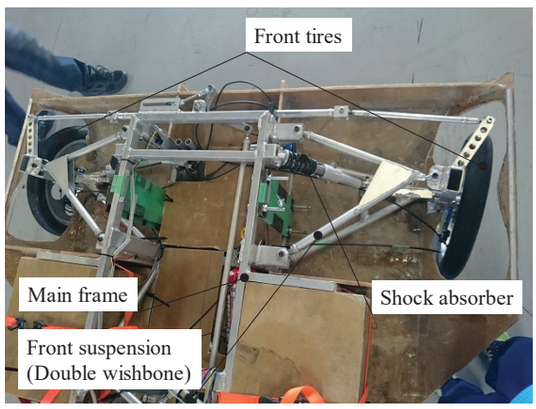
The team participated in the rallies held at Ogata-mura 22 times consecutively from 1993 to 2014, with the team's record running distance at 844 km and seven victories in the class. However, as the number of units entering the rally has decreased to a minimum in recent years, the students debated switching their entry in 2015 to the rally at Suzuka-shi, Mie Prefecture, where there were many entrants. This rally is held at the 5.807 km circuit of the international racing course. The course,

with large undulations, demands a vehicle's stable driving performance.

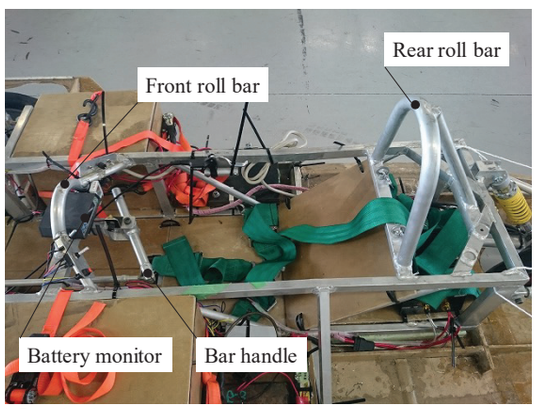
Figure 9 shows the exterior appearance of the solar car made in 2017. In this figure, (a) is an overview of the solar car, (b) is an overview of the front-wheel steering, (c) shows the inside of the car, (d) shows the state of the rear wheel, and (e) is the electric system diagram. 182 solar cells (2.6 W per cell) with a gross output of 480 W were used, with an in-wheel motor of 1.5 kW rated output and sealed lead storage battery of 57 Ah total capacity. For the solar cells, two units of buck-boost-type DC/DC converter were used to obtain direct current of 60 V. For the tires, 14-in tires exclusive for solar cars were used.



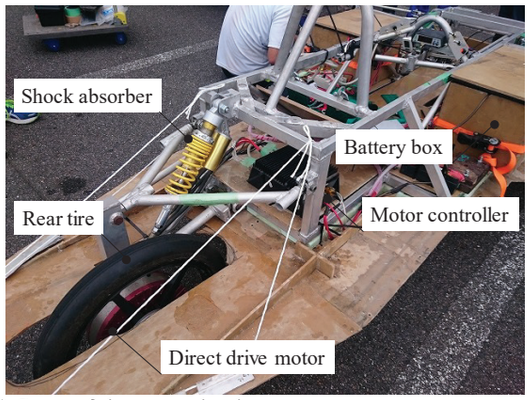
(a) Appearance of the solar car Asanagi



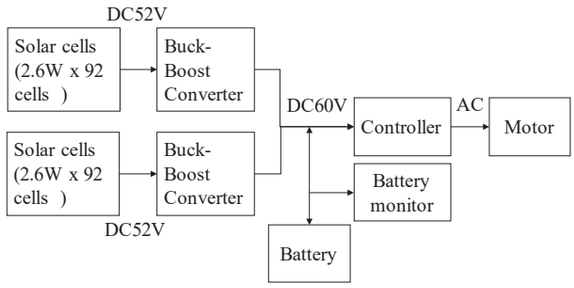
(b) State of front-wheel steering



(c) Inside the car



(d) State of the rear wheel



(e) Electrical system diagram

Figure 9. External appearance of the solar car Asanagi produced in 2017 (Solar car race Suzuka, Rank: 10th place in Enjoy I class)

The vehicle made in 2015 ran only 23.228 km because of technical trouble, but the 2016 vehicle ran 104.526 km to finish in 13th place in the Enjoy I category. Later, after improvements made for entry in the 2017 race, the running distance extended to 162.596km, attaining a maximum average speed of 57.2 km/h. Thus, the students steadily improved the technical level.

Table 1 shows the specifications of the solar car. Assuming the speed of the car is 60 km/h, the frame was made with aluminum alloy. In addition, a solar cell was used that is taut to the curved surface of the body.

Status of manufacturing

At present, approximately 20 students in three groups are tackling solar car manufacturing after school, with the Mechanical Group designing and manufacturing the body by means of three-dimensional computer-aided design, the Electric Group in charge of designing and manufacturing of electric circuits, and the Cowl Group responsible for body manufacturing.

There are three teachers to advise the club in its activities, whose functions are to provide technical consultation to the students and support them on traveling to participate in the rally. In addition, students receive advice from several technical staff as necessary. The students come up almost each year with new ideas for the vehicle, engage in designing, install components, and operate the vehicle, always keeping themselves busy with problem-solving types of experiments and manufacturing.

Table 1. Specification of solar car Asanagi produced in 2017

Size (L×W×H)	3,500×1,700×1,000 mm
Weight	120 kg*
Material of body	Insulation material, Mirafoam, GFRP
Material of chassis	Aluminum alloy (7N01)
Tire (3 wheels))	Size: 14 in (Sumitomo Rubber Industries, Ltd., D850)
Solar cell (single crystal silicon)	Total Output: 478 W (Nomura Corp., 2.6 W × 184 cells)
In-wheel type direct drive motor	Rated output: 1.5 kW, 60 V (Mitsuba Co. Ltd., M1560D)
Buck-Boost Converter	Output: 250 W (Kashiwakai, KW-BBMPPT × 2 units)
Control valve type lead storage battery	12 V, 57 Ah (Panasonic Corp., N-S65D26R/HV × 5 series)
Integrating ammeter	Amount of integrated current: 0.00-999.9 Ah (Namikoshi Electronics Corp., AH-703)

* Excluding driving battery, driver, onboard baggage

There were times when the control circuit of the motor and electric power measuring circuit were manufactured by using microcomputers. Currently, commercially available products are commonly used in view of the decreased manufacturing time and lack of technical capabilities. Some teams measure the current consumption of vehicles remotely using wireless technology (Yamada et al., 2013). We hope students to positively challenge the technology of electronic circuits.

