TURKU AMK
TURKU UNIVERSITY OF
APPLIED SCIENCES

Juha Kontio, Meiju Keinänen,
Tarja Åberg & Elina Asukas (eds.)

ISATE – International Symposium on Advances in Technology Education Conference proceedings

August 17th–20th, Turku, Finland – part 2

Juha Kontio, Meiju Keinänen, Tarja Åberg & Elina Asukas (eds.)
ISATE – International Symposium on Advances in Technology Education
Conference proceedings
August 17th–20th, Turku, Finland – part 1
ISBN 978-952-216-794-1

Juha Kontio, Meiju Keinänen, Tarja Åberg & Elina Asukas (eds.)
ISATE – International Symposium on Advances in Technology Education
Conference proceedings
August 17th–20th, Turku, Finland – part 2
ISBN 978-952-216-795-8

Juha Kontio, Meiju Keinänen, Tarja Åberg & Elina Asukas (eds.)
ISATE – International Symposium on Advances in Technology Education
Conference proceedings
August 17th–20th, Turku, Finland – part 3
ISBN 978-952-216-796-5

Research Reports from Turku University of Applied Sciences 51
Turku University of Applied Sciences
Turku 2021

ISBN 978-952-216-795-8 (pdf)
ISSN 1796-9964 (electronic)
http://julkaisut.turkuamk.fi/isbn9789522167941.pdf

Turku UAS' publications: turkuamk.fi/julkaisut

Table of Contents

Collaboration between Educational Institutions and Industry

Continuous Improvement and Quality Enhancement

Development of Graduation Research in Food Texture Estimation
Shigeru Kato, Tomomichi Kagawa, Naoki Wada, Takanori Hino, Hajime Nobuhara

Follow-Up Report: A Classroom Study of TOEIC E-Learning at NIT, Hakodate College
Mariko Okuzaki

Visualization of Students' Generic Skills Growththrough Overseas Internships
Kuniaki YAJIMA, Koji KAWASAKI, Yoshikatsu KUBOTA, Takashi SHIRANE, Hiroshi FUKUMURA

Career Education Programs in National Institute of Technology, Toyota College
Toshhihiro Shimizu, Akihiro Kaneshige

A Continuous Survey of Students' Generic Skills From Pre-Admisson to Postgraduation
Koji Kawasaki, Yoshikatsu Kubota, Kuniaki Yajima

Using English Instructions for Specialized Subjects in a Second Language: Teacher Training and Trial Implementation
Yoko Nakajima, Hirotoshi Honma

Nanotech Platform Established for Average Technical Education Science Laboratories
Shiro Nagaoka, Masashi Yamamoto, Takuto Tsuji, Tomokazu Shikama, Tomo Shimizu, Robert Johnston, Kazunori Matsuda, Fusao Shimokawa, Hideo Horibe

Assignment Chatbot
Percy Wong

The Nature of Science and Its Impact on the Improvement of Scientific Education
Juan Antonio Sanchez Marquez

Enhancing Lecturer Teaching Competence in Cdio via Workplace Learning
Sin Moh CHEAH

Effectiveness and Improvement of Home Based learning
Choo Heang Lim

Effectiveness of Bite-Size Assessments on Students' Performance
Cheng Sheau Chin, Shella Tong

The Role of Quality Enhancement and Stakeholders' Engagement in Facilitating Student Mobility
Sin Tung Kwok, Cheuk Fai Yuen

Learning path for immigrant engineers
Anita Hartikainen, Matti Kivimäki, Pauliina Paukkala, Mari Tauriainen, Tiina Hirard, Heli Kamppari

Sustainable Development in Education

Initiatives in Maritime Education Class for the Purpose of Improving Motivation to Learn General Subjects
Keisuke Yamada

Open Classroom Approach Encouraging Interest in Engineering Inspired by the Japanese Traditional River Traffic "Takasebune"
Kazunori Hosotani, Junichi Morimoto

Educational Program to Develop Global Engineers based on Nagaoka CO-CORE Vision
Yasuko TSUCHIDA, Yoshihiro OMINATO, Shigehiro TOYAMA, Naritoshi AOYAGI, Susumu NAKAMURA, Hideaki ARAKI, Akihiro Suzuki

Practical Education of Biological Diversity and Sustainable Management of Environment Using Small Wetland on Campus
Shunichi Miyakoshi, Hiroshi Sakuraoka, Naoki Miyazato, Hisako Ooka, Takayuki Sato, Akihiro Horio, Kyoko Owada, Toru Aoi

An International Graduate-School-Level Collaborative Program in NIT Akashi on Cutting Edge Research and Project Developments
Hiroshi Nakanishi, Susan Aspera, Ryan Arevalo, Hideaki Kasai

Human Resource Development of the IoT Engineers Based on the Remote Island Engineering
Hidetsugu Fukuda, Tomonari Masuzaki, Takeshi Ito, Tomonori Tabusa, Mitsuo Tada, Koichi Kuzume

Efforts at Education and Student Guidance With a Focus on Comprehensibility and Diligently in KOSEN
Mitsuhiro Saito

Development of a Problem-Based-Learning Program in English to Foster Students' Thinking Ability and Cooperative Skills
Yoshihiro OMINATO, Yasuko TSUCHIDA, Michiaki OMORI, Noboru FUKUDA, Shozo URABE, Katsumi ICHIMURA, Namita MAHARJAN

Accelerating STEM Education through Virtual Exchange in the Digital Era
Eva L.Y. Mak, Jonathan K.F. Lee, Jimmy S.M. Tang, Johnny N.F. Kwong

New Challenges from Teachers' Perspectives in Vocational and Professional Education and Training (VPET) during Pandemic
Kit Man, Gloria CHUNG

The Impact of KOSEN Volunteers on Children's STEM Education
Kaori Tsukazaki, Takeshi Shintoku, Takaaki Fukuzoe

Development and operation of Chinese language teaching materials for science students
Manabu Hatamura

Development of wildlife survey system by industry, academia, government and residents
Yasuyuki Hirose

Collaboration between Educational Institutions and Industry

REGIONAL COLLABORATIVE EDUCATION FOSTERS FUTURE-MINDED ENGINEERS

Takuo FUJITA*, Motoki SATOH, Fuyuko EGUCHI, Shihoko ONAGA, Maiko MATSUURA, Harunori FUJITA, Kiyoshi ISE and Shigenori AKAMATSU

National Institute of Technology, Kochi College, Nankoku, Kochi, Japan

*tfujita@kochi-ct.ac.jp

Abstract

Career education is conducted to develop the ability and willingness to solve social issues. We explain active learning for career education of National Institute of Technology, Kochi College. We have made a special program which is named regional collaborative education.

The goal of the program is that students solve social issues together with people of the local area. This program proceeded as follows.

(1) Teachers gave the broad social issues to students of the first grade and the second grade.

(2) They made teams which consist of five or six students.

(3) They tried to find the local concrete problem by themselves.

(4) Each team discussed and proposed ideas to solve problems.

(5) Finally, each team showed ideas to teachers and local people.

The Teams which came up with good ideas were commended in our college presentation contest.

Students of the third grade have been making the above ideas realized. One example is as follows. Kochi Prefecture produces the largest amount of ginger in Japan, but or therefore it is often discarded. As the way of its reuse, students thought of making paper from discarded ginger. Kochi Prefecture is also one of centers of Japanese paper production and has many craftsmen of Japanese paper. Japanese paper is usually made from tree bark. Students came up with ideas of using discarded ginger instead of it. They learned from craftsman how to make Japanese paper made ginger paper only from discarded ginger. The papers have smelled ginger faintly. Craftsmen rejoiced it, and they say they feel like making ginger paper a specialty.

Furthermore, we have been designing advanced regional collaborative exercise program for the fourth grade students. In the exercises, teachers have provided the broad social issues to the students. They have to look for them by themselves. They have made teams which consist of five or six students with different specialties. They have discussed the issues and come up with ideas for solutions. Each team not only had showed ideas of solution, but also have been making the ideas realized by concrete system design, manufacturing and so on. Some of issues they have been addressing have included farming house issues, forestry issues, information security education for junior high school students, and cultural preservation. They have improved their skills as engineers by solving social issues, the ability to think while discussing as a team member, various communication skills through discussion with local people.

This regional collaborative education fosters future-minded engineers.

Keywords: *Regional collaboration, Social issues, Active learning, improving skills, curriculum design*

Introduction

Kochi National College of Technology has provided several active learning educations (e.g., Motoki Sato & Shihoko Onaga, 2018; Junko Nagahara, Shihoko Onaga & Motoki Sato 2018; David J. Grant 2017). Now we have developed a special program called regional cooperation education to combine and fuse a wide range of knowledge and technologies, and to develop hybrid human resources who can quickly respond to society's demands which technology and information are rapidly diversifying and changing. As a part of this, we have held an idea presentation contest, "Unazuku Presentation". In Japanese, Unazuku means nodding especially in order to show understanding, agreement or consensus. One of the academic achievement of students is to make presentation on the contest which aims to cultivate the foundation of engineers who can discover regional problems through cross-disciplinary learning and contribute to their solution. Furthermore, in the regional collaborative exercise for 4th grade students, we aim to acquire a multifaceted perspective that is not biased only to one's own specialty by working on solving regional problems with a team structure with diverse expertise.

Significance of activities and research

Fig. 1 Presentation practice in first grade class

In the activity of "Unazuku Presentation", all students (including majors) who are enrolled in our college are targeted, and the fresh ideas based on a student's free conception are combined with the specialty (engineering field) learning in technical colleges. This is an effort to present ideas that will lead to the solution of social problems such as aging and population decline, and problems in the primary industry, which is the main industry in Kochi prefecture. Students try to solve the problem with a team of 2 to 5 people, and 5 teams that have undergone the primary screening (A4 slides of 20 or less) hold the presentation in the final contest. In the final selection, persons involved in Kochi Prefecture and local companies and experts with a deep knowledge of the theme are invited from outside the college as judges.

In addition, all students in the 1st and 2nd grade are required to participate, and we will prepare for the contest in conjunction with the active learning type lessons of Japanese and social studies. By practical learning, the students learn methods for finding problems, raising problems, based on the survey and using presentation tools for creating materials, and tips on presentation skills. Third grade students and above can participate freely, grow significantly in not only the amount of knowledge, but also the presentation skills based on logical thinking and/or logical reasoning increased with advancing grade. Although this activity is one of event on campus, the results of the contest are provided to the local society. It

Fig. 2 Presentation of the 1st grade team

is the most salient characteristic of the contest, and it is also important that it is an opportunity for students to step out of the college / region by developing after the contest. In the " Unazuku Presentation " is expected that the following basic skills of working people will be acquired, (1) the ability to understand the sentences theoretically and convey the results of thinking to others in an easy-to-understand manner, (2) the ability to discuss based on the opinions of others through discussions within the team, and (3) the ability to consider various issues by using statistical data in consideration of regional characteristics and relationships with daily life, and the comprehensive presentation skills will be consequently improved. In addition, it becomes possible to clarify the required knowledge and skills of the specialized subjects to be studied at the college of technology, and to develop the habit of active learning in the 1st and 2nd graders, and to work with the community to solve problems. These ability and skills are able to solve social issues together with people of the local area on the regional collaborative seminar in 4th grade. In the five-year curriculum of a college of technology, which must develop not only the technical skills that have been required for modern engineers, but the ability and skills required of future engineers who are rooted in each region and work together to challenge problems Efforts play a large role.

(1) Holding of "Unazuku Presentation "

" The 4th Kochi National College of Technology Unazuku Presentation" was held at the Kochi National College of Technology Festival on Saturday, November 9, 2019.

In 2019, the theme was "Tourism x Engineering", and a method to solve the problems of Kochi Prefecture by " Tourism " was presented, and ideas to cover various problems such as human resource shortages by "Engineering" were proposed. We competed (80 teams entered).

The second-grade student team that announced "Automatic marketing creates Kochi!" was awarded the highest award. In addition, a multilingual system that uses AR technology to present sign explanations corresponding to inbound tourism, and tourism content

Fig. 3 Presentation of the Grand Prize Team

that enhances childcare and education as part of a migration promotion plan to stop population decline were announced as ideas. “Unazuku Presentation” would be the 4th time by 2019, and it would be seen by many on- and off-campus spectators increased in increasing time. The judges of the contest highly appreciate the efforts made by “Unazuku Presentation”.

In addition to improving students' problem-finding and/or -solving abilities and comprehensive presentation skills, there are many examples of advancing researches from the ideas, as in the “Ginger Paper” introduced below. The various results of the researches were awarded in off-campus contests and in conference presentations.

(2) Ginger Paper

By the activities of the students themselves, they obtained free materials from the major ginger wholesale companies in our prefecture and have been promoting product development based on the “Tosa Washi” (brand name of Japanese traditional handmade paper) manufacturing method. Regarding the manufacturing method of “Tosa Washi”, we held training camp and practical training at a craftsman of “Tosa Washi” (Harunori FUJITA et al 2019). We analyzed the strength of the obtained "Ginger Paper" using a thickness gauge and a small tensile tester (Fig. 4).

It became clear that Ginger Paper is classified as weak paper. However, it has been difficult to quantify the development of the color, scent, touch feeling and appearance of Ginger Paper before this, but this time, for the first time, we are able to make them realize that they were "Quantifying what they have developed and evaluating it".

The results have been announced on November 17, 2019 at the 2019 Chemical Society of Japan Chugoku-Shikoku Branch Scientific Education Research Conference (Momoi ARITA et al 2019). The students involved in the research even in 3rd grade had valuable experiences and experiencing the conference presentation.

In addition, on January 12, 2020, we have visited a handmade workshop in our prefecture to learn about the Tosa Washi manufacturing method and held a meeting to

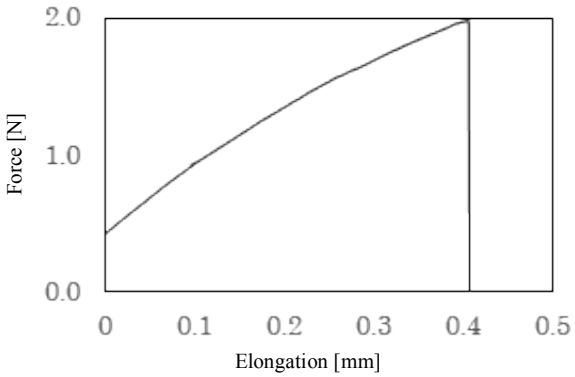


Fig. 4 Example of ginger paper tensile test

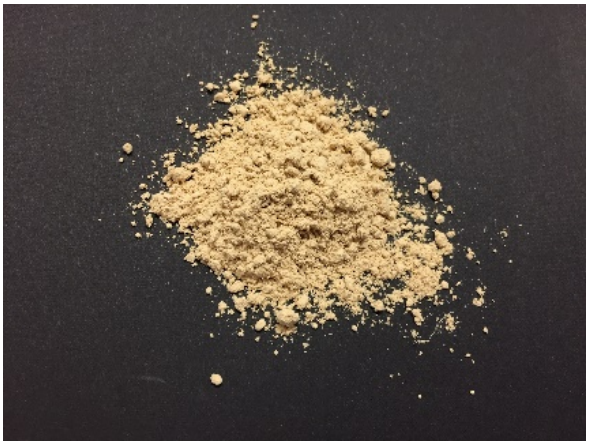


Fig. 5 Waste ginger powder

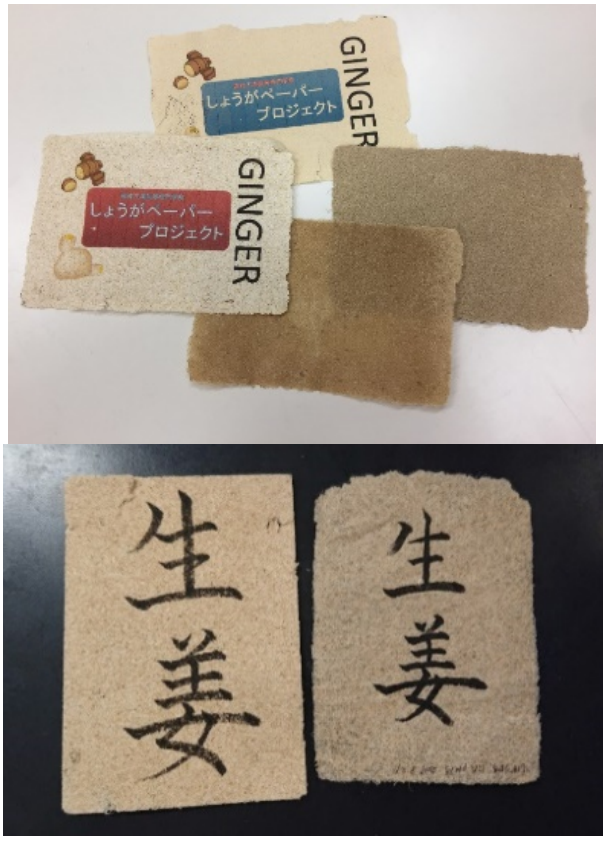


Fig. 6 Sample of ginger paper

further promote it in the future. As a result of the discussions, Ginger-based paper has been developed by our students incorporating Tosa Washi technology, while a method for absorption ingredients of ginger into the Washi paper on the basis of ordinary Washi paper making method has been developed by the workshop. The ginger component for absorption have been used by drying the ginger and making it into a powder form, the powder has been made by the students of our college. After the meeting, we proceeded with the production of powder of waste ginger using a dry food maker (Fig. 5).

Through this activity, we are able to make the students involved realize how to proceed, the importance of the conference minutes, and the importance of the deadline when working with companies. The first step is to create a business card. We have been able to create the business card in cooperate with the handmade workshop by the improved method of making paper (Fig. 6) .

(3) Regional collaboration exercise (4th grade)

The purpose of the regional collaboration exercises for 4th grade students is to understand the current situation in Kochi Prefecture and to cultivate practical problem-finding and -solving ability through actual sites and how to tackle the issues themselves. It is to cultivate the independence and acquire responsible behavior by carrying out group work while considering whether or not they can do it.

The goals of this exercises are set as follows.

(I) After gathering and arranging information on regional issues, they can discuss and discuss their own ideas and propose solutions.

(II) Being aware of the role of a team member regarding regional issues, be able to act responsibly and engage in collaborative work independently.

(III) To be able to work on the design of system / components suitable for the site and situation.

(IV) To be able to devise solutions to regional problems by combining expertise from multiple fields.

The method of class and the content and method of class are as follows.

Fig. 7 Field visit (livestock farmer)

(i) Conduct in groups that do not have barriers for each course.

(ii) Propose a solution suitable for the situation of the field to be surveyed.

(iii) Studies for base and preliminary knowledge of each field are conducted for each field.

(iv) Research theme setting and quest for problem solving are conducted for each course group

(v) Share progress and results through plans, weekly reports, interim reports, final reports, etc.

Through the above, we aim to educate students about the importance of combining knowledge and technology from multiple specialized fields to face one issue, and to acquire the ideal attitude as a hybrid human resource through practical exercises.

Specifically, based on the "implementation plan" presented by the faculty members, each team sets its own theme, and the teams share learning and inquiry. Report, contact, and consult about activities by submitting the “summary of results” and so on. At the end of the first semester, an interim report meeting of the results is held, and at the end of the second semester, the issue providers are invited for "poster presentations".

From May 24th to June 11th, 2019, the participating students had visited a field. In the problem-solving field, a team of 5 or 6 students with different specialized fields was divided into 18 teams to tackle 18 problems in 6 types of fields, and, we conducted on-site inspections of EKINGURA (AKAOKA Town), NANKOKU Style Co., Ltd. (NANKOKU City), MASHIMA Farm (NOICHI Town), Forestry Technology Center (Kami City), URADO Elementary School (Kochi City) and SAKAWA Town government (team SAWAKA, 2016). Through site visits, we deepened our understanding of on-site issues and repeatedly considered ideas for solving regional issues. At MASHIMA Farm, students and one teacher from a group received a general explanation from the representative regarding the operations of livestock farmers. Participating students actively asked questions about the calving situation of dairy cows and deepened their understanding of the specific issues facing livestock farmers. (Fig. 7)

Some of the issues they have addressed include farmer issues, forestry issues, information security education for junior high school students, and cultural protection in the region. They discussed the problems, and each came up with a solution idea. At the interim report meeting had held on Wednesday, August 7, 2019, comments were submitted by all participating students to the ideas of each team, which were summarized and fed back to each team.

On February 22, 2020, the seminar for regional collaboration exercises had been held by our 4th grade students at our college. The results of 18 teams and 78 students who found problems, presented solutions, and designed and manufactured solution systems were announced for each business site. At the presentation, people in charge from each business unit participated and lively questions and answers were held with the students. Each team not only showed the idea of the solution, but

Fig. 8 presentation seminar

also actively demonstrated the question and answer by devising an easy-to-understand explanation such as demonstrating the prototype manufactured. (Fig. 8)

According to a questionnaire from students, "I learned from the internship that the plans and process charts created in the class were actually used at company progress meetings." I realized that it could be done in a way. "It was suggested that this class was regarded as a graduation study and a dry run of work, and that he worked with motivation. By solving social problems, students improved their skills as engineers, the ability to think while discussing as team members, and various communication skills through discussions with local people.

Conclusions

- In the lower grades, the national language and social studies will work together to engage in liberal arts education and use active learning techniques to cultivate a local perspective using statistical data. And we aim to acquire the ability to discover and solve problems by themselves and to transmit them.
- By making students practice it through “Unazuku Presentation” and challenge the Regional Revitalization Idea Contest, they have broad perspective and experience level.
- The ideas developed in these activities will be concretely systemized in the regional collaborative exercises incorporated in the educational curriculum. Students from different fields of expertise make use of the group work techniques already learned to form teams and work together. The strength of our college is that students develop practical hybrid type human resources by focusing on local issues and technical issues and experiencing regional contributions.

This regional collaborative education fosters the future-mind engineers

References

David J. Grant (2017). Extensive Reading: A Foundation for Active Learning. *Bulletin of National Institute of Technology, Kochi College*, 63, 73-78

Harunori FUJITA, Hidenori YOSHIMATSU, Moe TANIWAKI, Shiori SHIMADU, Haduki YAMAMOTO, Yuma HORIIKE & Motoki SATO (2019). Development of a Paper used Disposal Ginger, “Shoga Paper”. *Bulletin of National Institute of Tecchnology, Kochi College*, 64, 37-44

Junko Nagahara, Shihoko Onaga & Motoki Sato (2018). Bibliobattle: A Reading Competition Game. *International Simulation and Gaming Association 49th Conference*.

Momoi Arita, Yui Sueuchi, Hina Shimomoto, Reina Nonami, Motoki Sato & Harunori Fujita (2019). Development of ginger paper "Shoga Paper" using traditional Tosa Washi papermaking technology. *CSJ West Japan Chemistry Forum 2019 in Tokushima*, 2P098

Motoki Sato & Shihoko Onaga (2018). Attempts on regional learning through Japanese language education for science and engineering students. *The 12th International Symposium on Japanese Language Education and Japanese Studies*.

team SAKAWA (2016). *Comprehensive plan to make together - Kochi Prefecture Sagawa style social design* -. Japan, ISBN978-4-7615-2621-4

EVALUATING THE EFFECTIVENESS OF STUDENT INTERNSHIPS IN EDUCATING FUTURE INNOVATORS

Brandon Siow

Aviation Management, School of Engineering, Temasek Polytechnic, Singapore
Brandon_SIOW@tp.edu.sg

Abstract

Internships are a collaboration between educational institutions and industry that is a commonly accepted form of experiential learning (Nicholas, 2016). The internship experience is widely deemed to be useful in nurturing interest and facilitating entry into the workforce, including the air transport sector in Singapore (SkillsFuture, 2020; CAAS, 2019). But while internships can train students for work, they do not necessarily train innovative workers. John Dewey cautioned that vocational training might create the mindset that work "to be chosen for adult life is made once and for all at some particular date (Dewey, 2010)." The irony is that successful internships risk creating specialists who are too ingrained to innovate. This is damaging, and pyrrhic, in today's knowledge economy where technology makes products- and professions- redundant at an increasing rate, and workers need to re-skill to remain employable. To avoid this, internships should also train innovation, which would better prepare them for the knowledge economy and "whichever path they choose (Sweitzer, 2009)." The objective of this paper is to determine the extent to which today's internships support innovation pedagogy by referring to the case of 50 polytechnic interns in various airline and airport operations roles over the course of 20 weeks. The method used is to refer to the interns' weekly learning journals for evidence of innovation. Learning journals are written by interns about their work experience and provide insight into the interns' reflective learning (Tang, 2002). This paper will identify instances of innovation learning in the journals using the framework made by the Turku University of Applied Sciences working group (Kettunen, 2013). Evidence from the journals will show that, while air transport internships provide workplace training, not all of them educate future innovators. This paper will determine the characteristics of those that do and discuss reasons for this. Finally, this paper will suggest how innovation pedagogy can be incorporated into all internships.