However, energy management has now become possible by measuring and analyzing the running position and speed remotely with the use of GPS built-in smart phones, as shown in Figure 10. Hereafter, turning out technicians skilled with circuits will become an issue.

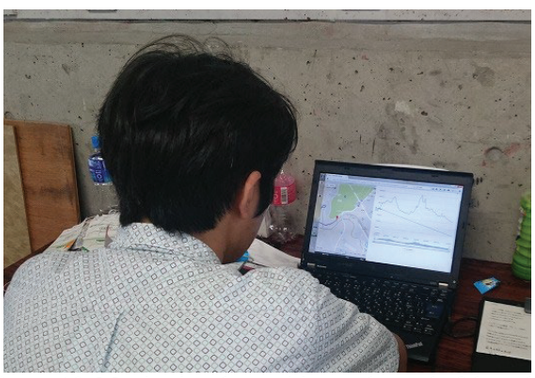


Figure 10. Monitoring the position and speed of the solar car

The students are getting technical information on higher-ranking winner teams from production workshops and the Internet, and will make solar cars based on these technical information. Of late, they are trying to improve their technical capability by exchange with the Hong Kong IVE (IVE Engineering Vocational Training Council) solar car team, which has been manufacturing high-performance solar cars since 2015, as shown in Figure 11. Some students join auto makers after graduation or team up in a volunteer group to enter the rally. Therefore, they are putting techniques learned during their club activities to useful purposes after graduation.

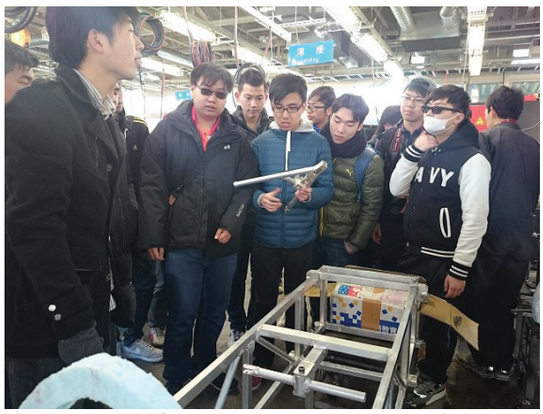


Figure 11. Visit from the Hong Kong IVE solar car team (March 23, 2015)

Figure 12 shows the solar cars exhibiting at local events. Students also exchange ideas with citizens. Students not only explain technical matters to citizens and children but also talk about their thoughts and dreams on the development of solar cars. Future engineers must confront energy issues. Through the production of solar cars, it is hoped that students will be interested in energy conservation and aim to become engineers who can solve environmental problems.



Figure 12. Display of the solar car Azusa (Nakano City Industry Exhibition, Nakano-shi, Nagano Prefecture, November 23, 2013)

Summary

This study addressed the status of solar car manufacturing as addressed by the students at National Institute of Technology, Nagano College since 1992. Although the budget was limited, the students sourced technical information from other solar car teams to further improve the performance of their vehicles. Dramatic progress may be difficult to achieve, but the students' activities will be supported by the college. We look forward to the success of our students.

Acknowledgements

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A CROSS CULTURAL LEARNING EXPERIENCE FROM URBAN FARMING

Sharmila Kanna [a], Jason Lim [a], Julia Lee [b]
[a] Republic Polytechnic, School of Infocomm, Senior Lecturer, Singapore [b] Republic Polytechnic, School of Infocomm, Lecturer, Singapore

sharmila_kanna@rp.edu.sg

Abstract

Singapore's Smart initiative journey on 'E3A': Everyone, Everything, Everywhere, All the time started few years back to enable greater connectivity, better situational awareness through data collection and efficient sharing of data collection using sensors. Urban farming is one of the Singapore's Smart Nation initiative to let urban farms to reach their full potential of health, technology, sustainability and profit.

In this paper, the authors share their experiences in bringing student leaders from two ASEAN countries to work together on an urban farming project using the Temasek Foundation International Specialist's Community Action and Leadership Exchange (TFI SCALE) platform. The TFI SCALE exchange program gives tertiary students an opportunity to collaborate and identify common social issues in the community and design solutions that extend across national and cultural boundaries. Authors also share the knowledge gained by students to demonstrate their ideas in urban farming that may lead to set up a business case studies for a sustainable and profitable food chain. In addition authors share the challenges faced by the students during the cross-cultural exchange programme.

Authors used Kolb's Experiential Learning model theory as a reference for this project to demonstrate and facilitate the learning cycle. Authors opined that the TFI SCALE program is a good platform that can bring many positive outcomes for creating future leaders through social, technical, and cross-cultural communication.

Key words: Smart Nation, TFI SCALE, cross-culture, urban farming, Kolb Experiential Learning, IoT.

Introduction

TFI SCALE is a student leadership program that is specially designed for student leaders from universities and polytechnics. Its goal is to build bridges between students across ASEAN countries.

In this paper, the authors share their experience on an urban farming project leveraging on the TFI SCALE IV programme, involving Singapore and Indonesian students. This program provided a framework that allowed student leaders of a Polytechnic in Singapore and two Indonesian Institutions, to collaborate effectively.

Cultural Diversity

Cultural diversity is a form of appreciating the differences in individuals. Diverse cultural perspectives can inspire creativity and innovation that leads to opportunities for both personal and professional growth. However, misunderstandings and misinterpretations could exist due to cultural differences in terms of working styles, differing professional etiquette, and including conversational habits.

Being a member of ASEAN, Singapore is in a region with multi-race and multi-culture as its main backdrop. While Singapore takes pride in having multiculturalism in its society at large, it is only a small part of a more diverse mix of societies in the ASEAN region. Therefore, outward exposure remains a key focus to achieve mutual understanding.

Open communications and interactions will help in dampening cultural friction. Along with this line of thought, the TFI SCALE programme provides a platform to bring two distinctive groups of students to work together, with the goal to encourage mutual understanding and to forge better appreciation among the participants.

Motivation

Rising challenge of food scarcity and security in Singapore

Due to Singapore's land paucity, only 1% of land is used for agriculture (The World Factbook 2018). Ultimately, agriculture appears distant from an urbanised Based on Figure 1, Singapore's food security becomes a major threat as the country is dependent on international markets for food supply. Moreover, the demand for food over the next decade is expected to increase by 1.1 percent annually (2), as the global food productivity gains continue to decline.

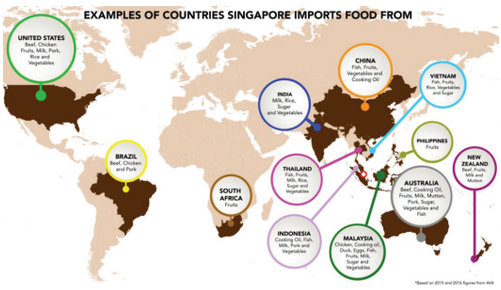

Figure 1: Major food importers for Singapore

Domestic ramifications, such as price increases in food imports and export bans by food suppliers, are major threats to food scarcity. Rapid increase in urban population and resource constraints on the global food system in the future are major threats that can ultimately lead to higher food prices in Singapore.

Food sustainability and food security are impending issues due to the threat of decreased food supply from agricultural countries due to changes in climate, lowering of water supply, pest manifestation etc. A 10 percent decrease in agricultural yield is forecasted due to climate change. Future resource constraints on the global food system present a critical need for alternative farming methods. A study led by the Agri-food and Veterinary Authority (AVA) of Singapore reiterated challenges in food source diversification, internationalization, and local production. "The AVA is working closely with International Enterprise (IE) Singapore to identify multiple sources for some of Singapore's main food items" (Paul Teng and Margarita Escaler 2010 Page 11).

Urban Farming – a budding initiative

There is a trend in urban farming taking place in major cities around the world (Urban Farming: the future of Agriculture n.d.). One of the contributing factors is the scarcity of land where space is a luxury. Singapore imports over 90% of the food consumed in the country (Paul Teng and Margarita Escaler 2010 Page 11).

Singapore, said to be one of the most digitally savvy countries (Global Information Technology Report 2016), is receptive towards technology adoption. With the advancement of technologies and the emergence of various IoT (Internet of Things) solutions, many innovative urban farming ideas have been conceptualized and tested. Applications built using IoT platform help farmers to address multiple agricultural needs, such as gathering data about plants, planting field conditions for better resource management, using GPS signals for monitoring weather information and using sensors and drones to monitor the growth of the plants (Urban Farming 2018). On the other hand, Indonesia has rich experience in the agricultural sector. This pairing presented good opportunities for knowledge exchange and mutual learning.

Methodology

Active learning has been suggested to achieve more concrete learning outcome (Keeton, M. and Tate, P. 1978) as it involves direct involvement, outside of the classroom. With that, the authors have adopted experiential learning, which is described in Figure 2, based on Kolb's learning model (Kolb, David 1984).

In accordance to Kolb's model, 4 phases, Concrete Experience, Reflective Observation, Abstract Conceptualization and Active Experimentation have been planned and implemented

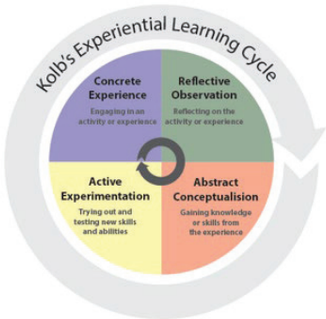

Figure 2: Kolb's Experiential Learning Cycle

Phase I – Concrete Experience

A group of 20 students from a polytechnic in Singapore and 20 students from two Indonesian Institutions, were engaged in a three-week immersion program. During this program, they participated in different activities based in Singapore, including visiting historical sites, understanding the culture, and experiencing the country's social life. Students participated in various team activities such as the Adventure Learning Programme (ALP) and the Problem Based Learning (PBL) pedagogy. This fostered good working relationships between the students from both countries, enabling students to identify and overcome the cultural barriers. For most of the Indonesian students, this program was remarkable since it was their first visit abroad.

In phase I, both Singapore and Indonesian students exchanged their cross-cultural experiences between the two countries. The Indonesian students shared their social life and their culture. The main source of income for most of the families is traditional farming. They shared the two main types of traditional farming. The first is traditional

subsistence farming, where families work together to plant and harvest crops to support their family with little left over to sell. The second method is traditional intensive farming, in which farmers increase their yield by increasing human and draft-animal labour, and using animal manure as fertilizers to obtain higher crop yield. They also shared on the consequences of setting forest and plantations on fire.

On the other hand, Singapore being an urban country, "farming" seems to be a foreign concept for most of the Singapore students, because 90% of the food is imported from other countries Paul Teng and Margarita Escaler (2010). As a part of Singapore's Smart Nation initiative, more urban farms, rooftop gardens are taking root in Singapore. "Such features have been gaining popularity in our urban landscape, as many Singaporeans have a keen interest in farming and gardening" (Wendy Wong 2017). During their discussions, one of the topics that captivated everyone's interest was the rising challenge of food scarcity and food security in Singapore. Root cause analysis was used to recognise the root causes of Singapore's food scarcity and security and to develop efficient interventions to address the same.

Phase II – Reflective Observation

Both Singaporean and Indonesian students reflected on the root causes and the new initiatives taken by Singapore to prevent food scarcity in the future. They decided to explore on the new techniques of using urban farming to increase local production in Singapore. Being a small country, land scarcity is one of the major constraints for conventional farming at Singapore Paul Teng and Margarita Escaler (2010). Urban farming being one of the Singapore's Smart Nation initiative to let urban farms to reach their full potential of health, technology, sustainability and profit. Urban farming in Singapore has moved into a new, high-tech phase to grow pesticide free garden-fresh edibles through innovative methods (Fresh Ideas for City Farms 2017). For the Indonesian students, it is new and Singapore students shared on the initiatives taken by Singapore, as a nationwide gardening initiative that enabled more than 1,000 community gardening groups to come together and grow edibles in community gardens.

Urban farming has become more popular for the children and the elderly to spend their time in a more meaningful way. It also builds on the "Go Green" technology. This is an eye-opening session for Indonesian students and it motivated them to explore further on different ways on applying at their home ground.

For Phase II, the aim was to explore more on urban farming. Field trips were organised to the different places (Agricultural farms, Fish farms, Hydro and Aquaponics farms, Community centre with Hydroponics system) to create awareness and understanding on the use of urban farming from different perspectives.



Figure 3: Field trip at Agricultural Farm

During site visits, students were engaged in fun activites whilst being introduced to the basic skills in using simple farming equipment. It was really an eye-opening for Singapore students because this was their first hand-on experience to farming. The field trip (Figures 3 and 5) and sharing session at farms was focussed in setting up urban farming in Singapore by making use of the resources across countries. The motivational talk created an awareness to overcome the cross-cultural differences and the importance of setting up urban farming to overcome food scarcity in Singapore.



Figure 4: Site visit to Community Garden

Reflections from site visits helped students to see the importance of urban farming. The visit to community Garden (Figure 4) helped them to better understand urban farming at community levels. It was an eye-opening session for Indonesian students and it motivated them to explore further on different ways of applying urban farming at their home ground.

Phase III – Abstract Conceptualization

Reflections and sharing sessions from the site visits helped the students gain more knowledge towards urban farming based on different scales. Based on the sharing session, the team managed to identify the different methods of urban farming that include indoor gardening, container gardening, community gardening and rooftop gardens (Urban Farming: the future of Agriculture (n.d.)).