Keywords: *internship, learning journal, reflection, innovation, aviation.*

Introduction

Internships have their roots in the apprenticeship system of the guilds of medieval Europe, which trained apprentices in skills for lifetime employment in specific industries. Internships, like apprenticeships, provide workplace training but internships- which are part of formal education- also provide personal development. Schools and industry tend to focus on workplace training to increase the chances of the intern securing immediate employment within the same company or industry. To illustrate, the University of Oxford (2019) states that its internships help the transition "from education to work." Goldman Sachs (2020)'s internships immerse participants in the "day-to-day" work. There is also much research on the effectiveness of internships in leading to employment, such as the 2018 study by the International Labour Organisation (O'Higgins, 2018).

However, an emphasis on equipping interns with specific workplace training might harm their employability in the knowledge economy where jobs disappear due to automation and skills become redundant. The National Endowment for Science, Technology and Arts (NESTA) estimates that 6 million people in the UK hold jobs that are likely to change or disappear by 2030 and seeks to motivate people to learn new skills (Nesta, 2020)." There is a need for workers who are creative, adaptable and capable of risk-taking, problem-solving and lifelong-learning (PICA, 2020; WSG, 2020). This can only be achieved if internships support innovation pedagogy so as to educate future innovators. Otherwise, interns will have the mistaken impression that "growth ends or is wholly circumscribed by that chosen field (Dewey, 2010)," to the detriment of their future employability.

Educating Future Innovators

The need to educate future innovators is already apparent in the substantial research on new classroom pedagogy. The Brookings Institute offers 6 pedagogical approaches to move teaching towards "21st Century skills (Instance, 2019)." The OECD recently did a 339-page study that measures innovation in the classroom (Vincent-Lancrin, 2019). In contrast, there is less research into innovation pedagogy for internships. One

of the few is Sweitzer (2009) that emphasizes the importance of training personal development in internships to impart life skills that are necessary for innovation and "whichever path (interns) choose." Kettunen (2013) sees internships as a form of Networked Learning, where interns learn innovation skills from their environment and the interaction "itself might result in creating new innovations."

This paper added to the existing research by detailing the precise innovation skills that were learnt during internships. It went a step further to evaluate the extent to which internships incorporate innovation pedagogy and, hence, their effectiveness in educating future innovators. This was measured with an evidence-based approach of a case study of 50 Temasek Polytechnic interns in Singapore's aviation sector from the 2019 academic year.

Context of the Case Study

Each year, Temasek Polytechnic's Diploma in Aviation Management assigns students to internships in various airline, airport or aviation ancillary organisations. Internships in Singapore's aviation sector also focus on training for employment. For instance, the Civil Aviation Authority of Singapore (CAAS, 2019), which regulates the aviation sector in Singapore, advertised its internships as suited "for those who are looking for a fulfilling career in Singapore's aviation industry." This emphasis is supported by the internship programme itself, which has learning outcomes that are geared towards obtaining skills needed for full-time employment and mentoring sessions on career opportunities.

This internship is part of the students' curriculum and is worth 12 credit units. Passing the internship is a requirement for graduation. As part of the internship, aviation interns are required to maintain weekly learning journals to record their experiences and learnings. At the end of the internship, the interns consolidate their journal entries into a final learning reflection report. Interns are graded on the quality and depth of their reflection in the final report and, hence, take the report writing seriously.

Method of Evaluation

This paper's method of evaluation had two parts. First, the paper examined the final reflection reports of the 50 aviation interns to identify the innovation skills learnt. The interns were assigned to the following aviation organisations in Singapore, listed in Table 1.

Table 1: Interns' Aviation Organisations in 2019

Airlines	Airport	Ancillary
AFKLM, Qatar Airways, Cathay Pacific, Singapore Airlines, Scoot, Jetstar, SilkAir	Changi Airport Group, Changi Airports Internatinoal, SATS, dnata,	CAAS, Immigration & Checkpoints Authority

In examining the final reflection reports, this paper considered the evidence presented in the students' reflective writings in the sections of the report titled, *Generic Life Skills Acquired* and *Reflections on Technical Knowledge and Skills Acquired*. It is widely accepted that students' reflective writings are useful in revealing the learnings because they require students "to think back on the learning activities, to explicitly and purposely identify what they have learned (Tang, 2002)." This would particularly be true in aviation internships where students know that they are graded on the quality of reflection. Sweitzer (2009) further made the link between reflections and internships in that the former helped turn the latter "experience into a learning experience." The only limitation found by this paper was that students with poorer writing did not describe their learnings clearly and there was a need to review the context of the entire passage carefully to identify the underlying innovation skill. For instance, 1 intern wrote about how she independently made decisions on her vacationing supervisor's behalf but did not explicitly describe her actions as showcasing independence.

From the reflection reports, this paper identified evidence of skills that future innovators would widely be expected to have (eg. OECD, 2001; PICA, 2020; NESTA, 2020; WSG, 2020), by referring to the innovation competency framework by Kettunen (2013) in Table 2, which was based on the work of the TUAS innovation pedagogy group.

Table 2: Innovation Pedagogy Framework

1. Individual Scale Innovation Competencies
a. independent thinking and decision-making
b. target-oriented and tenacious actions
c. creative problem-solving and development of working methods
d. self-assessment and development of own skills and learning methods
2. Communal Scale Innovation Competencies
e. ability to co-operate in a diversified team or work community
f. ability to take the initiative and to work responsibly according to the targets of the community; ability to work in research and development projects by applying and combining knowledge and methods of different fields
g. ability to work along the principles of ethics and social responsibility
h. ability to work in interactive communication situations
3. Network Scale Innovation Competencies
i. ability to create and maintain working connections
j. ability to work in networks
k. ability to co-operate in a multidisciplinary and multicultural environment
l. ability to communicate and interact in an international environment

The second part of the paper measured the extent to which the aviation sector internships imparted examples (a-l) of the 3 competency scales in Table 2. For confidentiality, this paper avoided listing organisation

names when citing examples. According to Kettunen (2013), individual scale competencies were a starting point and communal and network competencies would also be needed to "assure that working life expectations are met." The paper found that, while all internships imparted innovation skills, they did so in varying degrees. The paper explained the reasons for this. The findings were summarised in a frequency distribution table. Finally, suggestions were offered to make internships more effective in educating future innovators and identified the types of internships that did so.

Individual Scale Innovation Competencies

All interns displayed target-oriented actions. This was due to the nature of the aviation sector internships, where interns were not merely 'photocopying' but had clearly defined responsibilities with strict deadlines, as an intern at the airside control centre reflected in her report:

"Each of us is required to perform several tasks throughout our shift… ensure that all the tasks are done within 12 hours before handing over to the next team."

Office-based interns also had to meet work targets:

"Furthermore, as there were deadlines to meet, I have slowly cultivated the habit of completing all outstanding tasks quickly… before heading home."

Creative problem-solving was less apparent- at 23 out of 50- because many roles had standard procedures that required operational ability rather than creative flair. Still, an intern who did display creative problem-solving in handling a passenger's torn passport reflected:

"It has also taught me that flexibility is essential in this job; there isn't one fixed solution to any situation."

The number of interns that showed independent thinking and decision-making was even fewer, at 19. These interns were typically deployed at the frontline where operational decisions had to be made on the spot:

"It is sometimes expected of us to go solo and handle the flight… I felt these occurrences allowed me to become more independent and more confident in the decisions that I make."

However, not all organisations delegated decision-making to the interns. Hence, the lack of this ability might be due to the lack of opportunity.

Self-assessment and development was widely observed in terms of computer skills- Microsoft Office and Data Management. 32 such interns did not have significant prior knowledge and taught themselves.

"It was my first time using the software and there were no given guidelines regarding its functions. To proceed on, I took the initiative to learn the features and functions by myself using the web, without … help."

Communal Scale Innovation Competencies

All but 1 of the 50 interns reported developing communication skills. This should not be surprising as most of the interns interacted with customers and contractors in their daily work. An intern's regular duties was to brief new airline cabin crew staff. He wrote:

"Although I was nervous… this task allowed me to step out of my comfort zone and get used to speaking in front of a crowd. A useful skill for me for my future especially when giving presentations."

21 interns displayed abilities to co-operate in teams. It must be noted that the non-reporting of teamwork skills should not necessarily be deemed a flaw as many interns' job scope required them to work alone. For instance, 1 intern's primary role was to process air traffic controllers' training performance data, which was a solitary effort. Still, other interns who did learn teamwork skills had interesting insights that showed improvement:

"I had to quickly get to know the different working styles of my colleagues and the work environment within the department in order to get started on work… I had to quickly adapt to their working styles in order to assist."

Some interns even took on leadership roles with their teams. 1 such intern was entrusted to oversee the security of food catering operations at the airport and reflected on his leadership learnings in his report:

"I believe that leaderships is a relationship between a leader and his followers and that is built on respect and trust for on another."

The ability to work towards targets was evident for all interns who generally performed their jobs well. But, some interns did require more time and guidance:

"I was still adapting to my job scope and I forgot to create the flight bid for one of the months. My supervisor was kind enough to remind me."

Ethics and social responsibility abilities were rarely discussed. Only 1 intern, attached to the airport immigration and customs office, reflected on this:

"It would definitely be a contradiction and travesty if public servants like myself do not possess integrity considering that we are the individuals that enforce the laws and are tasked to protect our borders after all."

Network Scale Innovation Competencies

Internships are "typical examples" of Networked Learning (Kettunen, 2013). As such, it was not surprising that all the aviation interns developed network competencies, differing only in the extent.

All interns made working connections- even those who worked alone- as each intern had an industry supervisor who kept in close contact. Some interns went further and even managed to forge connections with vendors, like an intern in the airport safety department:

"At first, I had troubles when interacting with the vendors as I was new to this project. However, after several meetings… I have forged good connections with them and it is a pleasure to work with them."

However, only 16 interns displayed the ability to work in networks. This was because many interns took on entry-level work that did not require coordination with other aviation stakeholders. 1 of the interns who did work in networks was based at a corporate aviation company:

"The daily work… involved liaising with various parties such as ground handling agents, clients and hotel reservations agents."

As the aviation industry is international in scope, all the interns could communicate and interact in an international environment, be it with passengers, colleagues, airlines or dealing with international regulations from organisations like IATA. There were some interesting occurrences like a passenger services intern, who wrote about language barriers:

"This can be challenging with passengers who have difficulties conversing. This is when I have to use Google Translate on my phone …and basic sign language."

An example of international interaction at an informal level came from an intern in a ground handling company:

"I usually like talking to the foreign workers here, especially the Indian and Burmese, as I often find that they have really interesting life stories."

Only 8 interns worked in a multicultural environment, such as an intern who organised training programmes for participants from China and a cabin crew intern who worked with colleagues of various nationalities in flight.

There were no instances of multidisciplinary internships. This was because the internships were meant to orientate interns to work-life in their chosen discipline of study and job scopes narrowly tailored accordingly.

Results and Discussion

Table 3 summarised the paper's findings for each intern (Int) numbered from 1-50. The letters a-l correspond to each ability and skill listed in Table 2, grouped under their respective innovation competencies.

The first way to analyse the results would be in terms of the competencies that are most prevalent in the internship pedagogy. Encouragingly, all 50 of the aviation interns developed innovation competencies of being target-oriented (b), working towards targets set by the work community (f), making work connections (i) and interacting in international environments (l). The ability to work in interactive communication situations (h) was also widespread with only 1 exception.

Unfortunately, the pedagogy of aviation internships was found ineffective as follows. Only 42% of interns had the opportunity to co-operate in teams (e). Recalling that internships- unlike apprenticeships- have a personal development aspect, schools could address this by requesting that internship organisations craft projects for interns that require team work, even if it was outside the primary job scope. Other shortcomings- only 38% showed independent decision-making (a), 32% worked in networks (j) and 16% in multicultural settings (k) - would admittedly be more challenging to address. The former because organisations might not trust raw interns with making substantive decisions or dealing with external parties and the latter because not all organisations have multicultural workplaces or customers. To address these, schools would have to seek new internship partners, or consider overseas internships, where practicable. The last competency on ethics and social responsibility (g) was severely lacking with only 1 intern. A possible solution would be to request for interns to be part of corporate community projects.

Table 3: Evidence of Innovation Competencies

	Innovation Competencies												Count
	Individual				Communal				Network				
Int	a	b	c	d	e	f	g	h	i	j	k	l	
1	●	●	●	●		●		●	●	●	●	●	10
2	●	●	●	●		●			●			●	7
3		●	●			●		●	●			●	6
4		●	●	●	●	●		●	●	●		●	9
5	●	●	●	●		●		●	●	●		●	9
6	●	●	●			●		●	●	●	●	●	9
7		●	●	●		●		●	●	●		●	8
8	●	●	●		●	●		●	●	●		●	8
9		●		●	●	●		●	●			●	7
10		●		●		●		●	●			●	6
11	●	●	●	●	●	●		●	●	●		●	10
12		●	●		●	●		●	●	●		●	8
13	●	●			●	●		●	●			●	7
14	●	●			●	●		●	●	●	●	●	9
15		●		●		●		●	●			●	6
16		●				●		●	●			●	5
17	●	●	●	●	●	●		●	●	●	●	●	11
18		●	●	●		●		●	●			●	7
19		●			●	●		●	●			●	6
20	●	●	●	●	●	●		●	●	●	●	●	11
21		●		●		●		●	●			●	6
22	●	●		●		●		●	●			●	7
23	●	●	●	●		●		●	●	●	●	●	10
24		●	●	●	●	●		●	●	●		●	9
25	●	●		●		●		●	●			●	7
26		●		●	●	●		●	●	●		●	8
27		●		●		●		●	●			●	6
28		●		●	●	●		●	●			●	7
29	●	●	●			●		●	●			●	7
30		●	●		●	●		●	●			●	7
31		●			●	●		●	●	●		●	7
32	●	●		●		●		●	●	●		●	8
33	●	●			●	●	●	●	●			●	8
34	●	●			●	●		●	●			●	7
35		●	●			●		●	●			●	6
36	●	●			●	●		●	●			●	7
37		●		●		●		●	●			●	6
38		●			●	●		●	●			●	6
39	●	●				●		●	●			●	6
40		●	●	●	●	●		●	●			●	8
41		●	●	●		●		●	●		●	●	8
42		●	●	●		●		●	●			●	7
43		●		●	●	●		●	●			●	7
44		●		●		●		●	●		●	●	7
45		●		●		●		●	●			●	6
46		●		●		●		●	●			●	6
47		●	●	●		●		●	●			●	7
48		●	●	●		●		●	●			●	7
49		●		●		●		●	●			●	6
50		●			●	●		●	●			●	6
Sum	19	50	23	32	21	50	1	49	50	16	8	50	
%	38%	100%	46%	64%	42%	100%	2%	98%	100%	32%	16%	100%	

The second approach to analysing the results would be from the perspective of individual students. Plotting a frequency distribution in Table 4 revealed the following.

Table 4: Frequency Count of Innovation Competencies

Number of Interns	Count of Innovation Competencies
2 (4%)	11-12
8 (16%)	9-10
25 (50%)	7-8
15 (30%)	5-6

All interns had examples of individual, communal and network scale competences. While the majority developed 7 or more innovation skills, a sizeable number of 15 (30%) interns 'barely passed' with only 5-6 out of 12 innovation skills. Out of these 15, 1 intern only achieved 5 skills. He did solitary routine reporting in an airline back office. Schools might want to reconsider such assignments in future or request that the organisation amends the job scope. At the other end, the interns that developed the most competencies of 9-12 had frontline operational responsibilities in airline ground operations, ground handling, airside operations and airport security. Where practicable, schools could consider assigning interns to more of such roles in future.

Conclusion

This case study showed that internships in Singapore's aviation sector provided both workplace and innovation skills training. However, the effectiveness of internships' innovation pedagogy- and, hence, the degree to which future innovators were educated- varied according to the organisation and roles of the interns. The pedagogy was not very effective for 30% of interns and more systematic studies should be done to determine whether the fault lay with the intern, internship job scope or organisation. This case study also identified the specific innovation competencies, like social and ethical responsibility, which were missing from the internship pedagogy. Finally, this paper inferred the characteristics of internship roles that better educate innovation, namely, frontline, customer-facing and operations. Schools could expand the job scope of internships to include such roles, as these experiences better support the innovation pedagogy to train future innovators in all sectors.

References

CAAS (2019). *CAAS' Internship Programmes*. Retrieved from https://www.caas.gov.sg/who-we-are/internships.

Dewey, J. (2010). *Democcracy and Education*. USA: Feather Trail Press.

Goldman Sachs (2020). *Summer Analyst Internship*. Retrieved from https://www.goldmansachs.com/careers/students/programs/asia-pacific/summer-analyst.html.

Instance, D. (2019). *Approaches to pedagocial innovation and why they matter*. Retrieved from https://www.brookings.edu/blog/education-plus-development/2019/01/23/approaches-to-pedagogical-innovation-and-why-they-matter.

Kettunen J, Konst T and Kairisto L (2013). *Innovation Pedagogy and Desired Learning Outcomes in Higher Education* in On the Horizon. Retrieved from https://www.researchgate.net/publication/262938322_Innovation_pedagogy_and_desired_learning_outcomes_in_higher_education

Nesta (2020). *Nesta and Department for Education support innovations to pave the way for future employment in a changing workforce*. Retrieved from https://www.nesta.org.uk/news/nesta-and-department-education-support-innovations-pave-way-future-employment-changing-workforce.

Nicholas, A. (2016). Internships: Experiential Learning, Academic Connection and Assessment. Retrieved from https://digitalcommons.salve.edu/cgi/viewcontent.cgi?article=1061&context=fac_staff_pub.

OECD (2001). *Competencies for the Knowledge Economy*. Retrieved from http://www.oecd.org/innovation/research/1842070.pdf.

O'Higgins, N. & Pinedo, L. (2018). Interns and outcomes: Just how effective are internships as a bridge to stable employment? Retrieved from https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_637362.pdf.

PICA (2020). *Growing Future Innovators*. Retrieved from https://pica.org.au/learn/growing-future-innovators

Skillsfuture (2020). *Enhanced Internships*. Retrieved from https://www.skillsfuture.sg/enhancedinternships.

Sweitzer, H.F. & King, M.A. (2009). *The Successful Internship: Personal, Professional and Civic Development*. Belmont: Brooks/Cole, Cengage Learning.

Tang, C. (2002). *Reflective diaries as a means of facilitating and assessing reflection*. Retrieved from https://nursing-midwifery.tcd.ie/assets/director-staff-edu-dev/pdf/ReflectiveDiaries-CatherineTang.pdf.

University of Oxford (2019). Retrieved from https://www.careers.ox.ac.uk/internship-best-practice.

Vincent-Lancrin, S., et. al (2019), *Measuring Innovation in Education 2019: What has Changed in the Classroom?* Educational Research and Innovation, OECD Publishing, Paris.

WSG (2020). *Adapt and Grow*. Retrieved from https://www.wsg.gov.sg/adapt-and-grow.html.

COLLABORATION PROGRAMS TO TRAIN INTERNATIONAL CADETS FOR MARITIME ENGLISH EDUCATION ON BOARD

Jongdoc Park [*,a], Osami Yanagisawa [b], Jeric E. Bacasdoon [c] and Koji Masuda [d]

[a] Shipping Technology Department, National Institute of Technology (KOSEN), Oshima College, Yamaguchi, Japan
[b] Maritime Technology Department, National Institute of Technology (KOSEN), Yuge College, Yamaguchi, Japan
[c] Maritime Academy of Asia and the Pacific (MAAP), Bataan, Philippines
[d] Marine HR Team, Human Resources Group, NYK (Nippon Yusen Kaisya) Line, Tokyo, Japan

* park@oshima-k.ac.jp

Abstract

The collaboration to train international cadets and to develop a global internship program has been implemented by Japanese maritime KOSEN. This paper reports the programs prepared in collaboration with five maritime KOSENs, Philippine maritime academies and Japanese international organizations of shipping.

Firstly, Maritime Academy of Asia and the Pacific (MAAP) in the Philippines collaborated with K Line Maritime Academy Philippines have developed the global educational programs since 2012. We have done lots of international activities using the programs. It has been a good educational effect on Japanese students so far. Recently, MAAP has launched a new training ship, M/V KGO (Kapitan Gregorio Oca. In September 2019, MAAP's students visited Japan on their training ship supported by International Mariners Management Association of Japan and other organizations of shipping. Here, we introduce the short cross-cultural onboard training and its educational effects in detail.

Secondly, since 2015, the English study and training program have been performed at NYK (Nippon Yusen Kaisha) - TDG (Transnational Diversified Group) Maritime Academy (NTMA) in the Philippines. We have been joining the program with Japanese students and instructors every year. In October 2019, NTMA members visited NIT (KOSEN) Oshima college. We conducted the maritime educational program in English based on STCW (*Standards of Training, Certification and Watchkeeping for seafarers*). A survey questionnaire was conducted when the program was over amongst the students.

This paper reviewed how the collaboration programs work for training international cadets for maritime English education on board.

Keywords: *Collaboration, Maritime English, Maritime Department, STCW, KOSEN*

Introduction

As for international maritime officers, a deep knowledge of theory, operating skill and maintenance for the ship are a very important requirement for them. Aside from that, they need keen English communication skills for internal or external communication between ship to ship or ship to shore. Most of Japanese international shipping company hires many foreigners as a ship crew. It is necessary for international maritime officer to have daily communication with each other who have different nationalities. They need to communicate with SMCP (*Standard Marine Communication Phrases*) based on STCW (*Standards of Training, Certification and Watchkeeping for seafarers*).

Five maritime departments under the National Institute of Technology (KOSEN) in Japan namely Toyama, Toba, Hiroshima, Yuge and Oshima College have been working together to nurture the maritime officers and to enhance the professional English communication ability without any trouble (2013). "All maritime college study method improvement project" in 2006 - 2011, "Maritime Human Resources Development project" in 2012 – 2017 and "2nd phase of Maritime Human Resources Development project" in 2017 – 2019 supported by Japanese government have been carried out to achieve this goal.

Maritime Academy of Asia and the Pacific (MAAP) which was founded in 1998, is designed to be a world-class maritime academy equipped with the STCW in the Philippines. It has an enrollment of over 2000 students and have EOP which means English of policy. MAAP in collaboration with K Line Maritime Academy have developed the global educational programs through "Maritime human resources developing project" since 2012. During the project, we have done the maritime

English training program implemented by the invited English instructors from MAAP for several years. Recently, MAAP has launched a new training ship, M/V KGO (Kapitan Gregorio Oca) which was donated by the International Mariners Management Association of Japan (IMMAJ) and All Japan Seaman's Union (JSU). In September 2019, 49 students at MAAP's JSU-IMMAJ campus visited Japan on their training ship. On this occasion, we conducted joint on-board training such as voyage drills and lectures during ocean going navigation between Hiroshima and Nagoya port in Japan. Here, we introduce the short cross-cultural onboard training in detail that they will lead the future of the Japanese merchant fleet.

On the other hand, the English study and training program has been performed at NYK (Nippon Yusen Kaisha which is Japanese international shipping corp.) - TDG (Transnational Diversified Group of Philippines) Maritime Academy (NTMA) in the Philippines and has been referred to as the "NYK-MIRAI project" since 2015. The purpose on "NYK MIRAI project" 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. We have been joining the project with Japanese students and instructors. In the beginning of this, the global educational programs have been carried out successfully with Singapore Maritime Academy in Singapore, Kauai Community College in Hawaii and other community colleges in the Philippines. In October 2019, NTMA members visited NIT (KOSEN) Oshima college. We have conducted the maritime educational program in English based on STCW. We accepted the buddy system that makes a pair between Japanese and Filipino students. All students were staying in the training ship, Oshima MARU and have experienced the shipboard training. A questionnaire was conducted when the program was over amongst the students.

This paper reviewed how the collaboration programs work for training international cadets for maritime English education on board. It will help to measure on how the students could enhance their English competency, communication skills and cross-cultural onboard training using a global approach on five maritime KOSENs in Japan.

International internships and maritime English programs of five maritime KOSENs

Table 1 (2016-2019) shows the various international internships and maritime English programs of five maritime KOSENs since 2014. The MAAP for maritime English seminar and collaboration to shipboard training costs 0 because it is an inbound program which took place in Japan and all expenses were paid by IMMAJ. MAAP's English seminars gave a chance to many Japanese students to study English without any extra personal cost. Kauai Community College for three weeks and Singapore Maritime Academy for two weeks cost expensive price as compared to others. These are outbound programs. NTMA in the Philippines, conducting 11 days, costs 700 USD. It is an affordable price for them so that Japanese participants are increasing gradually. Outbound program at NTMA have a best cost performance among these programs. NTMA program includes outbound and inbound activities. As we mentioned, NTMA students and instructors have visited five maritime KOSENs every year since 2015. In 2019, Oshima college was the host. We will see details later.

Maritime English seminar from MAAP in the past

MAAP collaborated with K Line (Japanese international shipping corp.) Maritime Academy Philippines had developed a new international internship program. The five maritime KOSENs could invite English instructors from MAAP by using the program and requested them to conduct the "Maritime English Instructor's Training Course", "Student's onboard ship

Table 1. International internships and maritime English programs of five maritime KOSENs

Schools and places		Period Days	Price USD	Programs	Number of Japanese participants					
					14	15	16	17	18	19
MAAP (Maritime Academy of Asia and the Pacific)	Japan	14	0	Maritime English Seminar Collaboration to shipboard training	840	630	−	−	−	29
Kauai Community College	Hawaii	21	5000	English seminar Canoeing, Camp activity	10	16	12	11	canc elled	canc elled
Singapore Maritime Academy	Singap -ore	14	3000	English Seminar Maritime experiential learning camp	16	13	8	16	canc elled	canc elled
Emilio Aguinaldo College	Philip -pines	16	1200	English Seminar	8	10	16	15	26	22
NTMA (NYK-TDG Maritime Academy)	Philip -pines	11	700	Special English seminar Attend regular classes, Field Trip	−	4	9	10	23	16

Photo 1 Seminar view conducting active learning for 3rd year students at Oshima College

training in English", and “Daily English conversation educational program” for maritime colleges in Japan. New teaching style, discussion learning, role play active learning, U shape seat arrangement, among others were first introduced to Japanese instructors and then applied in the classes (see Photo 1). The content of program has already been edited and published into the textbook entitled "Let's Enjoy Maritime English". Then it has been introduced and adapted into the common curriculum in five maritime KOSENs.

Short cross-cultural onboard training

Now, we introduce the short cross-cultural onboard training which is initiated by MAAP, IMMAJ, JSU and JMETS (Japan Agency of Maritime Education and Training for Seafarers) last year. MAAP have launched the new training ship M/V KGO donated by IMMAJ and JSU. MAAP’s 49 students and their crew members came to Hiroshima port in order for the cross-cultural onboard training with Japanese cadets. For the Japanese cadets, onboard training must be a very effective way to be exposed maritime English. Especially, watchkeeping of departure and arrival port for nautical science course, and watchkeeping of main diesel engine for marine

Photo 2 Navigation chart used by the deck cadets (Japanese and Filipino) on training ship M/V KGO

Photo 3 Shipboard training view of the engine cadets (Japanese and Filipino) on training ship M/V KGO

engineering course students. The maritime KOSEN students were given the chances to experience an active learning of ship handling with Filipino cadets in practice.

Photo 2 shows the navigation chart used by the deck cadets (Japanese and Filipino) in the bridge. It is used by them to solve the distance or direction from the ship to land/islands. This is very important to be able to check the right directions how to navigate the ship. This tool is essential for the deck cadets to be able to communicate in the bridge.

As for the watchkeeping in an engine side, there are two engine cadets in the Photo 3. They are brainstorming what they have learned in the classes. They have to check the temperature, pressure, and operating condition etc. of the main engine. This is necessary for the engine cadets to have communication each other.

All cadets are having their safety training as shown in the Photo 4. They are now trying to evacuate to the life boats. They will abandon the ship since the ship is in under critical situation.

In 2020, this collaboration program is scheduled to take place in MAAP. We believe that Japanese students will be able to further improve their English proficiency by conducting shipboard training in the Philippines.

Photo 4 Safety drill (ship abandonment training) view on training ship M/V KGO

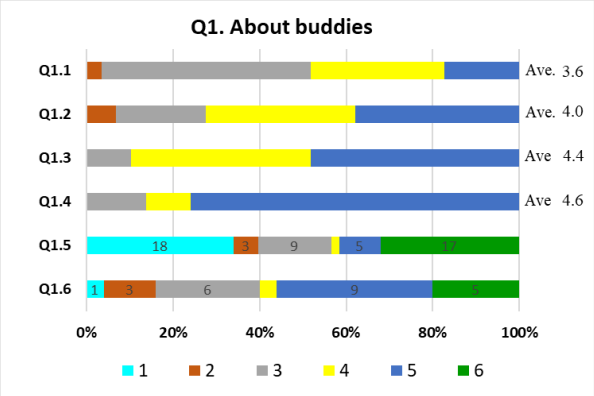


Fig. 1 Findings for the maritime KOSEN students about their buddies on training ship M/V KGO

Findings to the questionnaire survey on shipboard training

Here, you can see the findings to the questionnaire survey on shipboard training. The question lists are as follows:

Q1. About buddies

Q1.1 Did you understand your buddy's English?

Q1.2 Did you ask a question to your buddy in English?

Q1.3 Did you perform program in harmony with your buddy?

Q1.4 Did you enhance your understanding for your buddy (personally)?

Q1.5 What kind of topic was easy to communicate?

1: Hobby 2:Daily dormitory routine 3:Maritime subject 4:General subject 5:Social system 6:Culture

Q1.6 What kind of topic was difficult to communicate?

1: Hobby 2:Daily dormitory routine 3:Maritime subject 4:General subject 5:Social system 6:Culture

Q2. About classes (lecture, safety drill, watch keeping)

Q2.1 Did you understand teacher's instruction in English?

Q2.2 Did you like the class proceeding style?

Q2.3 Did you join the classes proactively?

Q3. About educational effects for the training

Q3.1 Did you enhance your understanding for Filipino through the training?

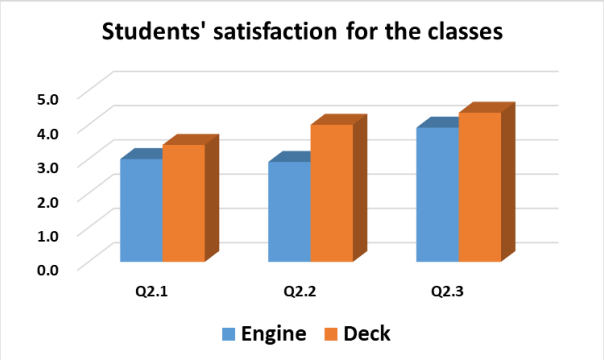


Fig. 2 Findings for the maritime KOSEN students about their satisfaction to the classes on board

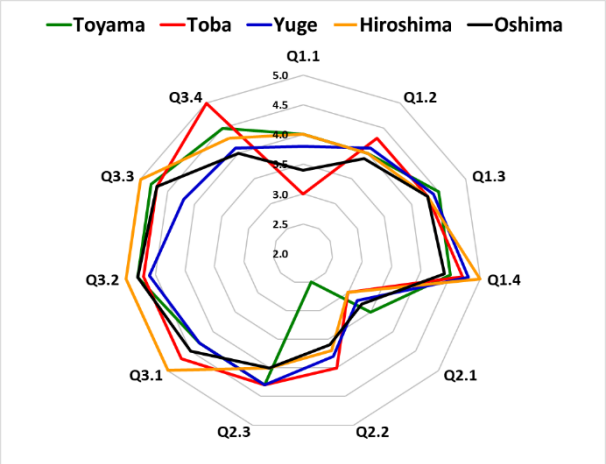


Fig. 3. Total results for the five maritime KOSENs to all questions on training ship M/V KGO

Q3.2 Did you enhance your motivation to communicate with foreigner?

Q3.3 Did you enhance your motivation to study the Maritime English?

Q3.4 Did you enhance your motivation to be an international ship officer and a ship manager at sea?

For the feedback, we asked the students to select one number from a scale of one to five (see below) for each question:

1 = very disagreeable

2 = disagreeable

3 = neither disagreeable nor agreeable

4 = agreeable

5 = very agreeable.

Firstly, the KOSEN students give high scores on the whole when it comes to their buddies as shown in the Fig. 1. Japanese students could communicate with their Filipino buddies even though they struggled speaking English as the Q1.1 got a low average. In Q1.5, for the question "what kind of topic was easy to communicate", they chose "Hobby or Culture". In Q1.6, for the question "what kind of topic was difficult to communicate", majority answered "Social System". The results imply the Japanese students' thought about English.

About classes such as lecture, safety drill, and watch keeping, KOSEN students have difficulty in English, during the classes. As for the bar graph in the Fig. 2, we could understand that the deck students' satisfaction for the classes is higher than engine students' one.

Figure 3 shows the total results for the five maritime KOSENs to all questions on training ship M/V KGO. As for Q1, the buddy system works well to have a lot of English conversation and understanding each other. In Q2 about the classes, the Japanese students have little opportunity to expose themselves to technical subjects in English, so that they respond very low value. Q3 indicating the educational effects obtains the higher value as compared to others. Most of students believe that they could enhance their motivation to be a seafarer through the international shipboard training.

Photo 5 Safety drill (boat handling training) view on NTMA campus in the Philippines

Collaboration programs between NTMA and Oshima college

The English study and training program has been performed at NYK - TDG Maritime Academy (NTMA) in the Philippines and has been referred to as the "NYK-MIRAI project" since 2015. NTMA 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. We decided to bring the Japanese students to NTMA for a short-term English training. Photo 5 shows the safety drill which is the boat handling training that they have to use to it as a seafarer. They can learn how to handle the boat movements and they can learn about the team-works. It is very important for them to learn how to use the navigational techniques. They can have the first-hand experience on how to handle boat movements: rolling and pitching etc.

Findings to the questionnaire survey on collaboration program

In October 2019, NTMA members visited NIT (KOSEN) Oshima college supported by the NYK-MIRAI project. We have conducted the maritime educational program in English based on STCW.

Photo 6 Shipboard training view of the deck cadets (Japanese and Filipino) on training ship Oshima MARU in Japan

Photo 6 shows the shipboard training view of the deck cadets (Japanese and Filipino) on training ship Oshima MARU in Japan. It is on roll-call in the bridge. The Chief Officer is giving instructions to the cadets before doing the training. They will learn how to use the navigational techniques based on the collaboration between Filipino and Japanese cadets.

Figure 4 shows the findings about the educational effects to the collaboration program. All sectors show remarkable motivation enhancement. It could motivate to communicate with foreigner and to be international officers in the future. Japanese students show the high educational effects. It had a good impact on Filipino students as well because Japanese students could support them during the training on board.

NTMA student's comments for the Oshima program in Japan

Here are NTMA student's comments for the collaboration program in Japan.

- *It was a very successful event/project. We are very satisfied in.*
- *We hope is that NTMA cadets to participate will be more next time.*
- *We hope the program will continue to inspire more.*
- *We may have additional time or longer stay in the future.*
- *It would be great to explore more about the culture, living and technical knowledge of the participants.*
- *I wish we would more opportunities not only technical skills but also decision making skills.*
- *We communicated a lot with our Japanese buddies and instructors.*
- *My experience in Japan will be exceeded better.*
- *It will make much better if you could add more interaction of all Japanese students.*
- *NYK MIRAI project is a great program because it allow us to actualized our theoretical knowledge in the training ship Oshima MARU.*

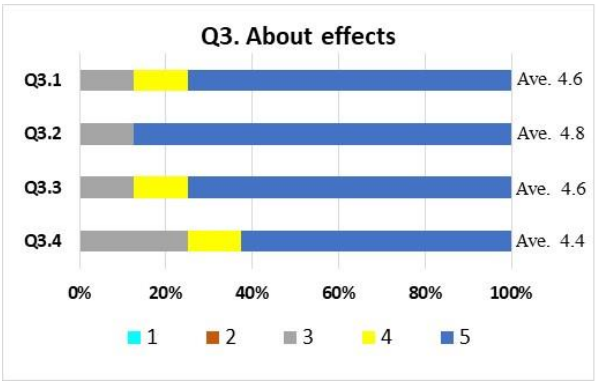


Fig. 4 Findings for the maritime KOSEN students about educational effects to collaboration program

Conclusions

The MAAP's maritime English seminar conducted by the instructors from Maritime Academy of Asia and the Pacific has already been edited and published into the textbook. Then it has been introduced and adapted into the common curriculum in five maritime KOSENs (2016, 2017). The international internship program in the Philippines will be encouraging that the maritime KOSEN students can put in practice the English training from now on.

The cross-cultural onboard training between Japanese and Filipino students was very affordable for every student in maritime colleges. The maritime KOSEN students were given the chances to experience an active learning of ship handling, watchkeeping and safety drill with Filipino students in practice. In addition, the students could have a lot of English conversation and understanding each other through buddy system on board.

Using English in the conversation flexibly with NTMA students who are speaking English as a secondary language, has become a place of good practice for improving the communication skills for Japanese students. Hosting NTMA gave a chance to many Japanese students to study English without any extra personal cost. It is very important to learn maritime English and also to understand inter-cultural background to be able to communicate with international colleagues in future work on ships.

The questionnaire for the program were reported to improve their comprehension about maritime English. We concluded that the collaboration programs to train international cadets for maritime English education was successful to enhance Japanese students' motivation and professional English communication ability for the future seafarer.

Acknowledgements

This program is sponsored by IMMAJ (International Mariners Management Association of Japan) and NYK (Nippon Yusen Kaisya) corporation. The authors would like to express gratitude to instructors and staffs of MAAP and NTMA to perform this program.

References

Kanki Iwasaki. (2013). "Development of human resources training system with corporation between college and industry in maritime area - Overview of Maritime human resources developing project". *Proceedings of Education forum for all colleges in Japan*. AP4 3 1.

Kyoko Ikeda and et al., (2013), *Surfing English - Maritime college series*, 1st edition, Kaibunndou Publishing Co..

Makoto Endo, (2013), "An approach to study method easy to understand and to fix in maritime department - all maritime college study method improvement project", *Proceedings of Education forum for all colleges in Japan*, AP4 3 2.

C, Chirea Ungureanu. (2014), "Intercultural education, a response to contemporary multilingual societies and a new challenge for Maritime Education and Training (MET) Institutions", Procedia, 116, 4260–4263.

Ding Zi-hua, (2015), "The Existing Situation and Training about Maritime English Teachers in China", Journal of Shipping and Ocean Engineering 5, 266-270.

Ahmad Fauzia, Patta Bundua, and Suradi Tahmira, (2016), "The Development of Maritime English Learning Model Using Authentic Assessment Based Bridge Simulator in Merchant Marine Polytechnic, Makassar", *International Journal of Environmental & Science Education*, 11, 10, 3231-3240.

Jongdoc Park and et al., (2016), "Educational Program for Maritime English with MAAP instructors adopted in Five NIT Maritime Colleges of Japan", International Symposium on Marine Engineering and Technology (ISMT) 2016, Busan Korea.

Jongdoc Park and et al., (2017), "International Maritime Education and Training in Collaboration with Philippines Maritime Academy", Proceedings of the International Symposium on Marine Engineering (ISME), Tokyo, Japan, D20-201, pp 507-510.

Hiroshi Ohyama and et al., (2018), "Development of Essential Personalities for Future Maritime Professionals -International Internships Programs Developing Global Adaptability-", NAVIGATION, 203, pp 20-13.

Osami Yanagisawa and et al., (2018), "Implementation of an International Maritime English Educational program at Maritime Technology departments in five NIT in Japan", 30th International Maritime English Conference (IMEC30), Manila, Philippine, pp 1-13.

Jongdoc Park and et al., (2019), "Enhanced English Competency of Teachers Using Global Approach for Maritime Colleges in Japan", Transactions of ISATE (e-book with ISBN: 978-4-9911159-0-5), the 13th International Symposium on Advances in Technology Education (ISATE2019), Paper No. 3012464, pp1-5.

REGIONAL COLLABORATIVE EDUCATION FOSTERS FUTURE-MINDED ENGINEERS

Takuo FUJITA, Motoki SATOH, Fuyuko EGUCHI, Shihoko ONAGA, Maiko MATSUURA, Harunori FUJITA, Kiyoshi ISE and Shigenori AKAMATSU

National Institute of Technology, Kochi College, Nankoku, Kochi, Japan

*tfujita@kochi-ct.ac.jp

Abstract

Career education is conducted to develop the ability and willingness to solve social issues. We explain active learning for career education of National Institute of Technology, Kochi College. We have made a special program which is named regional collaborative education.

The goal of the program is that students solve social issues together with people of the local area. This program proceeded as follows.

(1) Teachers gave the broad social issues to students of the first grade and the second grade.

(2) They made teams which consist of five or six students.

(3) They tried to find the local concrete problem by themselves.

(4) Each team discussed and proposed ideas to solve problems.

(5) Finally, each team showed ideas to teachers and local people.

The Teams which came up with good ideas were commended in our college presentation contest.

Students of the third grade have been making the above ideas realized. One example is as follows. Kochi Prefecture produces the largest amount of ginger in Japan, but or therefore it is often discarded. As the way of its reuse, students thought of making paper from discarded ginger. Kochi Prefecture is also one of centers of Japanese paper production and has many craftsmen of Japanese paper. Japanese paper is usually made from tree bark. Students came up with ideas of using discarded ginger instead of it. They learned from craftsman how to make Japanese paper made ginger paper only from discarded ginger. The papers have smelled ginger faintly. Craftsmen rejoiced it, and they say they feel like making ginger paper a specialty.

Furthermore, we have been designing advanced regional collaborative exercise program for the fourth grade students. In the exercises, teachers have provided the broad social issues to the students. They have to look for them by themselves. They have made teams which consist of five or six students with different specialties. They have discussed the issues and come up with ideas for solutions. Each team not only had showed ideas of solution, but also have been making the ideas realized by concrete system design, manufacturing and so on. Some of issues they have been addressing have included farming house issues, forestry issues, information security education for junior high school students, and cultural preservation. They have improved their skills as engineers by solving social issues, the ability to think while discussing as a team member, various communication skills through discussion with local people.

This regional collaborative education fosters future-minded engineers.

Keywords: *Regional collaboration, Social issues, Active learning, improving skills, curriculum design*

Introduction

Kochi National College of Technology has provided several active learning educations (e.g., Motoki Sato & Shihoko Onaga, 2018; Junko Nagahara, Shihoko Onaga & Motoki Sato 2018; David J. Grant 2018). Now we have developed a special program called regional cooperation education to combine and fuse a wide range of knowledge and technologies, and to develop hybrid human resources who can quickly respond to society's demands which technology and information are rapidly diversifying and changing. As a part of this, we have held an idea presentation contest, "Unazuku Presentation". In Japanese, Unazuku means nodding especially in order to show understanding, agreement or consensus. One of the academic achievement of students is to make presentation on the contest which aims to cultivate the foundation of engineers who can discover regional problems through cross-disciplinary learning and contribute to their solution. Furthermore, in the regional collaborative exercise for 4th grade students, we aim to acquire a multifaceted perspective that is not biased only to one's own specialty by working on solving regional problems with a team structure with diverse expertise.

Significance of activities and research

Fig. 1 Presentation practice in first grade class

In the activity of "Unazuku Presentation", all students (including majors) who are enrolled in our college are targeted, and the fresh ideas based on a student's free conception are combined with the specialty (engineering field) learning in technical colleges. This is an effort to present ideas that will lead to the solution of social problems such as aging and population decline, and problems in the primary industry, which is the main industry in Kochi prefecture. Students try to solve the problem with a team of 2 to 5 people, and 5 teams that have undergone the primary screening (A4 slides of 20 or less) hold the presentation in the final contest. In the final selection, persons involved in Kochi Prefecture and local companies and experts with a deep knowledge of the theme are invited from outside the college as judges.

In addition, all students in the 1st and 2nd grade are required to participate, and we will prepare for the contest in conjunction with the active learning type lessons of Japanese and social studies. By practical learning, the students learn methods for finding problems, raising problems, based on the survey and using presentation tools for creating materials, and tips on presentation skills. Third grade students and above can participate freely, grow significantly in not only the amount of knowledge, but also the presentation skills based on logical thinking and/or logical reasoning increased with advancing grade. Although this activity is one of event on campus, the results of the contest are provided to the local society. It

Fig. 2 Presentation of the 1st grade team

is the most salient characteristic of the contest, and it is also important that it is an opportunity for students to step out of the college / region by developing after the contest. In the " Unazuku Presentation " is expected that the following basic skills of working people will be acquired, (1) the ability to understand the sentences theoretically and convey the results of thinking to others in an easy-to-understand manner, (2) the ability to discuss based on the opinions of others through discussions within the team, and (3) the ability to consider various issues by using statistical data in consideration of regional characteristics and relationships with daily life, and the comprehensive presentation skills will be consequently improved. In addition, it becomes possible to clarify the required knowledge and skills of the specialized subjects to be studied at the college of technology, and to develop the habit of active learning in the 1st and 2nd graders, and to work with the community to solve problems. These ability and skills are able to solve social issues together with people of the local area on the regional collaborative seminar in 4th grade. In the five-year curriculum of a college of technology, which must develop not only the technical skills that have been required for modern engineers, but the ability and skills required of future engineers who are rooted in each region and work together to challenge problems Efforts play a large role.

(1) Holding of "Unazuku Presentation "

"The 4th Kochi National College of Technology Unazuku Presentation" was held at the Kochi National College of Technology Festival on Saturday, November 9, 2019.

In 2019, the theme was "Tourism x Engineering", and a method to solve the problems of Kochi Prefecture by " Tourism " was presented, and ideas to cover various problems such as human resource shortages by "Engineering" were proposed. We competed (80 teams entered).

The second-grade student team that announced "Automatic marketing creates Kochi!" was awarded the highest award. In addition, a multilingual system that uses AR technology to present sign explanations corresponding to inbound tourism, and tourism content

Fig. 3 Presentation of the Grand Prize Team

that enhances childcare and education as part of a migration promotion plan to stop population decline were announced as ideas. “Unazuku Presentation” would be the 4th time by 2019, and it would be seen by many on- and off-campus spectators increased in increasing time. The judges of the contest highly appreciate the efforts made by “Unazuku Presentation”.

In addition to improving students' problem-finding and/or -solving abilities and comprehensive presentation skills, there are many examples of advancing researches from the ideas, as in the “Ginger Paper” introduced below. The various results of the researches were awarded in off-campus contests and in conference presentations.