To conclude, students had a fruitful discussion that lead to an innovative method to build a prototype for Indoor Gardening using Hydroponics and Aquaponics systems that uses smart devices monitor and control the growth of plants using sensors. It is basically growing healthy plants without the use of a traditional soil-medium by using a nutrient like mineral rich water solution instead. It needs nutrients, water, and sunlight to grow.

Smart Nation Initiative on Championing Urban Farming

To overcome the land scarcity, Singapore's residential and commercial rooftops could be transformed into "sky farms" to increase the productivity of fresh vegetable, flowers and fruits using cutting-edge farming technology. Singapore being one of the global leader for hydroponic technologies, and together smart nation initiatives, urban farming has moved into a new high-tech phase. Hydroponics and Aquaponics systems allow plants to grow up to 50% faster than in soil and are healthier.



Figure 5: Hydroponic System

The next challenge they faced is choosing a feasible home-based hydroponics system. Based on the research there are six types of hydroponics system. All the six types of hydroponics systems (Drip System, Ebb-Flow, NFT, Water culture, Aeroponics and Wick System) mainly need 3 things, water/moisture, nutrients, and oxygen (Hydroponics Systems, n.d.). Hence the team decided to use Aeroponics method to grow plants.

Benefits of using Aquaponics over Hydroponics

The only difference between these two is, hydroponics revolves around a sterile environment whereas aquaponics embraces an all micro-organism approach to play an important part in the growing process. One advantage of aquaponics is it tends to have less diseases and pest problems because it eliminates the use of pesticides. On the other hand, hydroponics might use toxic chemicals to grow plants and to raise harvest.

For both hydroponics and aquaponics system, water conservation is 90% less when compared to traditional farming (Hydroponics Systems, n.d.). It does not require farmland with fertile soil, and it can be done on sand, gravel rocky surfaces. Energy conservation is less when compared to conventional farming. Food scarcity can be reduced to a certain extent by increasing the local yields. (Figure 6)



Figure 6: Aquapoincs System

Phase IV – Active Experimentation

Fusion between urban farming and Technology

Urban farming being the future of agriculture, more urban farms and rooftop food gardens are being developed to enhance the urban landscape, to reduce food scarcity and to make cities more eco-friendly more to be developed to as an enhancement of an urban greenery scheme (Urban Farming: the future of Agriculture (n.d.). As a part of Smart Nation initiative, automation of urban farming with innovative ideas using smart devices leads to greater efficiency, reduced manpower with lower cost of production. The Singapore students shared on the involvement of AVA to help farmers to raise production level through fusion between urban farming and technology to improve productivity and to promote local produce to consumers. AVA supports farmers to tap on its funding to modernise and to develop innovative technologies to automate farming systems. As a result, not only producers but every Singaporean will enjoy the benefits of having their own small farm regardless of whether they live

in a HDB or Condominium. This adds value to "Clean & Green Singapore" (CGS) campaign initiated by Singapore Government that provides a platform to connect people from different communities, to develop life-long learning skills and for active aging.

Implementation

During the implementation phase, students not only learned technical skills, but were also introduced to other skill sets such as strategic planning, purchasing, and marketing of their prototypes.

One of the project was to build an automated monitoring system that minimises the need of physical intervention. The team used Raspberry Pi to integrate sensors to monitor different parameters such as temperature, pH value, and water level. UV light and water pump were automatically controlled whenever it exceeded the threshold value, which is pre-set within the system. The web/mobile based system, Figure 7 gave the flexibility for the user to change the pre-set threshold values remotely as needed.

The teams decided to build their own system from scratch. Indonesian students have the skill sets of drilling and soldering while Singapore students are strong in their problem-solving skills. Their sharing and effective use of cross cultural skill sets, Figure 7 provided a source of experience for innovative thinking and collaboration between students from both countries.



Figure 7: Building an Aquaponics system

Some advantages of the system is electricity saving, real-time monitoring, less physical intervention, reusing and recycling of the waste from fish to plant and vice versa. To summarize, students' take-away from this project is a better understanding of the Reduce-Reuse-Recycle (3R) system. Referring to Kolb's theory, students learnt new skills in both technical and non-technical areas which led them to create and experiment within the system. Based on the observations, the students lacked in certain skills in reusing the waste from plant to feed the fish and vice versa.

Another project was to build an indoor Aeroponics system in which air or mist environment was used as a medium instead of soil or an aggregate medium. This method uses less water and energy to grow plants together with less maintenance. The system in Figure 8 will create mist using water and spreads the mist automatically to the roots of the plants for 15-20 minutes. The system uses the smart IoT device, Raspberry Pi to a relay that integrates and controls various parameters such as temperature, humidity, water levels. The Raspberry Pi camera module captures the images at various intervals and a program is used to continuously monitor the growth of plants.

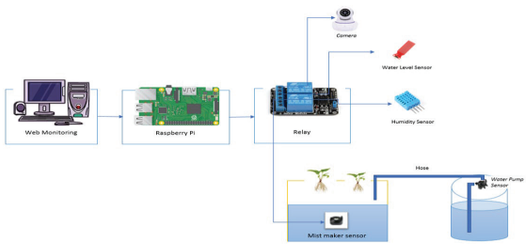

Figure 8: Aeroponic System

Both projects were focussed on the ultimatum to overcome the food scarcity and food security. It helps to lead a healthier life style by growing pesticide free garden-fresh greens at low cost. In addition, it nurtures the habit of developing passion towards gardening among young citizens and serves as a platform to integrate family members, communities through bonding sessions not only locally but also across countries.

Reflection

Even though Singapore and Indonesia are neighbouring countries, some form of individualism exists for two countries. Students are from diverse ethnic, social, and cultural background. Hence the most important things are to make them feel comfortable, particularly for Indonesian students when they are in a foreign country. Ice-breaking sessions played a vital role in them to open-up and share their personal capabilities and to break down the barriers between them. The team bonding sessions served as a platform to socialize and to understand the cultural similarities and differences between two countries. Field trips established a variety of cultural exchange sharing experiences that helped students to recognize and appreciate the similarities and differences between two countries. For most of the Indonesian students it was a memorable event as this was their first overseas visit in their life. The learning journeys provided a platform for good networking session.

For the implementation of project, the students managed to come up with a prototype, fusing together urban farming and technology. Solutions proposed are relatively cost-effective, low energy consumption, scalable and pesticide free. Yet they had challenges in reusing and recycling the fish waste to plants and vice versa. The challenges faced by the students were cultural differences to communicate between each other, lack of IoT skills and problem-solving skills. Nevertheless, with the help of ethical guidance, they managed to overcome those challenges and had smooth transition to complete the projects.