(2) Ginger Paper

By the activities of the students themselves, they obtained free materials from the major ginger wholesale companies in our prefecture and have been promoting product development based on the “Tosa Washi” (brand name of Japanese traditional handmade paper) manufacturing method. Regarding the manufacturing method of “Tosa Washi”, we held training camp and practical training at a craftsman of “Tosa Washi” (Harunori FUJITA et al. 2019). We analyzed the strength of the obtained "Ginger Paper" using a thickness gauge and a small tensile tester (Fig. 4).

It became clear that Ginger Paper is classified as weak paper. However, it has been difficult to quantify the development of the color, scent, touch feeling and appearance of Ginger Paper before this, but this time, for the first time, we are able to make them realize that they were "Quantifying what they have developed and evaluating it".

The results have been announced on November 17, 2019 at the 2019 Chemical Society of Japan Chugoku-Shikoku Branch Scientific Education Research Conference (Momoi ARITA et al. 2019). The students involved in the research even in 3rd grade had valuable experiences and experiencing the conference presentation.

In addition, on January 12, 2020, we have visited a handmade workshop in our prefecture to learn about the Tosa Washi manufacturing method and held a meeting to

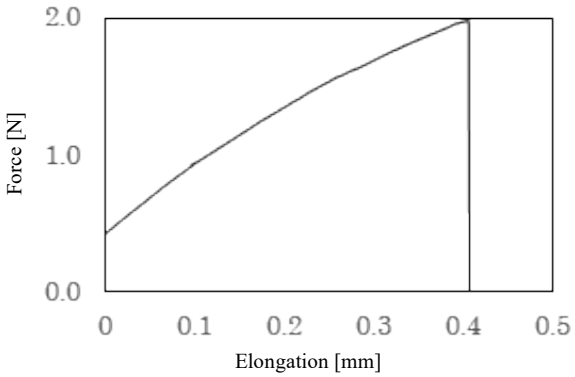


Fig. 4 Example of ginger paper tensile test

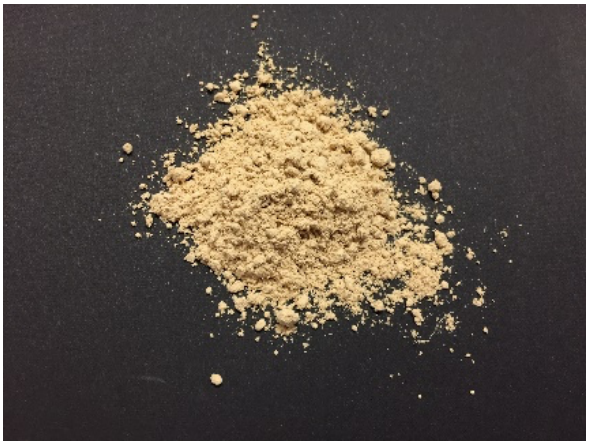


Fig. 5 Waste ginger powder

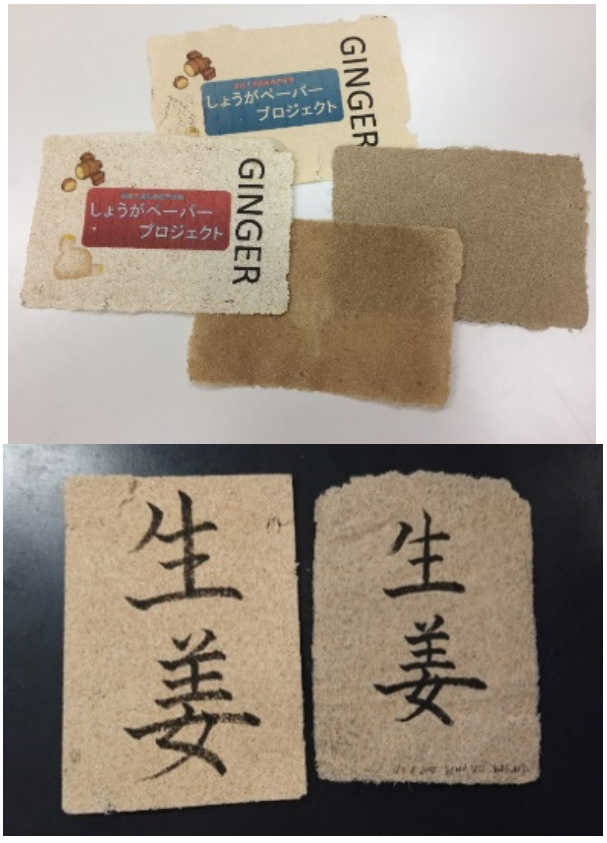


Fig. 6 Sample of ginger paper

further promote it in the future. As a result of the discussions, Ginger-based paper has been developed by our students incorporating Tosa Washi technology, while a method for absorption ingredients of ginger into the Washi paper on the basis of ordinary Washi paper making method has been developed by the workshop. The ginger component for absorption have been used by drying the ginger and making it into a powder form, the powder has been made by the students of our college. After the meeting, we proceeded with the production of powder of waste ginger using a dry food maker (Fig. 5).

Through this activity, we are able to make the students involved realize how to proceed, the importance of the conference minutes, and the importance of the deadline when working with companies. The first step is to create a business card. We have been able to create the business card in cooperate with the handmade workshop by the improved method of making paper (Fig. 6) .

(3) Regional collaboration exercise (4th grade)

The purpose of the regional collaboration exercises for 4th grade students is to understand the current situation in Kochi Prefecture and to cultivate practical problem-finding and -solving ability through actual sites and how to tackle the issues themselves. It is to cultivate the independence and acquire responsible behavior by carrying out group work while considering whether or not they can do it.

The goals of this exercises are set as follows.

(I) After gathering and arranging information on regional issues, they can discuss and discuss their own ideas and propose solutions.

(II) Being aware of the role of a team member regarding regional issues, be able to act responsibly and engage in collaborative work independently.

(III) To be able to work on the design of system / components suitable for the site and situation.

(IV) To be able to devise solutions to regional problems by combining expertise from multiple fields.

The method of class and the content and method of class are as follows.

Fig. 7 Field visit (livestock farmer)

(i) Conduct in groups that do not have barriers for each course.

(ii) Propose a solution suitable for the situation of the field to be surveyed.

(iii) Studies for base and preliminary knowledge of each field are conducted for each field.

(iv) Research theme setting and quest for problem solving are conducted for each course group

(v) Share progress and results through plans, weekly reports, interim reports, final reports, etc.

Through the above, we aim to educate students about the importance of combining knowledge and technology from multiple specialized fields to face one issue, and to acquire the ideal attitude as a hybrid human resource through practical exercises.

Specifically, based on the "implementation plan" presented by the faculty members, each team sets its own theme, and the teams share learning and inquiry. Report, contact, and consult about activities by submitting the “summary of results” and so on. At the end of the first semester, an interim report meeting of the results is held, and at the end of the second semester, the issue providers are invited for "poster presentations".

From May 24th to June 11th, 2019, the participating students had visited a field. In the problem-solving field, a team of 5 or 6 students with different specialized fields was divided into 18 teams to tackle 18 problems in 6 types of fields, and, we conducted on-site inspections of EKINGURA (AKAOKA Town), NANKOKU Style Co., Ltd. (NANKOKU City), MASHIMA Farm (NOICHI Town), Forestry Technology Center (Kami City), URADO Elementary School (Kochi City) and SAKAWA Town government (team SAWAKA, 2016). Through site visits, we deepened our understanding of on-site issues and repeatedly considered ideas for solving regional issues. At MASHIMA Farm, students and one teacher from a group received a general explanation from the representative regarding the operations of livestock farmers. Participating students actively asked questions about the calving situation of dairy cows and deepened their understanding of the specific issues facing livestock farmers. (Fig. 7)

Some of the issues they have addressed include farmer issues, forestry issues, information security education for junior high school students, and cultural protection in the region. They discussed the problems, and each came up with a solution idea. At the interim report meeting had held on Wednesday, August 7, 2019, comments were submitted by all participating students to the ideas of each team, which were summarized and fed back to each team.

On February 22, 2020, the seminar for regional collaboration exercises had been held by our 4th grade students at our college. The results of 18 teams and 78 students who found problems, presented solutions, and designed and manufactured solution systems were announced for each business site. At the presentation, people in charge from each business unit participated and lively questions and answers were held with the students. Each team not only showed the idea of the solution, but

Fig. 8 presentation seminar

also actively demonstrated the question and answer by devising an easy-to-understand explanation such as demonstrating the prototype manufactured. (Fig. 8)

According to a questionnaire from students, "I learned from the internship that the plans and process charts created in the class were actually used at company progress meetings." I realized that it could be done in a way. "It was suggested that this class was regarded as a graduation study and a dry run of work, and that he worked with motivation. By solving social problems, students improved their skills as engineers, the ability to think while discussing as team members, and various communication skills through discussions with local people.

Since the regional collaboration exercises consist of teams of students from different specialties, their grade evaluation includes self-evaluation and mutual evaluation by students. Some of the comments in their self-evaluation were as follows:

"In the process of solving the problem, I realized that the range that can be solved only by my specialty is limited, so from now on, I will accumulate knowledge in a wide range of fields and connect it with my specialty.", "I realized the importance of working on my own and incorporating the opinions of various people in order to solve what I don't understand. I learned that it is important for people with different specialties to help each other and solve problems, so I would like to act with these in mind so that I can make use of them in the future." As mentioned above, they said they noticed their narrow field of vision. They also said that they realized that their communication skills had improved through a year of team activities. In addition, they say that they have more contact with people outside the college, and they can work on it while paying attention to the wording, so it is effective in preparing for job hunting.

Fig. 9 graduation research presentation

Students who completed the regional collaboration exercise in the 4th grade took advantage of their experience to engage in graduation research, job hunting, and higher education activities in the 5th grade.

For example, a student who developed a mobile tourism application in the regional collaboration exercise conducted a UX (user experience) evaluation study of this application in a graduation research. Focusing on the difference between using it as a resident or as a tourist, he evaluated usability, improved the application, and presented his research results at his graduation research presentation on January 22, 2021. (Fig. 9)

In addition, some students have been working on solving regional issues as their graduation research theme, such as "Research on digital signage systems aimed at improving operational efficiency through content sharing between industry, academia, government, and the private sector."

These activities have elements such as collaboration with external institutions, combination of students with different specialties, and practice of project management, so students can experience how to work in a company before employment. Students use this experience for their graduation research, job hunting, and higher education activities.

Conclusions

In the lower grades, the national language and social studies will work together to engage in liberal arts education and use active learning techniques to cultivate a local perspective using statistical data. And we aim to acquire the ability to discover and solve problems by themselves and to transmit them.

By making students practice it through “Unazuku Presentation” and challenge the Regional Revitalization Idea Contest, they have broad perspective and experience level.

The ideas developed in these activities will be concretely systemized in the regional collaborative exercises incorporated in the educational curriculum. Students from different fields of expertise make use of the group work techniques already learned to form teams and work together. The strength of our college is that students develop practical hybrid type human resources by focusing on local issues and technical issues and experiencing regional contributions.

“Unazuku Presentation", which was launched in 2016, initially had many teams including students in the third grade and above. Since the start of the regional collaboration exercise in 2019, students have been learning regional collaboration as follows: 1st and 2nd graders through "Unazuku Presentation", 4th graders through regional collaboration exercises, and 5th grade through graduation research. In the 4th grade regional collaboration exercise, the theme of "Unazuku Presentation" can be continued, and this year, 3 teams are working on the realization of the idea of "Unazuku Presentation". Several teams in the second grade have embodied the idea of "Unazuku Presentation" in the third grade and are challenging the off-campus contest, but not all the third graders are working on it.

The current issue is that there is no curriculum on regional collaboration in the third grade and students' motivation for solving regional problems is not maintained. To stay motivated, we are considering a curriculum to learn local issues in the third grade. Through this curriculum, third graders can join the fourth grade team of regional collaboration exercises from the second semester.

In addition, until now, "Unazuku Presentation" was conducted as part of the Japanese language and social classes for first and second graders, but it was difficult to hold events in the classes and the burden on the teachers in charge was heavy. In the future, "Unazuku Presentation" will be separated from the lessons and will be held as a school event by the Career Support Office and the Regional Cooperation Center. We intend to invite local businesses and local governments to the event so that the event is truly a collaborative project in collaboration with the community.

This regional collaborative education fosters the future-mind engineers

Acknowledgement

This work was supported by a research grant from the Chuden Foundation for Education.

References

David J. Grant (2018). Extensive Reading: A Foundation for Active Learning. *Bulletin of National Institute of Technology, Kochi College*, 63, 73-78

Harunori FUJITA, Hidenori YOSHIMATSU, Moe TANIWAKI, Shiori SHIMADU, Haduki YAMAMOTO, Yuma HORIIKE & Motoki SATO (2019). Development of a Paper used Disposal Ginger, “Shoga Paper”. *Bulletin of National Institute of Tecchnology, Kochi College*, 64, 37-44

Junko Nagahara, Shihoko Onaga & Motoki Sato (2018). Bibliobattle: A Reading Competition Game. *International Simulation and Gaming Association 49th Conference*.

Momoi Arita, Yui Sueuchi, Hina Shimomoto, Reina Nonami, Motoki Sato & Harunori Fujita (2019). Development of ginger paper "Shoga Paper" using traditional Tosa Washi papermaking technology. *CSJ West Japan Chemistry Forum 2019 in Tokushima*, 2P098

Motoki Sato & Shihoko Onaga (2018). Attempts on regional learning through Japanese language education for science and engineering students. *The 12th International Symposium on Japanese Language Education and Japanese Studies*.

team SAKAWA (2016). *Comprehensive plan to make together - Kochi Prefecture Sagawa style social design -*. Japan, ISBN978-4-7615-2621-4

WORKPLACE LEARNING AND ASSESSMENT IN APPLIED EDUCATION IN HONG KONG

Candy K.Y. Liu*, Jonathan K.F. Lee and Raymond C.S. Man

Vocational Training Council, Hong Kong, China

*candyliu@vtc.edu.hk

Abstract

Workplace Learning and Assessment (WLA) is a structured pedagogical approach newly initiated by the Vocational Training Council (VTC) in Hong Kong. It aims to nurture skilled talent capable of performing up to occupational and industry standards leading to vocational qualifications, by integrating the school-based and work-based learning components in programmes. By launching this initiative, closer collaboration between the VTC and the employers for sustainable manpower development can be achieved. The Government is also strongly supporting this initiative by introducing the Pilot Incentive Scheme to Employers to encourage employers to join hands with the VTC to develop and implement structured WLA activities.

Referencing the best practice of the German and Swiss dual-track vocational and education systems which have been internationally recognized, and the well-established WLA model adopted in New Zealand, the VTC has developed its own WLA system to suit the local applied education environment. In accomplishing this, the VTC has cooperated with employers in developing unit standards and assessment tasks for assessing trainees' competence against the employers' requirements. A tripartite platform is therefore also established to enable competence-based learning and assessment with the participation from the VTC, employers and trainees. Not least is the programme curricula enhancement which can be attained by incorporating the latest skills, knowledge and technologies required by the industry.

In order to conduct WLA in a systematic and credible manner, the VTC has established a robust quality assurance mechanism to govern WLA implementation, including the assessment workflow and the accreditation of workplace trainers, verifiers and assessors. Meanwhile, a web-based assessment system has been devised to facilitate trainees and employers in conducting WLA. With the system, the learning progress of trainees can also be tracked at all times.

WLA approach enables trainees to learn and sharpen their skills in the workplace, and acquire industry-recognised competencies, thereby contributing to sustain a well-trained and qualified workforce for our society. This paper focuses on the aforementioned features of the VTC's WLA system, particularly the collaboration with employers in WLA development and implementation.

Keywords: *Workplace Learning and Assessment, Applied Education, Vocational and Professional Education and Training*

Introduction

In the VTC, "Workplace Learning and Assessment" is a structured pedagogical practice where education is integrated into the work setting, and trainees' competence is assessed in an authentic workplace. WLA enables the integration of the school-based and work-based learning components in academic programmes, and becomes part of the curriculum requirement to enhance trainee learning motivation. Academic programmes can therefore keep abreast of the latest industry developments. Through the structured workplace assessment activities, employers can have a clear picture of the trainees' performance. The training activities can be fine-tuned based on the trainees' assessment results to enhance their competence.

To launch the WLA initiative in the Vocational and Professional Education and Training (VPET) in the first quarter of 2020 in Hong Kong, the VTC has made reference to the international best practice of the dual-track systems and the WLA model. Trainees study part-time at the VTC while they receive apprenticeship training at the companies they work for at the same time. The VTC collaborated with the employers to develop WLA activities that are widely practicable in the industry. The Government is also strongly supporting this initiative by introducing the Pilot Incentive Scheme to Employers to encourage employers to join hands with the VTC to develop and implement structured WLA activities for particular industries. Participating employers will receive a subsidy in conducting WLA.

This paper elaborates on the VTC WLA system, the related quality assurance (QA) mechanism, the engagement of employers, the web-based assessment system, and the feedback from employers and trainees.

International Practices of Workplace Learning and Assessment

To develop a WLA system to suit the local applied education environment, the VTC has made reference to the internationally recognized practices over the world, for example, the dual-track vocational education and training (VET) systems in Germany and Switzerland, and the workplace learning and assessment system in New Zealand.

The dual-track VET system in Germany is a systematic integration of the merits of training in a company and education in a vocational school. It aims to strongly facilitate a successful transition of young people from school to work and to guarantee a skilled workforce underpinning a successful economy (Fürstenau, Pilz and Gonon, 2014). Over the course of two to four years, trainees spend a couple of days a week, or even blocks of several weeks at a time, at a vocational school where they acquire theoretical knowledge. At the same time, they gain practical knowledge and hands-on experience in a company or public sector institution (Hockenos, 2018). Trainees' competence is assessed both in the school and the workplace. Employers and industry practitioners play a critical part in the delivery of workplace training and assessment design (Hoeckel and Schwartz, 2010). The graduates are qualified as skilled workers after passing the examination and this qualification is recognized throughout the country. Each year about two-thirds of them manage to secure full-time employment from the same training firms upon graduation. The graduates can also articulate with bachelor or even master degrees in universities of applied sciences or other post-secondary institutes (Legislative Council Secretariat Research Office, 2015).

In Switzerland, the dual-track VET system is also predominant. The majority of the young people commence vocational education and training after the lower-secondary level. Trainees will have practical training (apprenticeship) on three to four days at a training company, and the training is supplemented by theoretical classes on one to two days at a vocational school (FOC, 2021). Similar to the German dual VET system, workplace is one of the settings where trainees' competence is assessed through on-the-job assessment (Hoeckel, Field and Grubb, 2009). Trainees can concentrate on their profession after graduation. They can also reach successive higher levels of education through extra training. The federal vocational baccalaureate allows trainees to study for a bachelor's degree at applied universities (SWI swissinfo.ch, 2020).

Not only do European countries, such as Germany and Switzerland place emphases on the workplace in vocational training and education, New Zealand has also established a well-structured WLA system. The WLA model in New Zealand is also characterised by the mixture of on-the-job training and off-the-job training, where the former takes place in a company and the latter is conducted at a polytechnic or a technical college, so as to maximise the benefits of the complementarity between school-based and work-based learning. In this connection, assessment will be arranged in the polytechnic and/or workplace (Vaughan and Cameron, 2009). The structured provision of WLA in New Zealand is arranged and managed by the Industry Training Organizations (ITOs) that are recognised by the Associate Minister of Education (Tertiary Education) (New Zealand Qualifications Authority, 2021). ITOs work with industries to develop assessment materials, including the unit standards. A unit standard describes what a trainee who has achieved the standard knows and can do. Each standard has a defined credit value, which reflects the level of complexity of the skills and knowledge that are recognized by the standard. To gain credits for a unit standard, trainees have to demonstrate that they are competent. Workplace assessors play a key role in supporting learners throughout the training and assessment processes. There is a systematic registration system of assessors in New Zealand.

VTC Workplace Learning and Assessment

To nurture a highly skilled workforce, the VTC has taken a leap forward to develop its own WLA system by making reference to the international best practice. The VTC has cooperated with employers in developing unit standards and assessment tasks for assessing trainees' competence against the employers' requirements. A tripartite platform is therefore established to enable competency-based learning and assessment with the participation of the VTC, employers, and trainees. The Engineering Discipline of the Hong Kong Institute of Vocational Education (IVE) of the VTC has developed WLA elements for its Higher Diploma (HD) programmes and Diploma of Foundation Studies (DFS) programmes (Table 1). The programme curricula are enriched by incorporating the latest skills, knowledge, and technologies required by the industry.

Table 1: IVE programmes with WLA

Programmes
HD in Automotive Engineering
HD in Building Studies
HD in Building Services Engineering
HD in Civil Engineering
HD in Computer Engineering
HD in Computer and Electronic Engineering
HD in Electrical Engineering
HD in Mechanical Engineering
HD in Surveying
DFS (Aviation)
DFS (Engineering)

Development of Workplace Learning and Assessment

In the VTC, workplace assessment is the process of assessing the professional skills, knowledge, and attributes of a trainee in an authentic workplace. It

involves the collection and recording of real-time, authentic, reliable and valid evidence demonstrating a trainee's competence in each unit standard to prove the trainee knows about and/or can do the tasks in a repeatable and consistent way. The development of workplace assessment reinforces the learning outcomes and provides a foundation to ensure that all stakeholders (trainees, employers, VTC) share the same teaching and learning emphases and are working towards the same learning objectives.

At the beginning of the WLA development, attempts were made to identify the feasible WLA elements from the programme curricula that were practically oriented, common and core in the industry (Step 1 in Figure 1) in consideration of the apprenticeship training plans of both large corporations, as well as small and medium enterprises (SMEs). Those companies were also consulted on the practicality of the WLA elements (Step 2 in Figure 1) so as to make sure the WLA tasks were practicable across different employers in the industry. After the WLA tasks were identified, reference was made to the local (e.g. the Specification of Competency Standards (SCS) in Hong Kong) and international standards (e.g. unit standards in New Zealand). After that, unit standards and other assessment materials, including trainee assessment records and assessor guides were drafted. Unit standards reflect the competency requirements of particular tasks and the expected outcomes trainees have to demonstrate. Trainee assessment records contain all the assessment tasks that trainees are required to perform to meet the required outcomes of the unit standards. These records also provide instructions on what and how the evidence is to be collected and presented, and the assessment requirements and conditions to be met. Trainee assessment records also serve as evidence records to document the progress, results and the verifier/assessor's feedback on the assessment tasks/activities. Assessor guides provide the assessor with the structure of the assessment, the type of evidence required and how it should be collected and judged.

After the assessment materials were drafted, further consultations with employers were conducted to solicit their opinions on the feasibility of implementation, coverage of requirements/tools/methods, and implementation schedule. The WLA materials were adjusted and finalized based on their feedback (Step 3 in Figure 1).

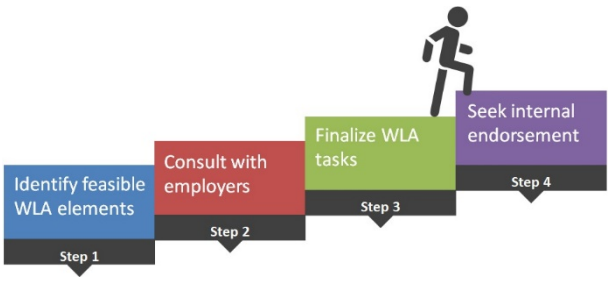


Figure 1: Major steps in WLA development

As employers play a critical part in the delivery of workplace training and assessment, they will take up the roles of trainers, verifiers and assessors in WLA.