Feedback gathered

Feedback gathered from the students shows their involvement to understand diverse cultural perspectives that leads to both personal and professional growth. Below are the quotes extracted from students' feedback.

"Aeroponics and Hydroponics are an eye-opener to how a simple design requires tremendous amount of work if done on a large scale…Apart from learning from the excursions, it also made me felt a sense of pride and relief that I will be a part of the IT industry in the future." – Student A

"The most memorable thing in Singapore was to go to our Faci, house for Deepavali celebration." – Student B

"4 oct 17 — then at the 3rd day we start to explore the project problems definition with exploring some farming house in Singapore. At the first farming house I was so excited with the presenter."– Student C

Conclusion

To conclude, authors found that cross-cultural differences exist among students and it has an impact on communication among students between two different cultures. They believe that the TFI SCALE platform provided a framework to build bridges between student leaders from a polytechnic in Singapore and Indonesian Institutions. The three-week bonding programme helped to overcome the barriers and helped in the understanding of the strengths and weaknesses of individualism, to build a smooth relationship across two countries and to develop their leadership skills through cross-cultural networks. It provided a platform to share the similarities and differences between the students from the two countries. Further, it helped them to address the common issues between two countries and co-create feasible solutions. Along their journey, students learned to apply their critical thinking skills to innovate new ideas to discover the customer needs that can be translated into opportunities. They also gained experience to test those innovative ideas, to overcome the challenges in implementing them and reflecting back to generate a more feasible solution. In this paper, authors used Kolb's Experiential Learning styles to co-develop solutions to address social and community issues to implement new technologies and techniques in urban farming.

Authors conclude that due to cultural socialization, when students from different culture communicate to work together, they explore different leaning styles to improve their cognitive and behavioural skills.

Acknowledgements

We would like to express our gratitude to TFI, which provided an opportunity for students to build their leadership skills and to experience the social, cultural, and technical skills between Singapore and Indonesia. We would also like to thank the two Indonesian institutions (Politeknik Negeri Malang and Politeknik Kota Malang) for their support to make this program a successful one.

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AN INTERNATIONAL IDEATHON WITH THE THEME OF ITS COLLABORATING WITH INDUSTRY

Naruki Shirahama* and Tatsuki Fukuda

National Institute of Technology, Kitakyushu College / Department of Creative Engineering, Japan

*E-Mail naruki@kct.ac.jp

Abstract

We report on the implementation of human resource development program "Ideathon" by Kyushu-Okinawa area KOSEN, triggered by the ITS (Intelligent Transport Systems) Asia-Pacific Forum being held in Fukuoka in May 2018. Human resource development by ideathon is highly appreciated by industry field. Industry particularly needs those who can collaborate and solve problems and propose new services and values. In response to such a request, we hold the ideathon at the ITS-AP Forum. We have launched an industry-academia collaboration team and brushed up the contents of ideathon. "Ideathon" is a coined word combining "idea" and "marathon". It is an event by group work which is done for creating new ideas. We decided this ideathon period to be 4 days. That is one day to ice break and pre-learning. On the second day, participants are required to give lots of ideas. On the third day, participants pick out candidates from among many ideas issued and refine them with a multilateral perspective. And the participants made a presentation on the final day.

The main purpose of this event is to train next-generation of human resources with the theme of ITS. Overseas students gather from various fields and create ideas for themes. Participants learn about economic, social and cultural differences as well as technology, and propose suitable solutions through communication, and cultivate global minds and acquire analytic reasoning, complex problem solving, collaboration skills, and teamwork. International mixed teams including invited overseas students present solutions to the problem. Nearly 40 overseas students come from 11 colleges in 5 countries participated the ideathon. Almost the same number of students participated from Kyushu Okinawa district KOSENs. From the viewpoint of youth generation, students provide and share new ideas about ITS specialized services and products that combine elemental technologies and advanced technologies such as IoT fields. Finally, we report on the competency evaluation by students themselves.

Keywords: *Intelligent Transport Systems, Ideathon, Active Learning, Collaboration, and Competency*

Introduction

The momentum for developing next-generation engineers is increasing more and more. Now it is not uncommon for new technologies or new services to spread all over the world instantaneously. It can be said that it is an era when it is impossible to secure even large corporations that have secured a big position so far. In the era when the advancement and diffusion of technology accelerates, the ability required of engineers can be said to be the ability to create products and services by combining existing elemental technologies and new technologies.

Another ability required of next-generation engineers is the ability to be the active in international stage as well. It is pointed out that high-function, high-quality products developed only for the domestic market cannot overcome products in the global market. After all, since the global market is larger than the domestic market, profits corresponding to development costs can be obtained. Therefore, products, technologies, and services developed by companies should aim at global standards. As a result, companies have come to cross global areas rather than the national framework.

Also, Japan has another serious problem, the problem of population decreases due to the declining birth rate. Population decline is believed to cause two problems. One is the shrinking domestic market, and the other is the labor shortage. Therefore, it is necessary for us to work with international education whether in the domestic or overseas. These are a serious problem for local small and medium-sized Japanese companies. In recent years, more and more expectations are given to the 'KOSEN', National Institute of Technology, Japan as an educational institution to solve these problems. In other words, it is a global engineer human resource education. In response to such industry demand, KOSENs in Kyushu-Okinawa district has promoted global human resources development such as overseas internship or international exchange program. ITS-AP Forum 2018 Fukuoka Executive Committee requested us to implement ideathon during the Forum period. In the discussion, we realized that the local companies highly valued KOSEN education. We also consider international exchange as important, so we accepted the request.

Materials and Methods or pedagogy

We explain the overview of ideathon implementation method here. Several requests were received from the Executive Committee in the implementation of the ideathon. The main conditions are listed below.

1) Main focus on human resource development.
2) Inviting a number of overseas guests and making it an international event.
3) The theme of ideathon shall be selected from the field of ITS.

Regarding condition 1, it is consistent with our purpose and there is no big problem. We requested cooperation from Kyushu-Okinawa district KOSENs to achieve condition 2. Not only overseas educational institutions that each KOSEN has exchanges, they invited their international students to participate. In order to achieve condition 3, we held a pre-learning workshop.

In this way, since the outline and concept of the event was decided, we addressed this event as "ITS Ideathon in Kyushu". We describe the implementation period and timetable.

The ITS-AP Forum was held for three days. However, we planned to implement the ideathon over a more extended period of time. We held preliminary study sessions on the day before the forum in order for participating students to get a more effective idea. The variety of students' background also is one of the reasons for planning advance learning. We also expected the effect of ice-breaking.

We show the implementation contents of ITS ideathon held in the four days from May 7th to 10th roughly.

- Day 1, Preliminary study, Welcome party
- Day 2, Ideathon 1
- Day 3, Ideathon 2
- Day 4, Presentation Contest, Award Ceremony

On the first day, we requested cooperation from organizations related to ITS Japan and dispatched lecturers for preliminary learning. This enabled participating students to learn much about practical ITS knowledge. We also held a welcome party at dinner after preliminary study. For most of the participants, this day is the first meeting and it is also important to deepen the mutual friendship. At the time of a welcome party, the principal of Kitakyushu College and the chairman of the sponsor company explained the greetings and purpose and appealed to the participants that this attempt to develop human resources is an industry-academic collaboration. Appreciation of the planetarium at the dome theatre was offered by the generosity of Fukuoka City Science Museum.

The second day and the third day allotted to ideathon throughout the day, but both have their respective objectives. The contents of the second day are mainly focused on widely expanding a lot of ideas. Another object is to organize the team and elect a leader. Of course, this is supposed to change flexibly later. Just a casual argument does not create a good idea. Various methods for effective thinking are proposed as design thinking. It is important for participating students to experience and practice the process of intellectual creation. This time, we asked a professional facilitator to proceed ideathon to learn the latest idea method. The staff for progressing the ideathon consists of one facilitator, one assistant, a few advisors to answer technical questions, and nearly ten mentors to encourage discussion actively. First of all, on the morning of this day, the students created two worksheets called an idea sheet and a plan sheet. Both worksheets had templates and devised so that students can easily express ideas and plans. Students vote on these two worksheets. The top ten of the ideas and plans that won many votes will be adopted as a team task for ideathon. The creator of these selected idea sheets and plan sheets would be the leader. These selection works were done using lunch break time, since adjustment work such as putting together similar ideas is necessary. In the afternoon we organized a team according to the chosen idea. We made some adjustments in organizing the team. Even though it was a similar idea, we used different teams for different approaches. Moreover, because it is the purpose of fostering international sense, we made it possible to consist of students from various countries as much as possible.

From the afternoon, we organized 13 teams according to the selected ideas and plans. We made some adjustments in organizing the team. Even though they have similar ideas, they have different teams when an approach is different. Moreover, because it is the purpose of fostering international sense, we made it possible to consist of students from various countries as much as possible. After the team formation, the students had a discussion until 17:30 PM.

The goal of the morning on the third day is an intermediate presentation. Because there are close to 80 participants, the number of teams will exceed 10 inevitably. At this point, we supposed to narrow down to excellent ideas and interesting ideas. We also held an interim presentation concurrently with the examination. The style of the intermediate presentation is to report about 5 minutes of news. We aimed at the effect that students think about the impact of technology on society by reporting our ideas and plans as news. As a result, any team's presentation was meaningful, so we did not reduce the number of teams.

Students visited the ITS-AP Forum on the morning of the third day. We conducted a preliminary study session. However, we hoped that ideas would be better by utilizing the latest ITS technology exhibited at the venue. Because the idea and the goal of the team became clear, the students actively watched the exhibition to contribute to the team. From the afternoon, each team introduced their own ideas. This introduction was done in the form of what kind of news it can be reported when their idea was realized. It can be expected that the students think about the influence of their idea on society with this work.

The presentation contest was held on the last day. In the presentation, instead of PowerPoint, posters that they created by handwriting were used. Two sheets of 788 × 1091 mm in size were used. Presentation of all 13 teams was held in the morning. A judging committee was held by a panel of judges, including sponsor companies, and

one best prize and four sponsorship awards were decided. An awards ceremony was held in the afternoon and five teams won each.

Results and Discussion

In this section, we consider the results of activities of students in ideathon. First of all, we refer to the participants' background. It was one of the goals of this ideathon to organize international teams with students from various countries and to have them experience collaboration. In order to achieve this objective, we requested participation in educational institutions from various countries. Figure 1 shows the total number of participants by country. Since it is a local host and all the KOSENs in the Kyushu and Okinawa districts participate, the country with the largest number of participants was Japan. There are also many participants in Hong Kong, Singapore, Mongolia, Thailand. Two students from Mongolia, one student from India, Senegal, and Cambodia are studying in KOSENs.

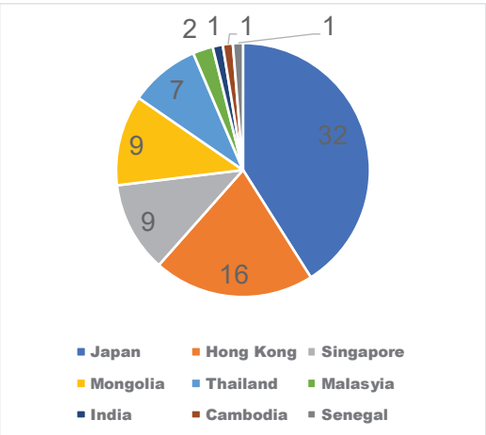

Figure 1. Number of participants by countries

Table 1 shows the number of participants by the educational institution. In addition to the exchange school of Kyushu Okinawa area KOSENs, educational institutions invited by ITS-JAPAN are included. Educational institutions invited by ITS-JAPAN are also included in this table.

Table 1. Number of participants by educational institution

Institution	
Kosen (Kyushu and Okinawa)	38
Hong Kong VTC	15
Chulalongkorn University	4
Republic Polytechnic	4
Kasetsart University	3
Temasek Polytechnic	3
Mongolian Kosen	6
University Putra	2
Nanyang Technological University	1
Singapore Institute of Technology	1
Hong Kong Polytechnic University	1
Total	78

As you can see, there are many participants from East Asia and Southeast Asia.

Next, we consider the ideas they conceived. The main theme was "to realize a world without traffic accidents". The main element technologies that they focused on were GPS, speed sensor, image recognition, face recognition, deep learning and so on. As factors preventing accidents, they focused on inter-vehicle control, blind spot detection, pedestrian detection, the situation of intersections, age, driver's consciousness, and so on. As an idea with very high identity, there are those that focus on the functions of tires and ideas that applied train technologies to automobiles.

The Best Ideathon Award
- National Institute of Technology, Japan -

Team: ultron
"*Utilization of drive recorder data by deep learning*"

For the purpose of reducing traffic accidents, they proposed to utilize the data of the drive recorder. Data analysis using deep learning can detect dangerous situations in advance.

The Sponsor Award
- TOYOTA MOTOR KYUSHU, INC. -

Team: sakura
"*Real time pedestrian detection*"

To prevent traffic accidents, they proposed a system that detects pedestrians in real time using sensors and other technologies.

The Sponsor Award
- ZENRIN CO., LTD. -

Team: KLM
"*Facial Conscious Evaluation (FaCE)*"

This team concluded that it is important to recognize the consciousness of the driver in order to prevent traffic accidents. Recognizing the loss of consciousness due to a sudden change of physical condition, the degree of drowsiness and fatigue, we proposed a system that supports the driver.