Workplace trainers and verifiers are experienced trade practitioners who shall work closely with the trainee in the workplace. Often they are the supervisor of the trainee. Workplace trainers, who are the experts in their fields and have proven technical skills and knowledge, provide training, coaching and feedback to help the trainees in meeting the standards. On the other hand, verifiers confirm that a trainee can consistently perform specified tasks in the workplace. They record their observations on trainees' performance on the trainee assessment records, provide feedback to trainees, and pass on the verifications to the assessors. Assessors, who are experienced trade practitioners in the capacity of supervisory level or above, have the key role to judge the trainees' competencies at the workplace. They must make objective and evidence-based decisions about the trainees' competencies and have overall responsibility for the assessment process. Depending on the nature of the companies and the deployment of WLA staff of the companies, workplace assessors can cover the role of verifiers to verify trainees' assessment work and performance.

Quality Assurance Mechanism of VTC Workplace Learning and Assessment

In order to conduct WLA systematically and credibly, VTC has established a robust quality assurance (QA) mechanism to govern WLA development and implementation. The QA measures ensure the validity of the assessment materials, tools, processes, and judgments made to the trainees' performance. It is also a supportive mechanism for continuous improvement of the contents and standards of WLA and the design of the assessment methods and materials. The unit standards developed are required to be reviewed and endorsed by the VTC programme boards before application (Step 4 in Figure 1). Pre-assessment moderation has to be conducted to ensure the WLA materials are fit for purpose and appropriate to the level of credit value of the unit standard. In order to assure the appropriateness of assessment decisions, post-assessment moderation has also to be completed. It aims to verify whether assessment decisions are made according to the performance criteria, and using evidence that is current, valid, accurate, authentic and sufficient. It is also a strategy to provide feedback to the assessors and assessment developers on good practices, and/or make recommendations for continuous improvement.

To ensure the right people to implement WLA, the eligibility of workplace trainers, verifiers, and assessors are required to be accredited by the VTC programme boards. They are nominated by their employers and have to fulfil the requirements relevant to the unit standards. They are required to be holders of the relevant recognized degrees or professional qualifications with relevant experience in the industry. Furthermore, it is necessary

for the nominated workplace verifiers and assessors to complete a training workshop offered by the VTC Quality Enhancement and Accreditation Office (QEAO) to equip them with the knowledge and practical skills in delivering WLA.

To enable workplace trainers, verifiers and assessors to conduct assessments in the workplace more effectively within the QA framework, the QEAO has provided handbooks for them.

Engagement of Employers in VTC Workplace Learning and Assessment

Employers are the key stakeholders in WLA. Without them, it is almost impossible to implement WLA. A series of ongoing promotion activities are conducted to encourage employer participation in WLA. For instance, promotional materials and videos were produced to promote WLA highlighting its advantages and the roles of employers in its implementation. Promotion visits to relevant trade associations, training boards and individual companies were also arranged to introduce WLA and encourage employers to nominate their staff to be trainers, verifiers and assessors. Besides, large-scale briefing sessions to employers were held to provide an interactive platform for them to know more about WLA.

Web-based Assessment System for Workplace Learning and Assessment

The VTC has pioneered a web-based assessment system to facilitate the implementation of WLA among trainees, employers and the VTC. The assessment tasks are constructed on the system with the unit standard and the assessment progress displayed on the interface (Figure 2).

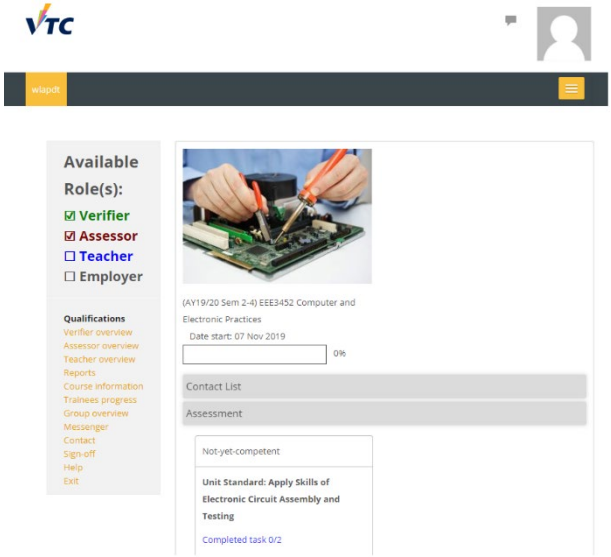


Figure 2: Web-based assessment system for WLA

On the web-based assessment system, the trainee, verifier and assessor can perform a series of action to complete the WLA tasks. The trainee can complete the assessment tasks online and upload the assessment evidence, such as written reports, photos and videos which have recorded the competence that the trainee has demonstrated. The verifier will then verify the assessment evidence and provide the feedback online for the trainee. Based on the verification, the assessor can make judgement about the trainee's performance and also give feedback to the trainee on the system. The WLA tasks submission/verification/assessment status is clearly displayed on the platform. After each step is completed, the trainee/verifier/assessor will be notified of the status via email. VTC teachers can also view the submission/verification/assessment status at all times.

With this web-based assessment system, WLA can be conducted without the constraints of place and time. The system also replaces the traditional paper and pen approach to conduct assessment so as to enable a good electronic record of the trainee's learning progress and performance, thereby contributing to effectively build up a learning portfolio for the trainee. In this regard, the areas of improvement of the trainees could be more easily identified which would help analyse the training needs. Moreover, this digital platform can save time from passing the documents among the parties concerned and it is convenient to search for the information required and assessment results.

Example of WLA Development and Implementation

One of the WLA tasks of the HD in Computer and Electronic Engineering programme is taken as an example in this paper to elaborate on the development and implementation of WLA. After reviewing the syllabus of the programme and the apprenticeship training plans of employers, the learning content on electronic circuit assembling and testing was identified as the WLA task. Employers, including large corporations and SMEs were then consulted on the practicality of this WLA task. As this WLA task was fundamental and more common in the industry, the employers agreed to adopt it. After the WLA task was confirmed, the programme team drafted the unit standard and other assessment materials with reference made to the international standard. The employers were invited to comment on those assessment materials again before the WLA materials were enriched and finalized.

Before the commencement of WLA, pre-assessment moderation was conducted as explained in the earlier section about the QA mechanism. Besides, pre-assessment meetings were held with the trainee, workplace verifier and assessor to ensure they understood the assessment task, the unit standard and the performance criteria thoroughly before the task was carried out. While the employers were undertaking the WLA task, VTC provided continuous support to them wherever it deemed appropriate. After the assessment, post-assessment moderation was organised to check the

consistency of assessment decisions according to the assessment materials and performance criteria, and using evidence that was current, valid, accurate, authentic and sufficient.

Feedback from the Employers

After the employers had completed the WLA activities with the trainees in the first year of the programmes, questionnaire surveys were conducted to collect the feedback from all the 30 employers in the HD and DFS programmes on the implementation of WLA and the web-based assessment system.

In the survey, the employers were invited to rate different aspects related to the implementation of WLA and the web-based assesssment system on a 5-point Likert scale. Rating of '1' denotes that the respondent strongly disagrees with the given statement whereas a rating of '5' denotes that the respondent strongly agrees with the given statement.

Regarding the survey results of the implementation of WLA, 24 out of 30 (80%) employers returned the questionnaires. Positive feedback was generally given by the respondents with an average rating of 4.0 in the overall satisfaction on the WLA implementation. As shown in Table 2, the average rating given by the respondents on each dimension was close to 4 or even higher than 4. In the survey, qualitative data were also collected to study the employers' views. According to the employers' feedback, they commented that the unit standards with the concise performance criteria were helpful in making assessment judgements. They also appreciated that WLA could facilitate trainees to achieve the skill standards required by the industry and obtain practical work experience before graduation. From the employers' perspective, WLA could help identify the strengths and weaknesses of the trainees, as well as the areas for improvement, such that the employers could improve and adjust the workplace training. The employers also stated that WLA had improved the communication among trainees, employers and the VTC.

Another questionnaire survey was also conducted to collect the feedback from employers on the WLA web-based assessment system. 23 out of 30 (76.7%) employers returned the questionnaires. In general, employers rated the system positively with an average rating of 4.0 in the overall satisfaction on the WLA web-based assessment system. As presented in Table 3, the average rating given by the employers on each dimension was around 4. As reflected from the qualitative survey results, the employers claimed that the paperless system could help protect the environment and improve the effectiveness in conducting assessments. The employers also remarked that the system was easy to use and it was convenient for them to check the assessment records of trainees.

Table 2: Feedback from the employers on WLA implementation

Statement	Average rating
Sufficient time was given to conduct WLA.	3.9
Sufficient WLA tasks were given to trainees.	3.9
WLA was helpful to organize the workplace training.	3.9
The assessment materials facilitated the delivery of workplace assessments.	3.9
The performance criteria facilitated judgement on assessment evidence.	4.0
Sufficient support was provided by the VTC.	4.3
Overall satisfaction	4.0

Table 3: Feedback from the employers on the WLA web-based assessment system

Statement	Average rating
The system was user-friendly.	4.0
The interface of the system was clear.	4.0
The system functioned smoothly.	4.0
It was convenient to use the system anytime and anywhere.	3.9
The system facilitated the delivery of workplace assessments.	4.1
The system enabled me to keep a good record of the trainees' performance.	4.0
Adequate training materials and guidance were provided by the VTC.	4.0
Overall satisfaction	4.0

Feedback from the Trainees

Similarly, questionnaire surveys were arranged to collect trainees' feedback on the WLA implementation and the web-based assessment system. Questionnaires were sent to all the 104 trainees who participated in WLA in the HD programmes and the DFS programmes.

All of the trainees had completed the WLA activities in the first year of the programmes. 66 out of 104 (63.5%) trainees responded to the questionnaire on the WLA implementation. As reflected in Table 4, the feedback given by trainees was generally positive with an average rating of 3.8 in the overall satisfaction with the WLA implementation. The average ratings given by the trainees on the other dimensions were around 3.7, except for the aspect of the sufficiency of WLA tasks, which had a rating of 4.5. The trainees commented that WLA had facilitated the enhancement of their practical skills and better understanding of the employers' requirements. For the survey on the WLA web-based assessment system, 85 out of 104 (81.7%) trainees returned the questionnaires. An average rating of 4.0 was obtained in the overall satisfaction with the WLA web-based assessment system. As revealed in Table 5, the average rating given by the trainees on each dimension was

around 4. The trainees expressed that the system had enabled them to access the feedback from the verifiers and the assessors more conveniently which was helpful for them to reflect on their performance. The trainees also thought that the system was easy to use.

Table 4: Feedback from the trainees on WLA implementation

Statement	Average rating
Sufficient time was given to complete WLA.	3.7
Sufficient WLA tasks were given to me.	4.5
WLA enabled me to understand my employer's requirements.	3.7
WLA enabled me to identify the areas for improvement.	3.7
Sufficient support was provided by the VTC.	3.8
Employer's feedback was helpful.	3.7
Overall satisfaction	3.8

Table 5: Feedback from the trainees on the WLA web-based assessment system

Statement	Average rating
The system was user-friendly.	4.0
The interface of the system was clear.	3.9
The system functioned smoothly.	4.0
It was convenient to use the system anytime and anywhere.	4.0
The system facilitated assessment submissions.	4.0
The system enabled me to keep a good record of assessment results and the employers' feedback.	4.1
Adequate training materials and guidance were provided by the VTC.	3.9
Overall satisfaction	4.0

Conclusions and the Way Forward

This paper presents the VTC WLA model with the elaboration of the collaboration between the VTC and the industry in the development and implementation of WLA. After the first-year implementation of WLA, both the employers and the trainees generally appreciated the WLA practice.

Grounded in the successful launch of WLA in different engineering HD and DFS programmes and the valuable experience gained, the VTC has planned to expand the WLA approach to more engineering programmes so as to benefit more trainees and industries. Meanwhile, the VTC is exploring different ways to promote WLA to encourage employer participation.

In the near future, generic and soft skills, such as language skills, communication skills, and interpersonal skills could incorporate the WLA approach as these types of competence could also be learnt and assessed in the workplace. With the WLA of both the trade-specific and generic skills, trainees' competence could be assessed in a more all-round manner to meet the industry requirements.

References

Federal Office of Culture (FOC) (2021). *Swiss education: Vocational education and training*. Retrieved from https://swisseducation.educa.ch/en/vocational-education-and-training-0.

Fürstenau, B., Pilz, M. & Gonon, P. (2014). The Dual System of Vocational Education and Training in Germany – What Can Be Learnt About Education for (Other) Professions. In Billett, S. et al. (Eds.). *International Handbook of Research in Professional and Practice-based Learning* (pp. 427-460). Dordrecht: Springer Science+Business Media Dordrecht.

Hockenos, P. (2018). *How Germany's Vocational Education and Training system works*. Retrieved from https://www.cleanenergywire.org/factsheets/how-germanys-vocational-education-and-training-system-works.

Hoeckel, K., Field, S. & Grubb, W. N. (2009). *Learning for Jobs: OECD Reviews of Vocational Education and training – Switzerland.* Paris: OECD.

Hoeckel, K. & Schwartz, R. (2010). *Learning for Jobs: OECD Reviews of Vocational Education and training – Germany.* Paris: OECD.

Legislative Council Secretariat Research Office (2015). Information Note: Vocational education and training in Germany. Hong Kong: Legislative Council Secretariat Research Office.

New Zealand Qualifications Authority (2021). *Accredited Industry Training Organisations*. Retrieved from https://www.nzqa.govt.nz/for-business/ito.do.

SWI swissinfo.ch (2020). *Why Switzerland's dual-track education system is unique*. Retrieved from https://www.swissinfo.ch/eng/business/school-and-work_why-switzerland-s-dual-track-education-system-is-unique/45512392.

Vaughan, K. & Cameron, M. (2009). Assessment of Learning in the workplace: A Background Paper. Wellington: Industry Training Federation.

NARROWING DIGITAL GAP IN CHILDREN WITH FEMALE COLLEGE STUDENTS

Kaori Tsukazaki*[a], Takeshi Shintoku[b] and Takaaki Fukuzoe [c]

[a] National Institute of Technology, KOSEN, Academic Affairs Section, Tokyo, Japan
[b] National Institute of Technology (KOSEN), Kagoshima College, Department of Information Technology, Kagoshima, Japan
[c] National Institute of Technology (KOSEN), Kagoshima College, Department of Electric Control Engineering, Kagoshima, Japan

*tsukazaki@kosen-k.go.jp

Abstract

Only 15% of the number of students who major in Engineering in higher education in Japan are female. Judging from the fact that this figure was 0.9% in 1975, a gender balance in this field has not been attained in the intervening decades. In 2017, female students attending a National College of Technology (KOSEN) in a local city in Japan initiated a chapter of a student-run international volunteer organisation to teach ICT skills to children. Their major goals are to foster interest in STEM in younger generations and to introduce them to female role models. They believe that this will lead to gender parity in Engineering in the future. In addition to the gender gap in STEM, another educational issue is most notable. The educational situation in rural parts of Japan is very different from that in Tokyo and its surrounding areas. This is what we call the 'urban-rural divide' in education (e.g., Amini & Nivorozhkin 2015; Warf 2019). Moreover, when it comes to STEM education, children in rural areas have less opportunities to get involved in pleasurable STEM workshops or meet key role models in the related fields. The purposes of this paper are i) to focus our attention on the digital gap between children in rural areas and urban areas in Japan and ii) to discuss the possibility of a project to narrow this gap. With the help of the local Board of Education and industry who appreciated the project to teach digital skills to children in local cities for the purpose of increasing the number of female students in STEM in the future, the college student volunteers held four workshops within a two-month period in 2019. Results from the post-workshop questionnaires indicate that the workshop was successful in motivating most of the participants and increased their interest in more advanced computing and robotics.

Keywords: *digital gap, STEM education, programming robots, industry, the Board of Education*

Introduction

According to *The White Paper on Gender Equality 2019* published by the Gender Equality Bureau Cabinet Office in Japan, the number of female students who major in Engineering in higher education is only at 15%. Judging from the fact that this figure was 0.9% in 1975, a gender balance in this field has not been attained in the intervening decades (*The White Paper on Gender Equality 2019*).

In 2017, female students in a National College of Technology (KOSEN) initiated a chapter of a student-run international volunteer organisation to teach ICT skills to children. Their goal is to foster interest in STEM and introduce children to female role models. They believe that this will lead to gender parity in Engineering in the future (see Tsukazaki, Shintoku & Fukuzoe 2019).

The purpose of this paper is to discuss a project carried out by female college students to bridge the urban-rural divide in STEM education in Japan from two perspectives. First, children who live in a local city far away from Tokyo need to be provided with the same opportunities to learn STEM. Children who live in urban areas seem to have more opportunities to attend events such as a STEM workshop and meet female role models such as the 'STEM Girls Ambassadors' coordinated by the Gender Equality Bureau Cabinet Office of the Japanese government. In contrast, children who live in a local city are much less likely to meet those 'super' role models in STEM and they have fewer opportunities to attend a STEM workshop in rural areas. For these reasons, the female college students established the volunteer organisation in a local city in Japan for the purpose of providing children with STEM workshops.

Second, children who live in a geographically remote area also need to be provided the same opportunities. The word 'remote' in this paper is defined as a place where it takes hours to get from the central part of a local city by public transportation such as bus, train, ferry, or plane. If there is no public transportation, it is necessary to have a car and a driver to get there.

After two years of hosting workshops to teach ICT skills to children through this project, we found that children who lived in remote areas had significant difficulties in attending the workshops for themselves and they needed their parents or teachers' support to join us. This situation emerged as an example of an urban-rural divide in STEM education in Japan. We realised that just visiting schools close to KOSEN to have programming workshops was not sufficient to reach all children, or those already suffering from a lack of opportunity. It follows from this experience that visiting elementary and junior high schools in remote areas is essential.

A Project with the Board of Education in a Local Government

The following section outlines how we organised workshops in remote areas. Since the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan decided to teach computing skills at elementary schools in 2020 and junior high schools in 2021 (see Tsukazaki, Shintoku & Fukuzoe 2019), we had a request from the local Boards of Education for our students to become mentors for children to engage with them in the computer classroom and particularly at the weekend. Therefore, in order to have access to schools in remote areas and analyse their needs in a STEM workshop, we decided to cooperate with the local Boards of Education.

In addition, a leader in the Engineering industry appreciated the college students' efforts to increase the number of female students in Engineering in Japan. As a result, we had the opportunity to introduce some of the latest Japanese technologies in the workshops: a game with the facial recognition system and two robots who talk as programmed. A team of engineers who supported the student volunteers was sent to the venue every time we had a workshop. In this way, we had four workshops for children in remote areas in September and October in 2019: three workshops on an island where it takes two hours by plane to get and another workshop in a local city which takes two hours by car to reach from the central part. Figure 1 shows one of the workshops on the island.

Figure 1. A STEM Workshop for Pupils

Results

First, Table 1 shows the number of participants in the workshops. Workshops A and B were held for fifth and sixth graders (11 years and 12 years) at elementary schools. Workshop C was held locally. Representatives from elementary and junior high schools in the area made a presentation on their scientific study in summer holidays. Workshop D was held in a junior high school. The number of 'adults' in Table 1 includes people who observed the workshops such as Principal, Vice Principal and teachers of the schools, leaders in the local Boards of Education, and so on. As for workshop C, the number of 'adults' includes children's parents and grandparents.

Table 1. Number of Participants in Workshops (September and October in 2019)

	Boys	**Girls**	**Adults**	**Total**
Workshop A	10	8	9	27
Workshop B	4	17	9	30
Workshop C	5	13	45	63
Workshop D	22	17	14	53
Total	41	55	77	173

In order to understand participants' background, we asked the participants in workshop D about their experience of using computers. Table 2 shows that 38 out of 39 ninth-grade junior high school students (97%) had used a computer before. 26 students (67%) used a computer both at home and at school, whereas four students (10%) only used a computer at home and eight students (20%) only used a computer at school.

Table 2. Participants' Experience of Using a Computer (Workshop D)

Home	4
School	8
Home and School	26
No experience	1
Total	39

Furthermore, Figure 2 shows their purpose of using a computer whether it was at home or at school. 17 students searched for information on the Internet. 13 students played games. 12 students used a computer for programming. 11 students used a computer to do their assignments. Six students used a computer to watch videos on websites. Two students made a CD and a New Year's card via a computer. One student read an e-book. Another student searched for particular sounds on the Internet.

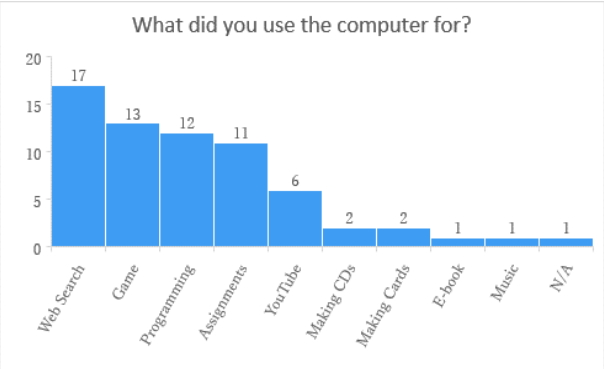


Figure 2. Participants' Purpose of Using the Computer

The results of the feedback on workshop D are provided below [see Figures 3(a) and 3(b)]. Figure 3(a) shows that 38 participants out of 39 said that the workshop was fun (97 %), and Figure 3(b) shows that 92 % said that they were able to control the robot well.

In other words, only one student said that it was not fun [Figure 3(a)] and three students out of 39 said that they could not control the robot [Figure 3(b)].

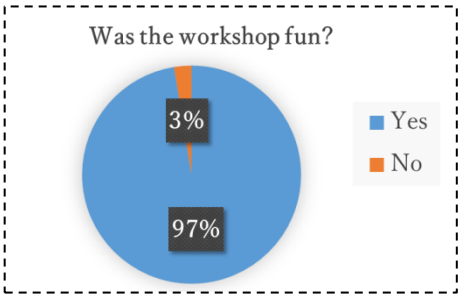


Figure 3(a). Feedback on Workshop D

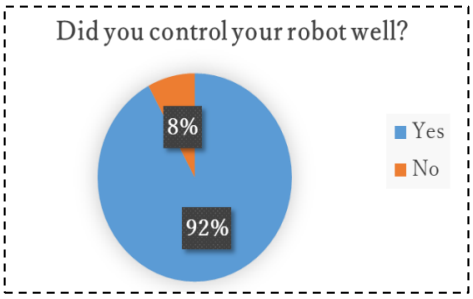


Figure 3(b). Feedback on Workshop D

Discussion

Judging from the percentage of junior high school students who said the workshop was fun (97%) and were satisfied with their own skill in controlling the robot (92%), workshop D seemed to be successful [see Figures 3(a) and 3(b)]. According to the questionnaire, most participants in workshop D became interested in programming the computer and assembling a robot and were motivated to learn more. It was a great pleasure that the workshop motivated some students to learn about advanced computing and possibilities of robots in the future. Others wanted to study Science and Mathematics with college student volunteers in addition to ICT skills. They were also interested in their academic life in a College of Technology (KOSEN). One of the junior high school students said that it was so enjoyable that time passed very quickly in the workshop.

On the contrary to the positive feedback, we also received negative feedback. It should be noted that only one student who said that the workshop was not fun had not experienced using a computer before (see Table 2). The workshop might well be demanding for the student with the lack of basic skills in using a computer. Warf (2019) defines 'the inequality' of having regular access to the Internet or technical skills as 'digital divides'. He also points out that 'Internet access' is 'increasingly necessary for a successful or convenient life'. It follows that we need to pay attention to children with a different level of ICT skills as well as to provide them with opportunities to use a computer.

In order to reach a greater number of children and motivate their interest in STEM and choose a study or career path in a STEM-related area, the local Board of Education can play an important role. In this study, the local Board of Education helped us understand the educational needs of local schools. Without this, it would have been difficult for us to find out which school needed our support to teach ICT skills to their pupils. However, the total number of pupils who attended was modest in both workshops A and B in Table 1. This number reflects the typical size of an elementary or junior high school in a remote area. Due to small numbers of children, more than two grades are sometimes taught together in the same classroom, or an elementary school and a junior high school are combined to be one.

Visiting remote areas often can be challenging. Therefore, it may be more effective to join a local event in order to impact the maximum number of children even on a short visit to rural areas. It should be borne in mind that student volunteers are normally occupied with studying at their college and it is expensive to visit remote areas by public transportation, especially by plane. Furthermore, it is sometimes pointed out that impacting children's parents as well as teachers is important because they affect the children's academic path greatly. For these reasons, workshop C was a successful model in that we reached as many as 63 participants at a time. In a similar study, National Institute of Technology (KOSEN), Sasebo College asked participants' parents to complete a questionnaire to better understand their needs and satisfaction with the activity (Tsukazaki & Ohshima 2020). In our future study, the parental questionnaire on the workshop also needs to be considered.

Finally, there is a possibility that college student volunteers may be more involved in teaching ICT skills to elementary school pupils and junior high school students. This is because the 'GIGA School Program' was launched by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) during a pandemic in 2020. In our study, Tables 2 and 3 showed that the junior high school students were not familiar with using computers in their everyday lives. However, the GIGA School Program enabled each pupil or student to have a device with a high-speed network at school by the end of March in 2021. In order to promote 'optimized and creative learning' with the use of the device, pupils and students as well as teachers need to learn how to use a computer. This raises the possibility of the college volunteers' contribution.

Conclusions

It can be concluded that female college volunteers' project of teaching ICT skills to children satisfied educational needs of some rural schools to some extent. A wide range of support from the local government, media, industry, and their own college realised this project and made it meaningful and pleasurable for children. It is extremely important to keep working for children in rural areas so that they will not be left behind in the modern society where Big Data, IoT, AI, and robots are getting even more crucial in their lives.

Acknowledgements

We would like to express our deepest gratitude to NEC Corporation and Kagoshima Prefectural Board of Education for supporting *Robogals Kagoshima*. Without their great support, we would not have been able to reach local schools and provide them with our workshops in local cities. We would also like to thank Dr Aisling O'Boyle of Queen's University Belfast in the United Kingdom who is always such an inspiration to us by making us think about new perspectives.

References

Amini, C. & Nivorozhkin, E. (2015). The urban-rural divide in educational outcomes: Evidence from Russia. *International Journal of Education Development* 44, 118 – 133.
Online: https://doi.org/10.1016/j.ijedudev.2015.07.006

Gender Equality Bureau Cabinet Office (n. d.). STEM Girls Ambassador.
Online:
http://www.gender.go.jp/STEM_Girls_Ambassadors/index.html [In Japanese]

Gender Equality Bureau Cabinet Office (2019). *The White Paper on Gender Equality 2019*.
Online:
http://www.gender.go.jp/english_contents/about_danjo/whitepaper/pdf/ewp2019.pdf

Ministry of Education, Culture, Sports, Science and Technology (2020). GIGA School Program.
Online: https://www.mext.go.jp/en/content/20200716-mxt_kokusai-000005414_04.pdf

Philip, L., Cottrill, C., Farrington, J., Williams, F., & Ashmore, F. (2017). The digital divide: Patterns, policy and scenarios for connecting the 'final few' in rural communities across Great Britain. *Journal of Rural Studies* 54, 386 – 398.
Online: https://doi.org/10.1016/j.jrurstud.2016.12.002

Tsukazaki, K. & Ohshima, T. (2020). Empowering Women in STEM: College Students and School Pupils. *The 13th International Symposium on Advances in Technology Education*, 91 – 94.
Online: https://www.kosen-k.go.jp/Portals/0/kokusai/ISATE/Proceeding(all)/Transactions_of_ISATE_2019.pdf

Tsukazaki, K., Shintoku, T., & Fukuzoe, T. (2019). Teaching ICT Skills to Children and the Empowerment of Female College Students in STEM in Japan, *IOP Conf. Series: Materials Science and Engineering* 551 (2019) 012036
DOI :10.1088/1757-899X/551/1/012036
Online: https://iopscience.iop.org/article/10.1088/1757-899X/551/1/012036/pdf

Warf, B. (2019). Teaching Digital Divides. *Journal of Geography* 118 :2, 77-87.
Online: https://doi.org/10.1080/00221341.2018.1518990

Sharing of the Hong Kong IVE Engineering Solar Car Project "SOPHIE" on Project-based Learning Outcome

Mike L.W. Sun[*,a], Simon S. P. Shum [a] and S. M. Tang [a]

[a] Department of Engineering, Hong Kong Institute of Vocational Education (Tsing Yi), Hong Kong SAR

* lsun@vtc.edu.hk

Abstract

Being one of the flagship projects of the IVE Engineering, Vocational Training Council, Hong Kong, the solar car project "SOPHIE" achieved several awards in the international competitions over the years. By sharing the success of the project, this paper not only emphasizes the benefits that SOPHIE bought to the Higher Diploma students through project-based learning pedagogy, but also explains how SOPHIE project facilitate academia-industry collaboration in the areas of innovative research by integrating inter-disciplinary knowledge. Since 2009, IVE Engineering staff and students have been working on a solar power vehicle project to support the initiatives of green transportation. From a small beginning, SOPHIE has evolved to seventh generations running 3000 km in Australia in the renowned WSC. The project is a good demonstration of how project-based learning and industry cooperation adds valuable elements to the curriculum and stimulate students' learning experience.

Throughout the project-based learning approach, students can explore the real problem in the world and enhance their understanding of the subject matter as well as latest development in the industry through working in a project collaborating with industry. On top of enhancing their technical competency, they could also develop their problem-solving skills, project management skills and communication skills and marketing/promotion skills. It also helps cementing collaboration between educational institutions and industry. In addition to leading students to ultimately achieve good results in the competition as well as strengthening students' design and practical skills, the SOPHIE project also opens up opportunities for joint applied research project with the industries to develop new products for the market. Successful examples of the SOPHIE project team would be shared in this paper.

Keywords: *Project-based learning, Industry collaboration project, SOPHIE, World Solar Challenge*

Fig. 1. SOPHIE and IVE Engineering Solar Car Team

Introduction

I. Background and History

Since 2009, the engineering discipline of the Hong Kong Institute of Vocational Education (IVE) under the Vocational Training Council (VTC) has initiated the solar car SOPHIE project and established the IVE engineering solar car team, which is also short form as SOPHIE team. The SOPHIE team, including IVE Engineering staff, students and graduates, has been working on a solar power vehicle project to support the initiatives of green transportation (VTC, 2019). Figure 1 shows the SOPHIE team with the SOPHIE solar car. Ten years later, the project has grown from a small scale to a self-developed solar car in Hong Kong. The world-renowned solar car race – Australia's World Solar Challenge (WSC) attracted 47 teams from 23 regions, including Australia, Belgium, Canada, China, Germany, Italy, Japan, Netherlands, Singapore, South Korea, Sweden, Switzerland, the United Kingdom and the United States (WSC, 2019). The SOPHIE team is the only representative in Hong Kong to participate in WSC 2019. Their engineering passion to perfect the design, the comprehensive planning and the perseverance to overcome the barriers in the race have all enabled the team to achieve third runner- up in the "GoPro Adventure Class" in WSC 2013 and third runner-up in the "Cruiser Class" in WSC 2017. In October 2019, SOPHIE 6s competed in the World Solar Challenge race in Australia (Fig. 2), which requires teams to drive relentlessly from the north to the south of the Australian continent in 5.5 days, covering a total distance of 3,021 km (WSC, 2019). The team was honoured as the Third-place award out of 14 international racing teams. Aimed at striving for excellence – the SOPHIE team, has developed into its seventh generation after 10 years of continuous effort.

Fig. 2. Driving SOPHIE 6s in Australia

The team has excelled themselves and proved their real ability to the World by completing the journey. A 3000 km adventures showcase how far SOPHIE has come and IVE student competence for the complex problem. International recognition for IVE Solar Car at World Solar Challenge proved the achievement entirely.

II. Objective

The development of green transportation has become an important part of the global environmental protection trend (Wang et. al, 2018). The purpose of the project is to demonstrate the excellence of IVE students and how IVE Engineering is committed to the develop young talents for green transportation development, smart city mobility and renewable energy applications. Adapted project-based learning method, the IVE Engineering Discipline strengthen student's ability to integrate and apply knowledge and skills while fostering their creativity, collaboration and problem-solving skills. The SOPHIE project is a shining example of the industry collaboration project how the hand-on problem-solving approach of Vocational and professional education and training (VPET) and also groom young professionals for future careers in green transportation.

This paper emphasizes how project-based learning method can benefit to students and also explains how SOPHIE facilitate academia-industry collaboration in the areas of innovative research by integrating inter-disciplinary knowledge.

Benefit students through project-based learning pedagogy

Project-based learning PBL are usually described as active, student-centred methods of instruction that encourage students to work in collaborative groups on real-world problems or challenges (Butzin, 2001). PBL integrates knowing and doing. Students learn knowledge and elements of the core curriculum, but also apply what they know to solve authentic problems and produce results that matter (Markham, 2011). The SOPHIE project is a good demonstration of how project-based learning and industry cooperation adds valuable elements to the curriculum and stimulate students' learning experience.

I. Study actively and understand problems by yourself.

The SOPHIE project revolves around the design and development of solar/electric vehicles. The nominal design of the solar car aims to participate in the World Solar Challenge from Darwin to Adelaide every two years. When students joined the SOPHIE team, the teacher introduced them to the international arena of WSC as a facilitator not a host, and shared with them the video of the previous competition and related competition rules, as an entry event. This format stimulates the student's ability to ask questions and inspires to think about their learning outcomes, e.g. the development of environmentally friendly solar car. PBL emphasizes that students are active in the learning process, rather than becoming passive recipients (Markham, 2011). In fact, based on the experience we have gained, students can gain deeper knowledge by actively exploring challenges and problems in the real world.

II. Select own topic and create sense of ownership

The organization of the SOPHIE team is comparatively simple due to small number of people, including of 5 external advisors, 19 staff members and 37 students. The hierarchical functional structure is used and have shown in Figure 3. The functional structure divides the team into subgroup based on specialty such as Business team/ Design/ Electrical/ Mechanical/ Media. One or two staff members are assigned to manage each subgroup. The advantage of a functional structure is that individuals are dedicated to a single function. These clearly defined roles and expectations limit confusion. As a small team (61 people), the communication among teams is easily achieved. Advantage with Project-based learning approach, an realistic environment for senior students or graduate to share knowledge and other useful skills with freshmen or junior students. Thus, students teaching students. In the midst of solving a problem, senior students with better research skills, greater knowledge as well as keen focus and observation are easily able to pass on the same to younger students. By this act of teaching, graduates reinforce for themselves the principles of the underlying project subject matter. Student will choose a

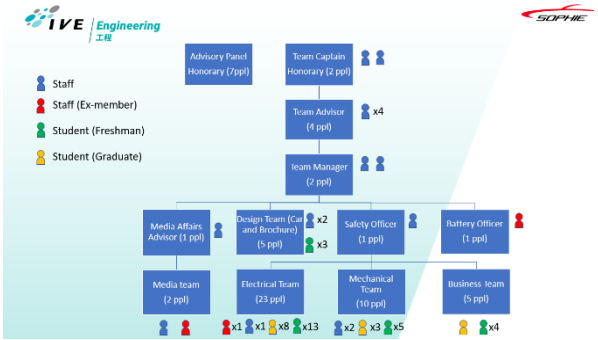


Fig. 3. Structure of IVE Engineering Solar Car Team in WSC2019

subgroup according to the learning content, and also perceive their project's topic and related task (as small as selection of the door hinge of the solar car) and then treat the task as personally meaningful that they want to do it well. Students feel more committed to the project and are willing to work harder when they have a sense of ownership.

III. Expose to the authentic working environment under IBSP scheme

Project-based learning (PBL) is a teaching method in which students gain knowledge and skills by engaging in a cumulative activity for a continued period of time to investigate and solve problems, leading to a final practical outcome (BIE, 2014). Students learn about a subject by working for an extended period of time to investigate and respond to a complex problem or challenge. The engineering discipline of IVE encourages teaching and learning with the engagement of industry exposure and provides an opportunity for higher diploma students to work in an authentic working environment with industry partners involvement. Industrial-based Student Project (IBSP) is part of the curriculum of the IVE Higher Diploma programmes. Students are required to attach to an organization (in academia or industry) for a period of time to obtain work experience and to identify industry-related topics for their final-year projects. The project aims to equip students and help them to get ready for the workplace as well as to facilitate their transition from study to work (VTC, 2019). Throughout the project-based learning approach, students can explore the real problem in the world and enhance their understanding of the subject matter as well as latest development in the industry through working in a project collaborating with industry (Cheung et. al, 2018). On top of enhancing their technical competency, they could also develop their problem-solving skills, project management skills and communication skills and marketing/promotion skills. It also helps cementing collaboration between educational institutions and industry. Cheung (2016) reported that under the IBSP program, students' abilities in communication skills, information management, critical thinking and problem solving, and demonstrating positive attitudes and behaviors are significantly improved.

IV. Develop soft skills

PBL equips students with problem-solving skills, critical think skills and collaboration skills, commonly known as 21st century skills. Thinking through the driving question, students need to apply higher-order thinking skills in analysing the situation, proposing solutions and expressing themselves in written or spoken forms (Larmer & Mergendoller, 2011). Working in a team, they have to find ways to communicate and collaborate well with teammates. Teachers can provide guidelines or rubrics to help student review their progress. Teachers encourage students to write logbook to chart the progress of the project and report their result in the regular meeting. It enables students to explain the project design and implementation to the other members. Therefore, PBL is an instructional strategy that enables students to achieve key competence in Vocational and Professional Education and Training (VPET) in the 21st century such as problem solving skills, project management skills and communication skills and presentation skills (VTC, 2019). Given the directions of project design and implementation, PBL paves the way for students to gain success in the workplace. Students value the realistic environment, can look at design from a systematic perspective, and appreciate technical challenges in the context of broader global economic, social and environmental requirements. It is regarded as an effective tool to develop lifelong learning, practice, and improve technical expertise, and strengthen engineering management principles (BIE, 2014).

Academia-industry collaboration in the areas of innovative research

The seventh-generation solar car SOPHIE 6s achieved outstanding results at the 2019 World Solar Challenge held in Australia 2019, demonstrating the learning achievements and technical strength of local young talents. The great significance of the SOPHIE project, as it has not only put PBL into real practice but has also dovetailed well with the government policy of increasingly leveraging innovation technologies. The success of SOPHIE is a collaborative synergy between academia and academia, as well as academic institutions and industry. A very noteworthy point is the inter-institutional support that has helped keep the team moving forward.

I. Academia and academia

a. Wind tunnel testing in RMIT

The streamline shape of the car is very important to enhance energy-efficient of the car (Hoeri, 2008). The SOPHIE team was honored to conduct joint research with

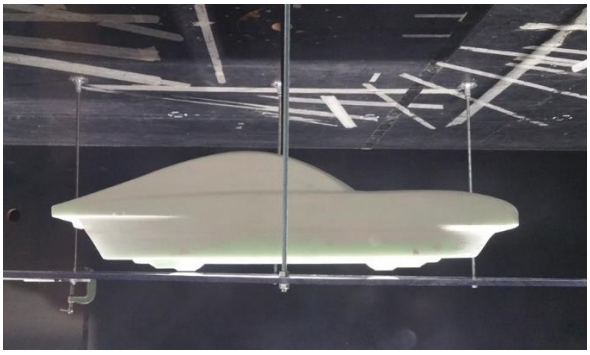


Fig. 4. Aerodynamic testing of the SOPHIE model car was performed in the wind tunnel of the RMIT

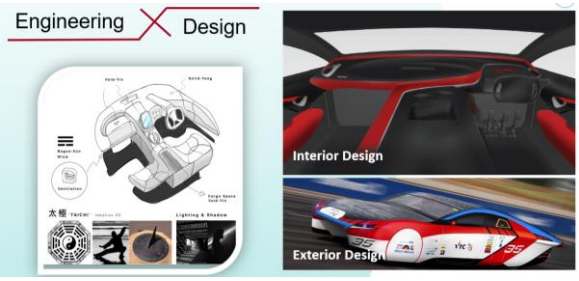


Fig. 5. Car design by HKDI

Royal Melbourne Institute of Technology RMIT. Computational fluid dynamics (CFD) and wind tunnel testing in RMIT were performed to numerical analyze car model structure and simulate the free-stream flow of the fluid, and the interaction of the fluid with car surfaces defined by boundary conditions. We strive to achieve a lower coefficient of air resistance on the car exterior. Cooperating with the RMIT University in Australia on wind tunnel tests we can fine-tune the entire car body design e.g. aerodynamic shape of the car chassis, lower drag area and drag forces according to test data obtained.

b. Car design by HKDI

The interdisciplinary cooperation between the Hong Kong Institute of Vocational Education IVE and the Hong Kong Design Institute HKDI under the VTC has been strengthened. Design and engineering students worked together to create the new exterior and interior design of the SOPHIE solar car. Red, blue, black and white were chosen as the main colors to match our VTC and SOPHIE logos. Design students have successfully realized the modern style with the theme of oriental "Tai Chi" in our SOPHIE car. Figure 5 shows the concept of Tai Chi and the exterior and interior design of SOPHIE 6s. The interior design presents the Tai Chi concept with free forms, curves and color, reflecting the perfect blending of human and nature. User-friendly interior design was successfully developed to enhance the driving experience of the driver. The practicality marks obtained in last competition was increased.

II. Academic institutions and industry

The Industry collaboration is critical to develop new generation SOPHIE solar car and contribute a better result in international competition. Applied research collaboration with VTC and Industry is established. Actively strengthen the cooperation between VTC and local enterprises, and with the support of manufacturers in Great Bay Area District, we develop a renewable energy-powered electric vehicles, encourage applied research with industry and provide feasible solutions for the development of sustainable green transportation. The development of SOPHIE is a multi-disciplinary project involving various aspects of engineering knowhow. Students from SOPHIE team completed the following applied research topics. The success of SOPHIE is a collaborative synergy between academic institutions and industry. A collaboration that is a win-win situation for industry and academia. Setup of collaborative research projects in the area of car exterior, interior of carbon fiber, suspension system, motor and battery. Collaborative research is a powerful means of creating opportunities for innovative knowledge exchange. Further expansion of the collaborative research is carried on to apply the joint Applied research project application (ITF).

With their entire support, Industry partners and SOPHIE team together shined in the competition – a collaboration that is a win-win situation for industry and academia. We have devoted ourselves to this competition because we also want to raise awareness among the next generation about the importance of adopting new technology to help leverage renewable energies like solar. We upgrade the new generation of the SOPHIE solar car to achieve the best results under new requirement for each competition. As the number of recharging time is reduced to 3 times, the IVE engineering staff and students jointly research and reduce the car loading, improve the storage battery capacity and enhance power management efficiency.

a. Composite material to reduce weight – HighGain

The body must be light and strong. It must have structural integrity to carry the weight of 2 passengers, batteries and other vehicle components in a static and dynamic balance manner. In addition, it should be easy to manufacture and conform to the aerodynamic streamlined appearance. The team adopted a honeycomb carbon fiber reinforced composite material structure and perfected the manufacturing process of the pre-impregnated autoclave.

b. Suspension – KaShui

In addition, they work with local companies to manufacture vehicle suspension systems using special high-strength rare-earth magnesium alloys. The components were fabricated using CNC machining and the loading tests were done using finite element analysis. We worked with KaShui on the use of magnesium alloys for the suspension and driveshaft enabling us to shave 80 kg off the overall weight. Material properties about Tensile strength, Yield strength and Elongation are enhanced by using rare-earth magnesium with the support of KaShui. The tailor-made Magnesium alloy suspension parts on SOPHIE 6s is 40% lighter than the previous generation by increasing the proportion of magnesium alloy in the car suspension system and introducing a new handling system. Lighter weight harder aluminum alloy and carbon fiber were used.

c. Battery pack – Totex

Noted another major enhancement regarding vehicle power. We have been able to enhance battery performance further with technical support from

industry. SOPHIE's batteries are the same type utilised by the other top teams, however, ensuring manufacturing consistency in the bonds between the cells and the structural arrangement is key to raising their efficiency and safety. We have made enormous strides in enhancing these bonds to ensure even transfer of energy and the batteries are now close to 98% efficiency, up 6% from last year.

d. Motor – QTEVM

Custom-made motor was supplied by QTEVM. SOPHIE 6s's drive motor operates for a longer period of time, which can achieve a maximum motor speed of 98%. Due to the All-in-One brake system including the brake disc, brake caliper and the brake motor together, the total weight of the components is 20% lighter than before. At the same time, the team also reduced the power consumption during voltage conversion, thereby improving energy efficiency. The technology that turns technology into practical application is already under development. Compared with the previous outsourcing motor system, the biggest breakthrough of the new motor system tailored for SOPHIE 6s is that the team successfully integrated the existing market technology and integrated some brake system components, including brake discs and brake discs. The caliper (brake caliper), etc., are combined with the motor as one. This new design of "lightweight" and "miniaturization" has a total weight of only 28 kg, which is 20% lighter than the previous outsourced motor system. The SOPHIE solar car developed for nearly ten years has been favored by manufacturers for the first time. The SOPHIE 6s motor system developed by the team itself will be sold on the market and will have the fruitful results as industry-academia cooperation. The production technology of the brand-new motor system is expected to be applied to lightweight transportation vehicles on the market, such as solar vehicles and small jets. And the related technologies have the opportunity to be used in light electric vehicle power system, such as new energy vehicles; and will be launched in the European and American markets in the future. New products will be created to meet the market demand.

Spread the Green Ideas to Hong Kong's Younger Generation

Encouraging innovativeness of new generation and exploring the use of renewable energy is a global trend. Transfer of knowledge from one generation to other is very crucial. IVE students take up this responsibility to conduct some promotion events. The Engineering Discipline of IVE organized the Youth New Energy Electric Vehicle Design Campaign to provide the initiative for the younger generation with immersive experiences in the application of solar power and deepen their knowledge of engineering and the STEM subjects in a fun and interactive approach. The campaign inspires young people's interest in renewable energy, innovative

Fig. 6. Youth New Energy Electric Vehicle Design Campaign 2019 in TY campus (Top); Workshop (Bottom Left) and Seminar (Bottom Right).

technology and STEM (science, technology, engineering and mathematics). Local secondary schools were invited by letters to organize a school team to participate, and they join hands with us to promote environmental protection to young people, and it helps to cultivate STEM professionals for the society. Secondary school solar car design competition aims to cultivate secondary school pupils' interest in engineering study through the development of two streams of solar car, i.e. Ridable solar car and Remote Speedy Solar Car class. The Campaign offered a series of workshops on solar car technology to local secondary school students in 2017, 2018 and 2019 for three consecutive years. Through these STEM-related workshops, secondary students will be equipped with the knowledge and skills that they need to build a solar car with efficiency innovation, creative logical thinking and problem-solving skills. And it will help to prepare them for their participation in the Rideable Solar Car and Remote Speedy Solar Car design competitions. Figure 6 shows the actively participation from local secondary students on competition, workshop and seminar. Groups of rideable solar cars and remote speedy solar cars specially designed by local secondary school students came to a showdown at the IVE(Tsing Yi) campus.

Curriculum development

SOPHIE will continue to be the flagship project of the IVE Engineering discipline. It will bring benefits to benchmark standards in energy conversion, aerodynamic design, electric motor technology, materials engineering, battery cell development, and intelligent mobility development. These will lay a solid foundation for interdisciplinary research. Strengthen cooperation and research in courses and interdisciplinarity. Considering the experience and technology gained through the SOPHIE project, the enrichment module ENG3409 "Introduction to Solar Vehicles" is being included in more teaching material packages. All of these include not only solar electric vehicles, but also Smart Mobility after the strategic development of VTC. Coordinating such a large-

Fig. 7. SOPHIE Workshop during enrichment module

scale interdisciplinary project also requires a lot of management, planning and guidance of students to develop important design thinking skills and entrepreneurial thinking in a real-world environment beyond the scope of classroom activities. Activity in SOPHIE workshop was carried on during the enrichment module class (Fig. 7).