The Sponsor Award
- Pasona Tech, Inc. -

Team: S.C. Tire
"*Tire support system according to every situation*"

Their idea is to physically deform the tire according to the situation to improve the performance. Its originality was highly appreciated.

We show what was honored from among these candidate ideas. The team name, the idea name, and the outline thereof are shown in figure 2 in order of 1st best prize and 4 sponsors awards.
The idea chosen as the best award was to detect dangerous conditions using deep learning. It seems that it was selected as the best award from the usefulness of the idea, the feasibility, the high level of the presentation etc.

The students learned various design thinking techniques in the course of two days, and the ideas of any team had a certain persuasive power.

Next, we consider the educational effect of the ideathon. We conducted a competency evaluation using the rubric form in order to measure the educational effect of the ideathon. The competency to measure was made into teamwork, leadership, problem-solving ability and communication. We set four stages of the rubric for each of the four competencies. Figure 2 shows the check sheet for four skills to be evaluated. Figure 3 shows the rubric form. This skill measurement was carried out for all 78 participants in the self-evaluation style. Figure 4 shows the histogram for every four skills.

Teamwork	**☐D**	**☐C**	**☐B**	**☐A**
Leadership	**☐D**	**☐C**	**☐B**	**☐A**
Solving Problems	**☐D**	**☐C**	**☐B**	**☐A**
Communication	**☐D**	**☐C**	**☐B**	**☐A**

Figure 2. Four skills to be evaluated

Teamwork
A. I can evaluate the activities of the team members.
B. I can mention my opinion or put out ideas actively and can contribute to the team.
C. I can understand the importance of that work for the team.
D. I could not do anything.

Leadership
A. I can act with the leadership.
B. I can understand the way of better leadership.
C. I can understand the importance of leadership.
D. I could not do anything.

Solving Problems
A. I can understand several solutions and can narrow down.
B. I can describe with organizing and structuring the essence of the problem.
C. I can explain my proposal of solution.
D. I could not do anything.

Communication
A. I can understand the process of consensus and can improve if necessary.
B. I can present a keyword that triggers the idea.
C. I can present description and figure properly.
D. I could not do anything.

Figure 3. Four stages of skill Rubric

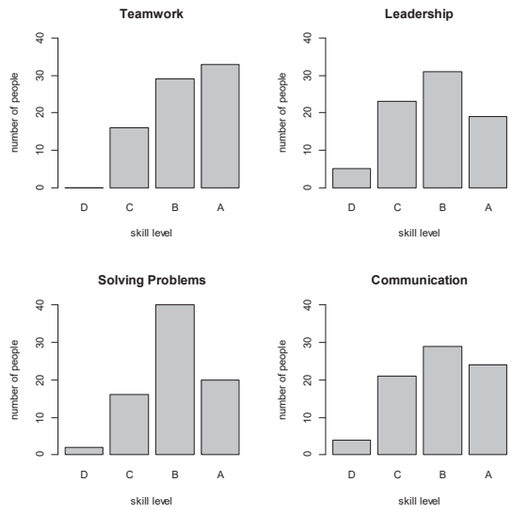

Figure 4. Histogram of 4 skills (Total)

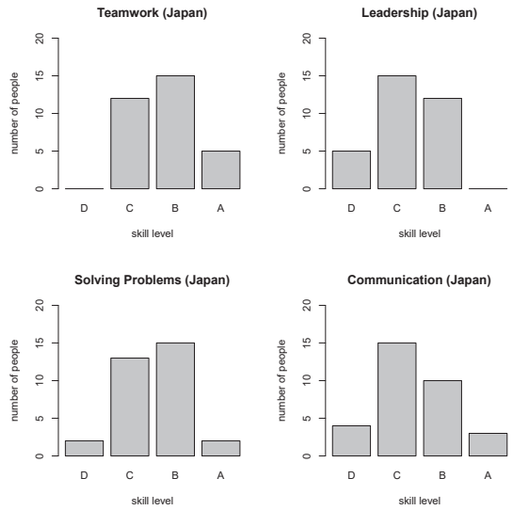

Figure 5. Histogram of 4 skills (Japan)

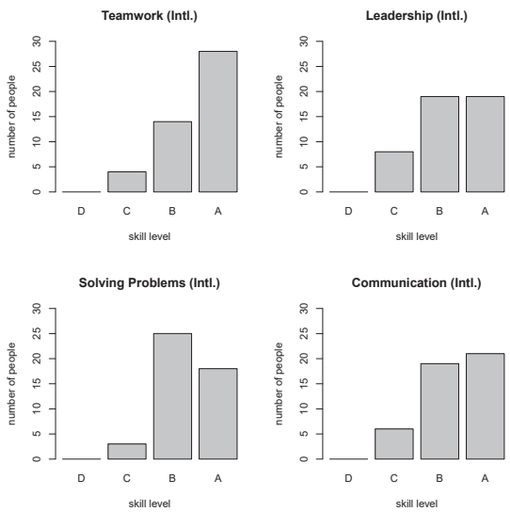

Figure 6. Histogram of 4 skills (International)

In analyzing this data, we decided to pay attention to what kind of conscious differences exist between domestic students and overseas students. Figure 5 shows the histogram for every four skills for Japanese students, and figure 6 shows the result for overseas students. We can know various features of these two histograms. One of the most prominent features is that none of the Japanese students could think that they act with the leadership. In contrast, none of the abroad students answered that they could not do anything about leadership. (Five Japanese students answered that they could not do anything about leadership.)

Figure 7 shows a comparison of histograms using normalized data for more detailed analysis. It can be confirmed that Japanese students have lower self-evaluation than overseas students in all four skills. We regarded these results as representing the current situation very well.

Therefore, we try to apply to a clustering method to this data experimentally. Assuming that Japanese students and overseas students are separated very well, we set the number of clusters was 2. Figure 8 shows the cluster dendrogram. In the first cluster, 20 out of 26 students were Japanese students. On the other hand, in the second cluster, 40 out of 52 people were overseas students. A cluster of students with low self-esteem was formed and it seems that many Japanese students were classified.

Conclusions

We held international ideathon with ITS as a technical challenge for students in East / Southeast Asia area. While there are many ideas to utilize the information communication technology, original ideas such as applying the shape of the tire and train technology were also seen. We organized an international student team with the aim of developing teamwork, leadership, problem solving and communication skills. Using a variety of design sinking techniques, experienced facilitators made students effectively think of many ideas and refined them. All 13 teams made presentations and five teams were awarded. Students, supervisors, sponsors, ITSAP-Forum secretariat, both were well received.