Discussion

In summary, the SOPHIE project is indeed a great example showing how project-based learning and industry cooperation adds valuable elements to the curriculum and stimulate students' learning experience and finally benefits to the students. By sharing the success of the SOPHIE project, this paper not only emphasizes the benefits that SOPHIE bought to the Higher Diploma students through project-based learning pedagogy, but also explains how SOPHIE facilitate academia-industry collaboration in the areas of innovative research by integrating inter-disciplinary knowledge. SOPHIE's proven long-range performance, aside from racing, clearly demonstrates that PBL empower today's youth and transforms them into tomorrow's professionals. We have devoted ourselves to World Solar Challenge because we also want to raise awareness among the next generation about the importance of adopting new technology to help leverage renewable energies like solar. Thought participating the competition, the SOPHIE project with project-based approach also has empowered the youths to design and built a viable means of green transportation to drive humanity forward. A greener future lies in the hands of the new generation and, for sure, the SOPHIE team will not stop here. Ready to shoulder the mission to inspire tomorrow's youth, we will continue to promote green transportation throughout Hong Kong.

Acknowledgements

Great thanks to Vocational Training Council (VTC) and the Hong Kong Institute of Vocational Education (IVE) Engineering Disciplines for the fully financial support provided to the IVE Engineering Solar Car SOPHIE project. At the same time, I would also like to thank all the sponsors of the SOPHIE project for their cash, in-kind, materials, resources, advices and support throughout the entire decade.

References

BIE (Buck Institute for Education). (2014). What is project based learning (PBL)? Retrieved from http://bie.org/about/what_pbl

Bridgestone World Solar Challenge WSC. (2019). 2019 Volunteer guide. Australia, p.5.

Butzin, S. M. (2001). Using instructional technology in transformed learning environments: An evaluation of project CHILD. Journal of Research on Computing in Education, 33(4), 367–373.

Cheung, H. Y., Chow, M. H., & Chiu, P. K. (2016). How science, technology, engineering, mathematics (STEM) project-based learning improves student learning, Proceedings of The 10th International Symposium on Advances in Technology Education (ISATE), Sendai, Japan.

Cheung, H. Y., Chow, M. H., & Leung, Y. C. (2018). Industrial engagement in engineering education to nuture smart people, Proceedings of The 12th International Symposium on Advances in Technology Education (ISATE), Hong Kong.

Hoerl, A., Larson, D., Stenson, M., Dennis, K. et al., (2008). Aerodynamic Design Improvement of NDSU Solar Car through Computational Fluid Dynamics, SAE Technical Paper 2008-01-2251, pp.1-2. https://doi.org/10.4271/2008-01-2251.

Larmer, J. & Mergendoller, J. R. (2011). The main course, not dessert: How are students reaching 21st century goals? With 21st century project based learning. Retrieved from http://lcps.k12.nm.us/wp-content/uploads/2015/10/The-Main-Course-Not-Dessert.pdf

Markham, T. (2011). Project Based Learning. Teacher Librarian, 39(2), 38-42.

Savage, R. N., Chen, K.C., and Vanasupa L. (2007). Integrating project-based learning throughout the undergraduate engineering curriculum. Materials Engineering: 1-18.

Vocational Training Council VTC. (2019). VTC Annual Report 2018/19. HK, p.4.

Wang, L., Xue, X., Zhao, Z. and Wang, Z. (2018). The Impacts of Transportation Infrastructure on Sustainable Development: Emerging Trends and Challenges. Int. J. Environ. Res. Public Health, 15, p. 1172.

ONLINE-BASED TRAINING PROGRAM TO ENHANCE ADVICE-GIVING PRACTICE OF COMMUNITY PHARMACY ASSISTANTS

W.K.Mak

Department of Health and Life Sciences, IVE (Chai Wan), VTC, Hong Kong

makwaikei@vtc.edu.hk

Abstract

Background: Most of the advice-giving duties are performed by community pharmacy assistants (CPAs) in Hong Kong. Local systematic program guiding advice-giving are lacking and there is no local study regarding the advice-giving practice of CPAs.

Aim:To develop a program targeted for CPAs to improve their advice-giving practice; Secondly, to evaluate the effectiveness of the program; And to investigate any changes in attributes as attitude, subjective norm, perceived behavioral control and intention that influence their advice-giving practice.

Study design: Theory of Planned Behaviour (TPB) is used to examine the effects on psychological variables including attitude, subjective norm, perceived behavioral control, and intention, on advice-giving practice. An eight-week novel online-based program based on TPB was developed - patient-centered communication (PCC) program.
Quantitative data obtained: (1) A self-administrated questionnaire on advice-giving filled by the CPAs before and after the program. (2) Student feedback questionnaire (SFQ) for program by CPAs.
Qualitative data obtained: (1) Open-ended questions in the questionnaire; (2) Open-ended questions in SFQ

Results: 67 CPAs have completed the program. First, the frequency of advice-giving increased significantly (P-value <0.05). For TPB attributes, both the attitude and perceived behavior control of CPAs for advice-giving increased significantly (P-value <0.05). The SFQ survey showed that CPAs appreciated the online study mode and satisfied with the overall program (8.13 out of 10 marks).

Conclusion This study showed that the PCC program significantly enhanced the advice-giving competency of CPAs in Hong Kong. The result is very encouraging that further online training in-service program should be developed and promoted to CPAs in Hong Kong.

Keywords: *Advice-giving, Patient-centered communication, Community Pharmacy Assistants*

Introduction

The study is designed to thoroughly assess and evaluate the efficacy of the advice-giving practice of Hong Kong Community Pharmacy assistants (CPA) under the novel Patient-Centered Communication (PCC) program. Also, to investigate the influence that incurred by the changes in attributes of CPA including the attitude (A), subjective norm (SN), perceived behavioral control (PBS) and intention of CPAs.

The significance of the PCC program is to equip CPA with medication and advice-giving knowledge and as a result greater confidence will be fostered in assisting patients in managing their disease states and medications. Through the program, clients will be encouraged to have appropriate self-care with over-the-counter medications and foster safety in client's medication. Also, it generates an effective advice-giving which enhance correct use of medications to meet the therapeutic goals. More effective communication between clients and CPA will be built and trusting relationship will be facilitated and foster a sense of partnership between CPA and their clients (Beardsley, Kimberlin & Tindall, 2012).

The Theory of Planned Behavior model (TPB) (Ajzen, 1988, 1991) is adopted to guide this research study. The theory is made on assumption that human social behavior is reason action (Fishbein and Ajzen, 2010). There are four attributes for prediction of behavior, which are attitude (A), subjective norm (SN), perceived behavioral control (PBC) and intention (I)).

Importance of advice-giving by Pharmacy staff

In community pharmacies, CPAs play a pivotal role to support consumers' purchases of non-prescription medicines. To ensure patient safety and quality service in community pharmacy surely require CPA's knowledge and skills (Benrimoj, Werner, Raffaele and Roberts, 2008). The provision of medicines in community pharmacies generally can be divided into two two stages: the patient assessment stage (information-gathering), and advice-providing stage (to give advice about the disease; or provide a product to relieve the signs and symptoms of the disease; and provide non-

pharmacological advice) (Blenkinsopp, Paxton and Blenkinsopp, 2009); (Brown and Isetts, 2009).

Problem of advice-giving in Hong Kong community pharmacies

In Hong Kong, the prescribing and dispensing right are not separated. The number of prescriptions issued to private market (community pharmacies) is very low. This situation is very similar to the case in Malaysia (Chua, Lim & Lee, 2013).

The Problem of counseling service in Hong Kong community pharmacies are identified.

Firstly, there is insufficient counseling provided to patients. Many studies have indicated that the counseling in community pharmacy is insufficient and need improvement (Horvat, Koder & Kos, 2012) (Mesquita, de Oliveira Sá, Santos, de Almeida Neto & Lyra, 2013). Neoh, Hassali, Shafie and Awaisu (2011) studied that the information given to patients on medication use is not adequate in most community pharmacies.

Another study showed that many staff working in general sales store and pharmacies are not capable to distinguish between different types of analgesics (Bardage, Westerlund, Barzi & Bernsten, 2012). Puspitasari, Aslani and Krass (2009) reviewed the counseling practices in community pharmacies and found that medication safety information are not often given to patients e.g. the side effects, drug interactions, precautions for drug use etc. Kelly, Williams and Benrimoj (2009) stated there is variation in pharmacy staff behavior. They provide in-depth service to patients when they provide more tightly legislated medicines, and they are more competent at providing verbal advice than assessment of symptom history.

Need for the PCC Program

There is no formal training program in advice-giving practice in community pharmacy in Hong Kong. Mostly advice-giving practice is provided as on-the-job training to new CPA by senior sales. The training need of advice-giving for CPAs is very evident.

The design of program content is made reference to developed countries standards e.g., UK, Australia and United States, but the content is localized and tailored made for local CPAs. Also, it contains component of evaluation and assessment of the advice-giving practice.

Methodology

The 8-week novel PCC program is run online to tailor for the CPAs working schedule that they could learn at their own pace. The program content was designed in Chinese, supplemented with simple English. The PCC program contained six learning outcomes. For example, CPA could identify the salient role of effective advice-giving practice. They could learn the updated advice-giving guidelines in developed countries. Also, they would understand the applications of effective communication skills in different situations in pharmacy especially special situations. They would know how to identify and meet individual patient's needs etc.

The weekly PCC program materials compiled into a program booklet. There were well-planned feedback mechanisms (email, SMS and WhatsApp group communication) to guide the students through the program materials. Simple formative assessment items (online quizzes) were devised to monitor the participants' acquisition of knowledge and tracked the progress and attainment of learning outcomes.

Video clips, online quizzes, case studies with video demonstrations and lecture notes were uploaded on the website.

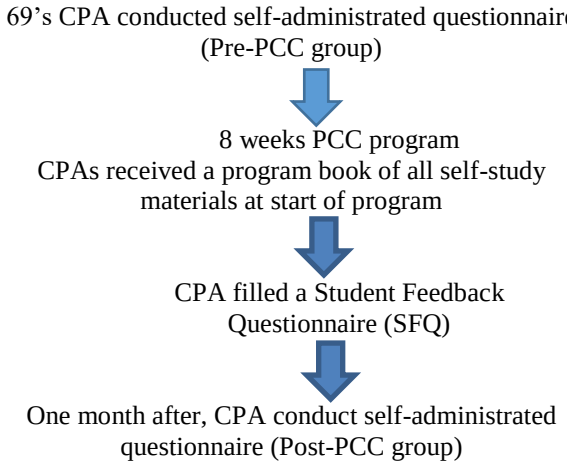
The Research Study

The research team visited the CPAs in their working community pharmacy. The researcher gave a briefing of the research project to the CPAs. The CPAs signed the informed consent to join the research and filled in the self-administrated questionnaire.

CPA were encouraged to provide feedback to the researcher by email, mobile or WhatsApp. The research team visited the CPA at their working pharmacy one month after completion of the 8-week program. The CPA then were then filled in the self-administrated questionnaire again.

The rundown of the research study was illustrated in Figure 1. 69 CPAs were enrolled and two CPAs were withdrawn from the study since they had left the post of CPA and opted not to continue the study.

Figure 1. Design of the Research Study



The questionnaire was modified by using standard TPB method (Francis et al, 2004). The behaviour to be studied is the advice-giving by CPAs during provision of medicines to customers in community pharmacy counter. Section I is the basic demographics of CPAs e.g., age and

gender, number of years as CPA, number of hours worked in pharmacy (per week), number of hours spent for advice-giving (per week) etc. Section II comprises of 14 questions. Question 1 is used to assess behaviour. Questions 2 to 10 are used for assessment of TPB variables (A, SN, PBC, and I) and Questions 11 to 14 are open-ended questions. Questions 2 to 10 are set as 7-point scale (which 1 is strongly disagree to 7 is strongly agree). CPA could grade their level of agreement or disagreement to items relevant to advice-giving practice. One item (Question number 1) is mapped for B, three items (Question number 2, 8 and 10) are mapped for SN, three items (Question 3, 7 and 9) are mapped for PBC, two items (Question number 4 and 6) are mapped for I, and one item (Question number 5 is divided into five sub-questions) is mapped for A. Questions 11 to 14 are open-ended questions. These are used to collect the self-reported comments by CPAs involved the following areas: (i) conditions of patients referral; (ii) questions to ask customers during provision of medicines; (iii) CPAs perception to deal with symptom request; and (iv) whether advice-giving is CPAs' responsibility

Measurement of Theory of planned behaviour attributes

Question number 1 counted the number of customers (out of latest ten customers) CPA provided advice-giving. The number was converted to score for behavior (out of 10 marks). The Attitude was measured by taking the average marks of four statements (helpful-unhelpful, necessary-unnecessary, satisfying-not satisfying, very easy-very difficult). It was counted in bipolar scales (1 is good practice while 7 is bad practice). Subjective norm was measured by taking average scores of three statements, but it is reverse scored. PBC was measured by averaging scores on three statements using bipolar scales (1 is difficult and 7 is easy). Intention was measured by averaging two score for statements.

Data analysis

For, Quantitative data analysis, P-value less than 0.05 was considered as statistically significant and rejected null hypothesis. The mean score and standard deviation of individual questions 1 to 10 of the questionnaires were calculated. And the mean score of grouped questions for attributes were calculated.

The score of questions of the questionnaires were analysed using t-test: paired two sample t-test for means of Pre-PCC group and Post PCC group i.e., before and after conducting the PCC program. For the Student Feedback Questionnaire (SFQ), the means and standard deviations of score for each question were calculated.

There were two parts of qualitative data collected in the research. First, there were four open-ended questions in the questionnaire. The individual open-ended questions of questionnaire referred to individual themes. The comments of individual open-ended questions were grouped in terms of similar words or phrases that are synonyms. The second is the Student Feedback Questionnaire (SFQ). CPAs' comments on the feasibility of online study mode and the PCC program are collected in open questions.

Results

For the Pre-PCC group, among the first ten questions, the score for question 5 (the opinion for CPA to provide advice during provision of medicines in community pharmacy counter), subset a (Good Practice-Bad Practice) and subset b (Helpful-Unhelpful), were the largest with score 6.07 and 6.09 respectively. The minimum score was question 2 (that CPA feel under social pressure to provide advice during provision of medicines in community pharmacy counter) with score 3.1. For Post-PCC group, in question 5 subset a, b and c, were the largest with score 6.28, 6.31 and 6.33 respectively. The minimum is for question 2 (CPAs feel under social pressure, from their colleagues, to provide advice during provision of medicines to the community in community pharmacy counter) with score 2.97.

2-Population t-Test for individual questions 1 to 10

First, the F-Test two sample for variance is conducted. For question subset 5a, 5b, and 5c, the P-values were smaller than 0.05, a t-Tests for Two-Sample Assuming Unequal Variances were conducted. For other questions, the P-values were larger than 0.05, so t-Tests for Two-Sample Assuming Equal Variances were conducted.

For Questions 2 and question 5 subset d, the scores for Pre-PCC group were larger than the Post-PCC group i.e. the scores decreased after the PCC program. For the other questions, the score for Post-PCC group were larger than the Pre-PCC group. For question 1, the average score increased from 4.58 to 5.84 out of 10 after taking the PCC program. There was significant difference (P-value is 0.004, which is less than 0.05) between the Pre- and Post- PCC group. The frequency of advice-giving by CPA increased significantly after taking the PCC program. For question 5 subset c, the average score increased from 5.93 to 6.33 after taking the PCC program. There was significant difference (P-value is 0.036, which is less than 0.05) between the Pre- and Post- PCC group. The attitude that CPA were necessary to provide advice during provision of medicines increased after taking the PCC program.

Paired t-Test for Grouped Questions

All the composite scores for A, SN, PBC and I increased for Post-PCC group, i.e. scores increased after taking PCC program. For both A, SN, and I, the P-values were larger than 0.05. There was no significant difference for A, SN, and I between the Pre- and Post-PCC group. For A, where the P-value was 0.074, it showed a certain towards significance.

For PBC, there was significant difference (P-value is 0.013, which is smaller than 0.05) between the Pre- and Post-PCC group. The PBC for CPA to provide advice during provision of medicines in community pharmacy

counter increased significantly after they completed the PCC program.

Student Feedback Questionnaire (SFQ) for the PCC program

CPAs were satisfied with the overall program (8.13 marks). The second highest score is question 8 that the teacher cared for the CPAs' learning progress and CPAs were provided with help (7.94 marks). For the open-ended question, many CPAs reflected that the PCC program was convenient and save time. They could study the program online anytime at any place. They enjoyed reading the teaching materials using mobile phone. Some CPAs appreciated that they could study the materials online at home and there was no need to study at certain place such as face-to-face lecture.

For question 11, 'how could this module and the teaching be improved?', many CPAs would like to have more teaching materials. They appreciated to have more interactive sessions e.g., online support, real person chatting etc. And some CPAs would like to have practical training session for advice-giving.

The result of open-ended questions of Questionnaire showed that CPAs with longer working experience tended to give more comment and feedback. The most frequent condition for referral to pharmacist were for pregnant and children. CPAs mostly asked customers for drug allergy, the age of customers, and signs and symptoms or condition of the customers. Only a few CPA would ask for the current medicine taken by customer and customer's disease history. For the dealing with customers' request to treat symptoms or conditions with OTC medicines, nearly 59% CPAs stated that advice-giving was not difficult. Among them, many CPAs stated that they could get help from pharmacist in-charge. Also, many CPAs said that they had drug knowledge and could solve drug problem using smartphone. While 41% CPAs found advice-giving difficult. Among them, many commented that it needed extensive product knowledge to answer customer enquiry.

Discussion

In this research study, community pharmacy is defined as a property registered pharmacy under supervision by one or more registered pharmacists. Over-the-counter (OTC) medicines are defined as medicines that are supplied without prescription in community pharmacy or medicine shop. An OTC consultation is defined as a health request by customer for themselves or on someone else's behalf.

The theoretical framework for the research is TPB. Apart from behaviour, the variables in the TPB model are psychological (internal) constructs. For construction of TPB questionnaire, direct measure of TPB constructs were adopted in this research. Direct measures of predictor variables were used in this research. The questionnaire items were easier to develop that the same format were used for a range of health studied behaviors. Also, the responses with respect to different behaviors could be directly compared. The positive endpoints of questionnaire items were aligned on the right-hand side for clarity and were more convenient for data entry.

The result of Self-administrated questionnaire is first discussed. All scores for questions (except question 2 and subset d of question 5), were larger for Post-PCC group compared with Pre-PCC group. For question 1, the average score increased significantly. The number of advice-giving sessions increased significantly (score increase by 1.26 out of 7 points, percentage increase by 27.4%). That reflected the CPAs significantly provided more advice-giving to customers after taking the PCC program. For question 5 subset c, the average score increased significantly. So the attitude that CPAs were necessary to provide advice increased after taking the PCC program. However, for the other questions, there was no statistically significant difference between the Pre- and Post- PCC group. Only for question 8, there was a certain towards significance.

All the composite scores for A, SN, PBC and I increased for Post-PCC group, i.e., scores increased after taking PCC program. There was a certain towards significance for A. While for PBC, there was significant difference between the Pre- and Post-PCC group. The increase in score was Perceived behavior control (score increased by 0.32 out of 7 points, percentage increased by 6.95%). The PBC for CPAs to provide advice increased significantly after they completed the PCC program. The third increase in score was Attitude (score increased by 0.21, percentage increased by 3.55%). It showed that CPAs were more confident to perform advice-giving in community pharmacy consultations. In short, CPAs attended the PCC program did improve in all TPB attributes in providing advice-giving in community pharmacy consultation.

As shown in overall result of the pilot study and the research study, the composite score for all TPB predictors (I, SN, PBC and A) and question one result increased for those CPAs after taking the PCC program. The most significant increase was the result of question 1 i.e. the number of customers (out of ten recent encounters) CPA provided advice in community pharmacy counter. This indicated an increase in awareness in advice-giving of CPAs and they had put their knowledge in actual practice. This was a promising result that the improvement in advice-giving practice was the main objective of PCC program.

Discussion of the Open-ended questions of questionnaire

Seasoned CPAs gave more comment and feedback. These CPAs are pharmacy managers or partners of the community pharmacy. They had rich frontline counter experience and responsible for supervisory and

managerial work including on-the-job training of new CPAs.

CPAs mostly referred pregnant and children case to pharmacist. Also, when customers required prescription drugs or had special conditions. It is common that CPAs would refer to pharmacist when they did not sure about the drug and they clearly understood that prescription drugs should be handled by pharmacist. CPAs should collaborate with pharmacist in-charge for better patient care.

During provision of medicines, most CPA would ask for drug allergy, the age of customer, and signs and symptoms or condition of the customers. However, many essential items are often omitted. For example, most CPAs did not ask customers the indication of drug, their current medication, and their disease history. And nearly all did not ask for side effect of drugs and whether customers have consulted doctor before. These show that most CPAs lack the technique of questioning of customers in advice-giving during provision of medicine.

Despite the unsatisfactory performance of questioning of customers, nearly 60% of CPAs stated that advice-giving was not difficult. Most of them would seek help from pharmacist or search drug information through internet. It should be noted that the pharmacist only attended two-thirds of the opening hours of pharmacy and had leave on Sunday and public holidays. Also, the drug information in internet varied and discretion was needed for the reliability of online information sources.

While 40% CPA shared the difficulty for advice-giving. One problem is the lack of patient medication history available in community pharmacy. The electronic health record (eHR) did not cover the community pharmacies in Hong Kong so that the only way to obtain information of customers or patients is by questioning. CPAs found difficult to identify overwhelming drug products available in the market. This illustrated the need for continue education for CPAs especially information for the new drug products. Also, CPAs expressed difficulties for differential diagnosis. This reflected the importance and need for advice-giving practice and tis is the aim of PCC program.

All CPAs in the research thought that advice-giving was their job duties and responsibility and were important to help customers. It reflected that CPAs were aware of the importance of advice-giving practice.

Conclusions

Community pharmacies are an integral component of the primary health care system. In community pharmacies, CPAs are usually the staff who provide service to patients. While they are responsible for most routine pharmacy operation, one of the main services provided is the advice-giving practice to patients. However, relevant training is currently not available. Thus, an online-based training program (PCC Program) tailor-made for local CPAs was developed.

As one of the first formal research project in Hong Kong community pharmacy targeted for CPAs, the research would bring benefit for community pharmacy industry that it increased the public awareness and confidence of CPAs to provide quality community pharmacy service. The research illustrated that the PCC Program could significantly enhance the advice-giving competency of CPAs. The program would be further promoted to community pharmacy industry.

Acknowledgements

The author would like to thank for the Hong Kong General Chamber of Pharmacy, and those community pharmacy staff who kindly taken part in the research study.

References

Ajzen, I . (1988). *Attitudes, Personality and Behaviour*, Open University Press, Milton Keynes.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50, 179–211.

Bardage, C., Westerlund, T., Barzi, S., & Bernsten, C. (2013). Non-prescription medicines for pain and fever—A comparison of recommendations and counseling from staff in pharmacy and general sales stores. *Health Policy*, *110*(1), 76-83.

Beardsley, R. S., Kimberlin, C. L., & Tindall, W. N. (Eds.). (2012). *Communication skills in pharmacy practice: a practical guide for students and practitioners.* Lippincott Williams & Wilkins.

Benrimoj, S. I., Werner, J. B., Raffaele, C., & Roberts, A. S. (2008). A system for monitoring quality standards in the provision of non-prescription medicines from Australian community pharmacies. *Pharmacy World & Science*, *30*(2), 147-153.