We set up the four skills necessary for the 21st-century type leader, created the rubrics respectively and conducted the competency evaluation. Self-assessment data from students showed that Japanese students' self-evaluation was significantly lower. It can be said that it is in conformity with the sense of Japanese teachers who lead the international exchange program. We strongly suggest that KOSEN teachers need to actively promote international exchange programs, in order to nurture the next-generation engineers who can take active globally. In order to improve this situation, we will continue to work on international ideathon / hackathon continuously.

Acknowledgments

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Prof. Shimada who has much experience of international exchange also provide us much useful advice. Assoc. Prof. Komura provided many valuable comments on the rubric design for the competency evaluation. They gave us many suggestions on internationalization and new teaching methods from the viewpoint of teaching staff in a NIT college. We also would like to thank the NIT colleges in Kyushu Okinawa district and overseas educational institutions who recommended many participating students.

We would like to express our gratitude to the four sponsors (TOYOTA MOTOR KYUSHU, INC., ZENRIN CO., LTD., ADVANTEST CORPORATION, and Pasona Tech, Inc.). Finally, we would like to take this opportunity to thank ITS-AP Forum 2018 Fukuoka Executive Committee.

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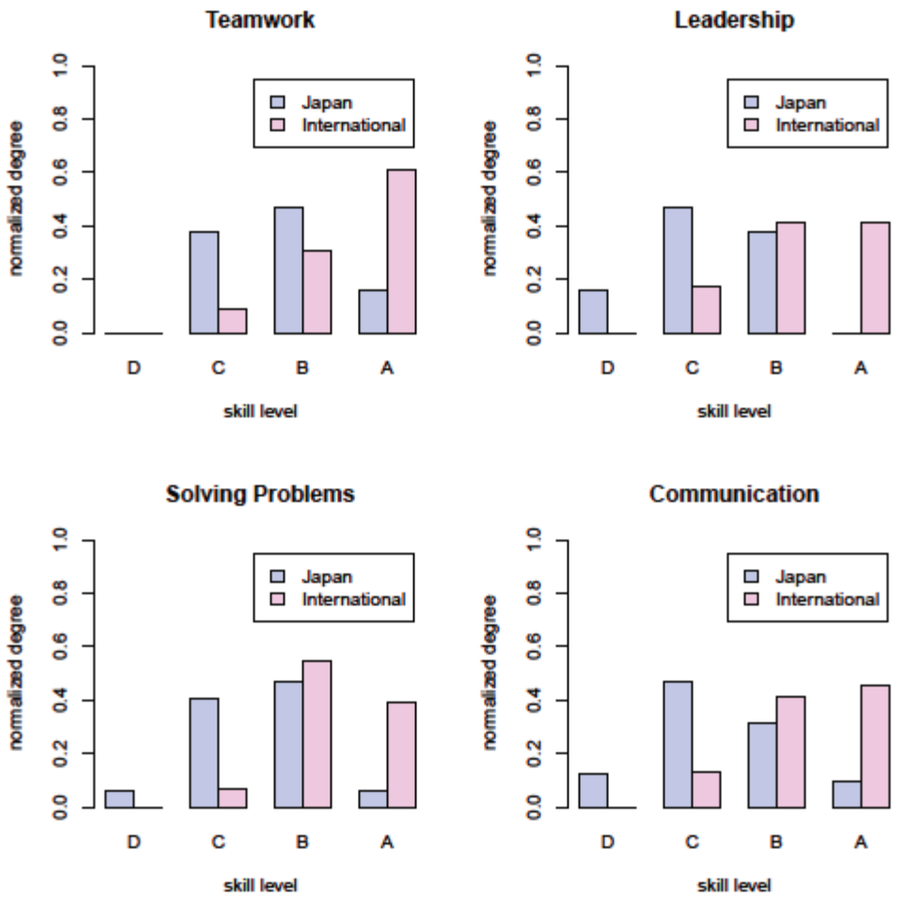

Figure 7. Comparison of students' competency evaluation between Japan and overseas

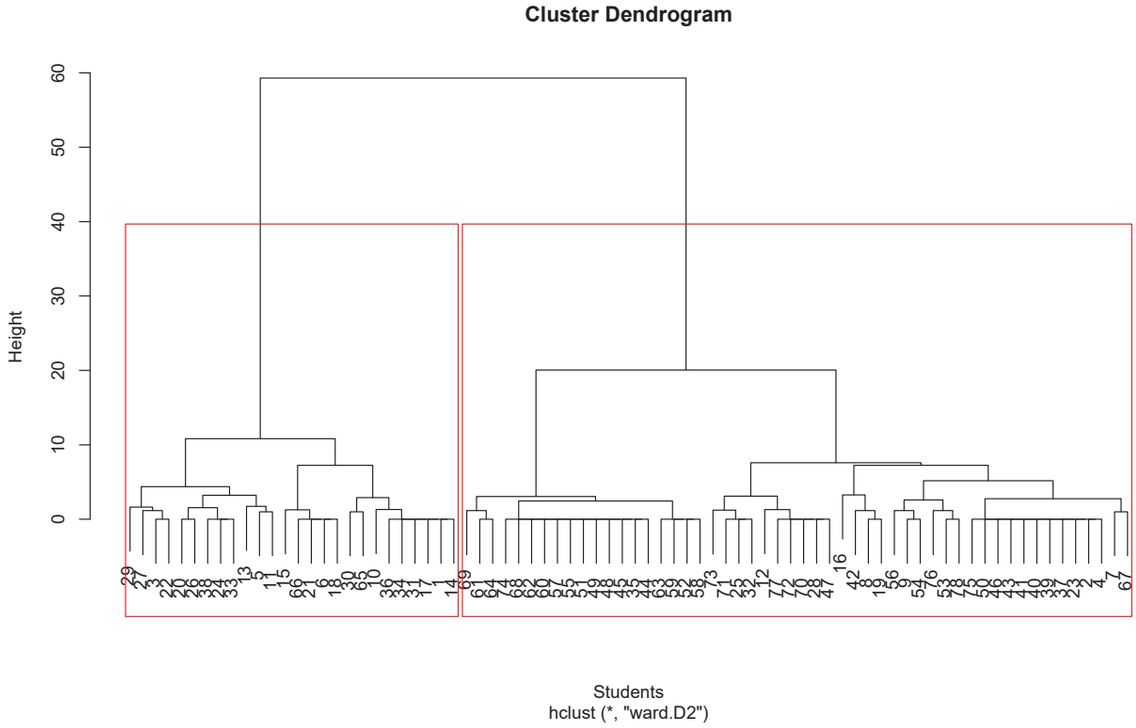

Figure 8. Clustering based on self-evaluation results of all participating students

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