Blenkinsopp, A., Paxton, P., & Blenkinsopp, J. (2009). *Symptoms in the pharmacy: a guide to the management of common illness*. Wiley-Blackwell

Brown, L. & Isetts, B. (2009). Patient assessment and consultation. In: Berardi, R.R., Ferreri, S.P., Hume, A.L., et al. *Handbook of Nonprescription Drugs: An Interactive Approach to Self Care*. 16th ed. Washington, DC: American Pharmacists Association.

Chua, S. S., Lim, K. P., & Lee, H. G. (2013). Utilisation of community pharmacists by the general public in Malaysia. *International Journal of Pharmacy*

Practice, *21*(1), 66-69.

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. New York, NY: Psychology Press.

Francis, J. J., Eccles, M. P., Johnston, M., Walker, A., Grimshaw, J. M., Foy, R., ... & Bonetti, D. (2004). Constructing questionnaires based on the theory of planned behaviour. A manual for health services researchers, 2010, 2-12.

Horvat, N., Koder, M., & Kos, M. (2012). Using the simulated patient methodology
to assess paracetamol-related counselling for headache. *PLoS One*, *7*(12), e52510.

Kelly, F. S., Williams, K. A., & Benrimoj, S. I. (2009). Does advice from pharmacy staff vary according to the nonprescription medicine requested? *Annals of Pharmacotherapy*, 43(11), 1877-1886.

Mesquita, A. R., de Oliveira Sá, D. A. B., Santos, A. P. A. L., de Almeida Neto, A., & Lyra, D. P. (2013). Assessment of pharmacist's recommendation of non-prescription medicines in Brazil: a simulated patient study. *International journal of clinical pharmacy*, *35*(4), 647-655.

Neoh, C. F., Hassali, M. A., Shafie, A. A., & Awaisu, A. (2011). Nature and adequacy of information on dispensed medications delivered to patients in community pharmacies: a pilot study from Penang, Malaysia. *Journal of Pharmaceutical Health Services Research*, *2*(1), 41-46.

Puspitasari, H. P., Aslani, P., & Krass, I. (2009). A review of counseling practices on prescription medicines in community pharmacies. *Research in Social and Administrative Pharmacy*, *5*(3), 197-210.

Continuous Improvement and Quality Enhancement

DEVELOPMENT OF GRADUATION RESEARCH IN FOOD TEXTURE ESTIMATION

S. Kato [*, a], T. Kagawa [a], N.Wada [a], T.Hino [a] and H. Nobuhara [b]

[a] National Institute of Technology (KOSEN), Niihama College, Ehime, Japan
[b] University of Tsukuba, Ibaraki, Japan

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

Abstract

This paper describes a suitable graduation research subject that makes students interested in AI (Artificial Intelligence). Food is familiar to us. Therefore, we built up a research topic related to food. The objective of the proposed subject is to design an intelligent system, which can recognize foods' textures. In the proposed research, AI estimates food texture from sound and load signals. Our original equipment measures these signals when the food is compressed or cut. The authors applied CNN (Convolutional Neural Network) to classify various texture type. CNN is one of the NN (Neural Network) models and regarded as one of the latest beneficial AI (Artificial Intelligent) techniques. The input of CNN is an image representing the load and sound signals when the food is cut or compressed by the equipment. The output is the estimated classification value of the food. In the research process, the students are required to figure out the electric sensors, such as load cells and the sound sensors, and learn the usage of the individual amplifier of the sensors. In the experiment stage, to collect signal data of the foods, the students have to measure the size of the food samples and memorize the experimental conditions as detailed as possible in the notebook. In this way, they can take advantage of their experience writing reports in student engineering experiments in their lower grades. Besides, the students should construct an information system using Matlab. By using Matlab, they can address building intelligent information systems quickly. They have to analyze the physical features of load and sound strength by calculating the mean and standard deviation (STD). Furthermore, they are required to comprehend the result of FFT (Fast Fourier Transform) and STFT (Short Time Fourier Transform) of the sound signal. The first half of the present paper shows the texture classification experiment of three kinds of snacks performed by a student. The latter half shows the experiment in apples' texture. Finally, conclusion and future work are discussed.

Keywords: *neural network, graduation research, artificial intelligence, CNN*

Introduction

AI (Artificial Intelligent) evolves rapidly in the latest few years, and it is necessary to nurture students in computer science to be capable of dealing with AI techniques. NN (Neural Network) model proposed by Rumelhart (1986) is an effective AI technique widely used for practical problems such as automatic control and pattern recognition. Our previous study (S.Kato, 2018) proposed an experiment to make students interested in NN. In the proposed experiment, NN is applied to food texture estimation. The food is familiar to us, and the presented AI pedagogy is unique, incorporating food texture.

On the other hand, CNN (Convolutional Neural Network) model proposed by Yann LeCun (1998) has made innovation in image recognition. Since CNN is beneficial in not only image recognition but also sound recognition, the students have to learn CNN. Therefore, we built up a research topic on CNN. We realized the food texture estimation system (S.Kato, 2019-2020), as shown in Fig.1. The input of CNN is the *characteristic image* comprising the spectrogram of a sound and a color bar representing load strength when the food sample is compressed or cut. The output is the classification result of the food, such as rice crackers, egg bolo, or corn snacks.

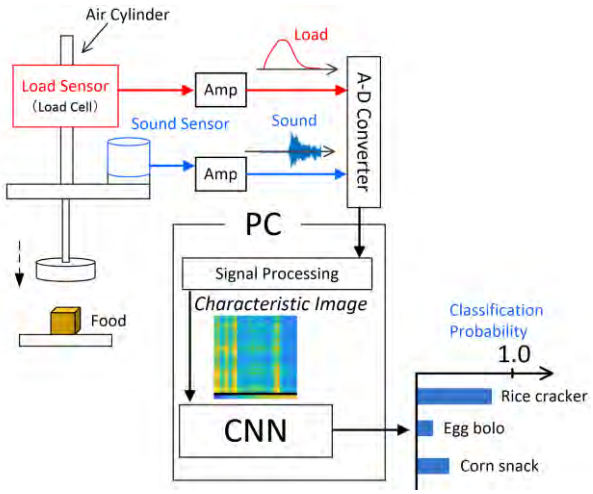


Figure 1 The overview of the presented system.

The present paper shows experiments conducted by a 21-years-old college student who belongs to our college. He

assisted our experiments using CNN. The first half of the present paper shows the texture classification experiment of three kinds of snacks. The latter half shows an experiment in apples' texture. Finally, conclusion and future works are discussed.

Overview of the present system

Fig.2 (a) shows the equipment to measure the sound and load of the food (rice cracker in the picture). The rod of the air cylinder moves plunger down to compress the food. As shown in Fig.2 (b), the rice cracker is compressed, and then the rice cracker is crushed, as shown in Fig.2 (c).

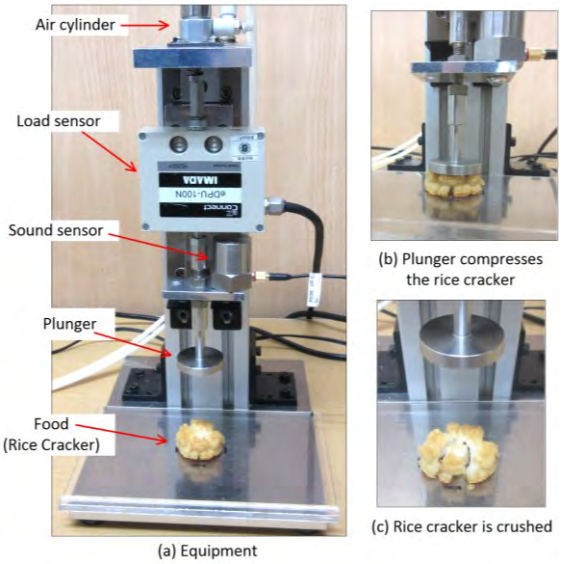


Figure 2 The equipment to measure the sound and load.

Fig.3 shows an example of obtained signals of the rice cracker. The upper graph in Fig.3 shows measured load and sound signals for 10-[s]. The middle graph is automatically extracted signals for 3.0-[s]. The bottom one is the FFT (Fast Fourier Transform) result of the extracted sound signal.

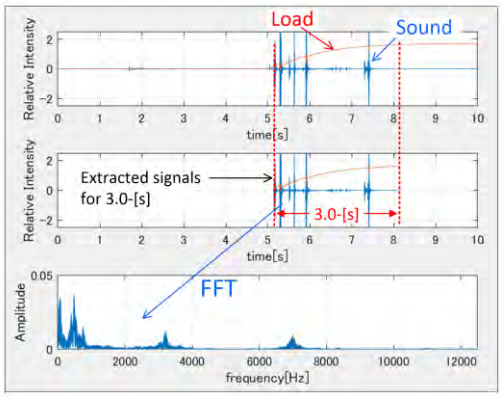


Figure 3 Example of obtained sound and load signals (Rice cracker: No.1).

As shown in Fig.4, the signals are extracted for the 3.0-[s] period to analyze the physical feature of food. Firstly, the maximum load point (1) is found, and then the point (2) at 10% of the maximum load is searched. The signals for the 3.0-[s] period from the point (2) are extracted as (3) in Fig.4.

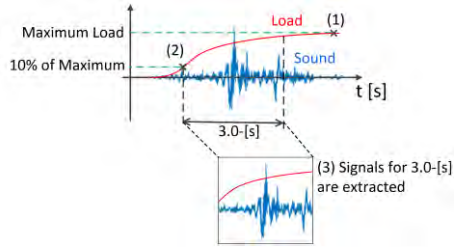


Figure 4 Signal extraction.

The *characteristic image* given to CNN is created. As Fig.5 shows, the extracted 3.0-[s] signals explained in Fig.4 are converted to 227-by-227 pixels RGB image. The sound signals are converted to the spectrogram by STFT (Short-Time Fourier Transform). The bottom color bar represents the load strength. The brighter the color, the higher the load. The detail is described in the papers by S.Kato (2019-2020).

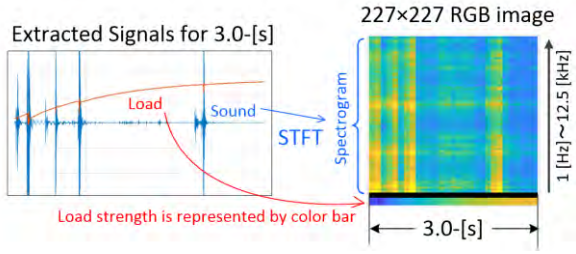


Figure 5 Creation of *characteristic image*.

Fig.6 shows the presented CNN. The input of CNN is a *characteristic image*. CNN outputs classification probability. *AlexNet* (A. Krizhevsky, 2012) is adopted to perform *characteristic image* classification. *AlexNet* is CNN and trained with a large amount of image data beforehand.

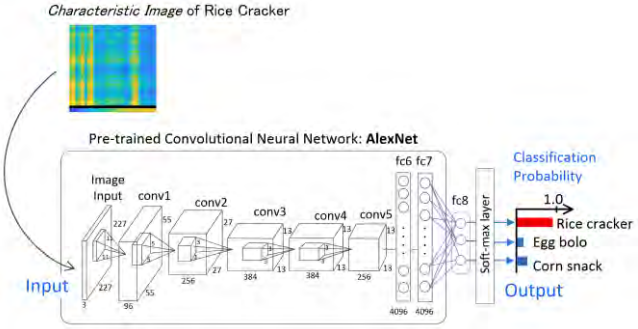


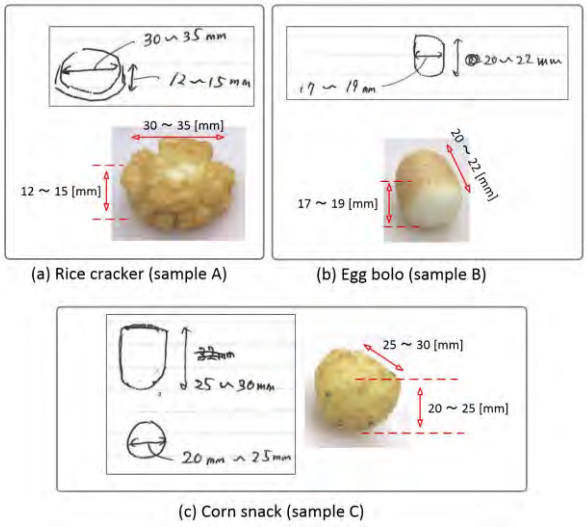
Figure 6 CNN (Convolutional Neural Network).

In the CNN training phase, the adjustment of connection weights between fc7 and fc8 is performed mainly to classify *characteristic images* correctly using *transfer learning* (Shin HC, 2016). The Deep Learning Toolbox of MATLAB is utilized for *transfer learning* (MathWorks, 2020). In Fig.6, the probability of "rice cracker" is the highest, thereby CNN estimates correctly because the inputted *characteristic image* is one of the rice crackers. The presented CNN is used in our previous

studies (S.Kato, 2019-2020). The details of CNN are explained in our previous papers.

Experiment in snack texture

The author and a student (21 years old, male) conducted the snack texture experiment to obtain signal data. We prepared three kinds of snacks such as rice crackers (named sample A), egg bolo (sample B), and corn snack (sample C) shown in Fig.7, purchased in the local supermarket.

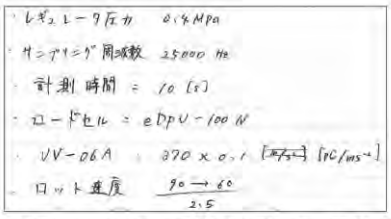


(a) Rice cracker (sample A) (b) Egg bolo (sample B)

(c) Corn snack (sample C)

Figure 7 Snack-size used in the experiment.

The author directed the student to draw and memorize the form and size of the snacks, as illustrated in Fig.7. Fig.8 shows experimental conditions. As well, the student memorized necessary details in the experiment in the notebook, as displayed in Fig.8 (a).

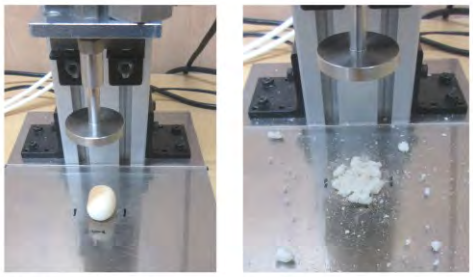

(a) Experiment condition written by student (in Japanese)

Date: 2020/3/19 (Thursday)
Time: 13:25 (Tokyo)
Weather: Cloudy
Temperature: 22℃
Humidity: 38 %
Air pressure of regulator: 0.4 [MPa]
Plunger down speed: 30[mm]/2.5[s] = 12[mm/s]
Sampling rate (A-D converter): 25 [k Samples/s]
Measurement time: 10 [s]
Type name of load cell : eDPU-100N
Type name of charge AMP for sound sensor: UV-06A

(b) Summarize of the experimental condition

Figure 8 Experimental condition.

The experiment is carried out under the condition presented in Fig.8. Fig.9 shows the picture when the sample B (egg bolo) is compressed.


(a) Egg bolo (Sample B) is set under the plunger.

(b) Egg bolo (Sample B) is crushed by plunger compression.

Figure 9 Picture in the experiment of sample B.

Fig.10, 11, and 12 show the signal examples of each snack kinds, such as "rice cracker," "egg bolo," and "corn snack," respectively.

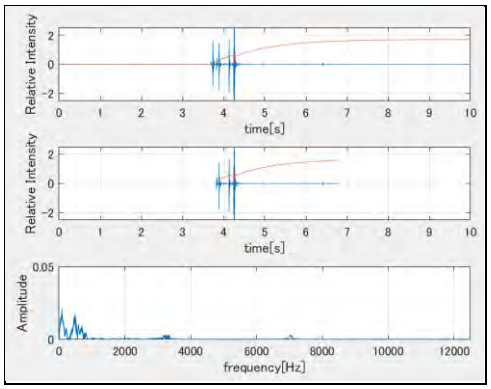


Figure 10 Signals of sample A (Rice cracker: No.2).

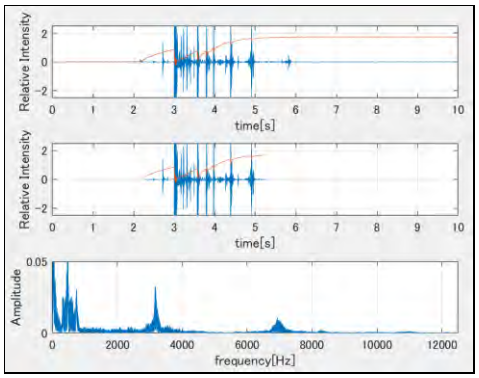


Figure 11 Signals of sample B (Egg bolo: No.1).

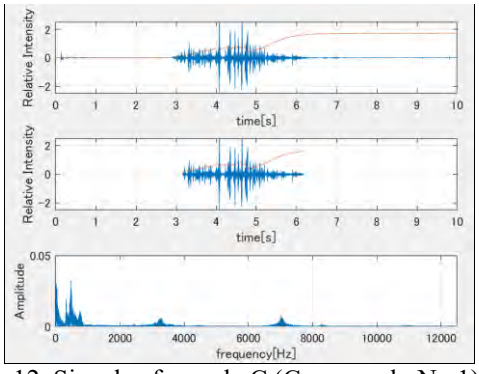


Figure 12 Signals of sample C (Corn snack: No.1).

The student obtained 20 signal data for each kind of three snacks in the experiment, respectively. Fig. 13 (a) shows the means of extracted 3.0-[s] period load signal averages for 20 sample data for each snack. Fig.13 (b) shows the means of the integral of FFT results. It is found that physical features are different among the snacks.

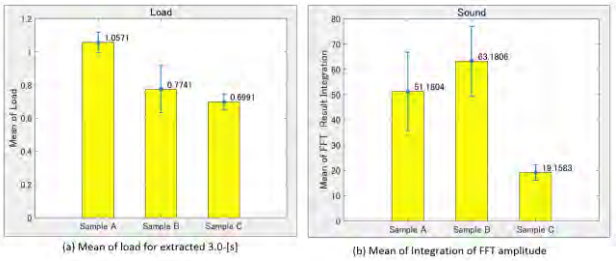


Figure 13 Mean of load and sound strength for each sample.

Since the rice cracker (sample A) is hardest, the load average is highest. On the other hand, the corn snack is not so hard, and the value is not high. The student would comprehend the physical features by seeing the chart in Fig.13. Fig.14 shows the *characteristic image* for each kind of snack. The features of the images are different depending on the kind of snacks.

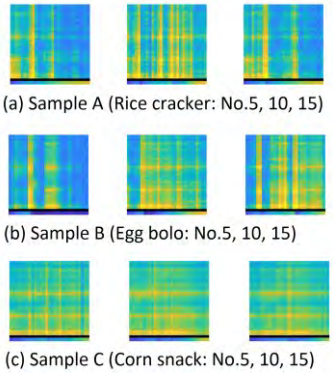


Figure 14 *Characteristic image* for each kind of snack.

CNN shown in Fig.6, is validated by using the *characteristic images*. We have 60 images (sample A: 20, sample B: 20, sample C: 20). Six-fold cross-validation shown in Fig.15 (a) is conducted.

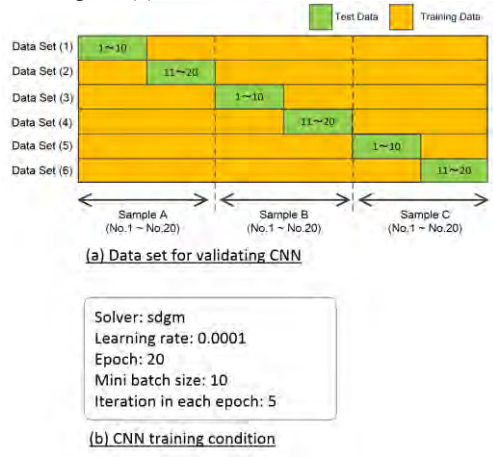


Figure 15 CNN validation using *characteristic images*.

As for Data Set (1), fifty data except No.1-10 of sample A are used for training CNN. After the training CNN, the classification accuracy of CNN is confirmed by using Sample A No.1-10. The training condition is shown in Fig.15 (b). For each data set, the accuracy was 90%, 90%, 90%, 100%, 90%, and 100, respectively. The average of the accuracy was 93.33 %. The student would comprehend the CNN effectiveness and validation method.

Experiment in apple texture

In the same manner, as the previous section, the author and the student carried out an experiment to obtain apple physical data. We prepared two kinds of apples named brand A and brand B, as shown in Fig.16, purchased in the local supermarket. The author directed the student to draw and memorize the form and size of the apples, as illustrated in Fig.16.

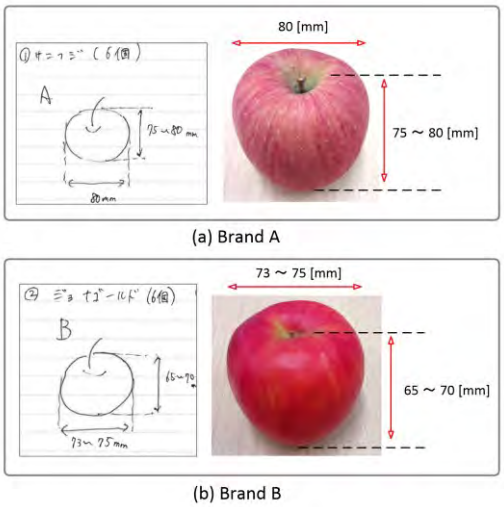


Figure 16 Pictures of apples and size used in the experiment.

As Fig.17 (a) shows, the flesh of the apple is hollowed out with metal pipe to be 17-[mm] diameter. And then, the hollowed-out flesh is trimmed in 30-[mm] length, as shown in Fig.17 (b). Finally, the sample flesh shown in Fig.17 (c) is created.

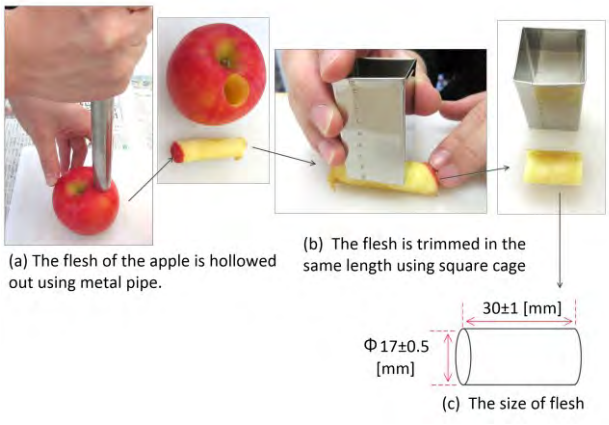
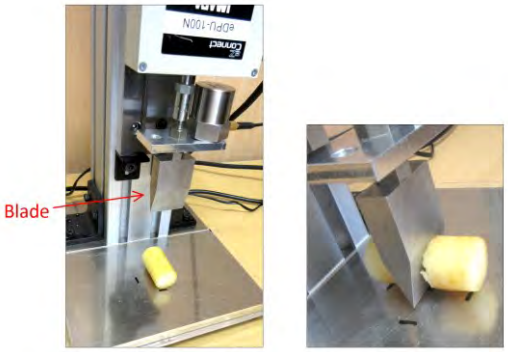


Figure 17 Process of apple flesh sample production.

The author and the student made up over 30 pieces of samples shown in Fig.17 (c) for each brand's apples to carry out the following experiment. The plunger of the equipment in Fig.2 is replaced with the blade, as shown in Fig.18 (a), and then the apple flesh sample is cut with the blade, as shown in Fig.18 (b) to measure the sound and the load when the apple flesh is cut. Finally, thirty signal data of the Bland A and B are corrected, respectively.

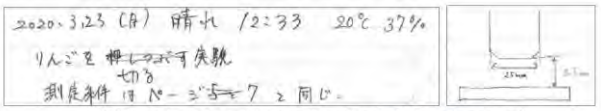


(a) The blade is attached instead of plunger.

(b) The flesh sample is cut by the blade

Figure 18 The apple flesh sample is cut by the blade.

The student memorized the necessary details in the experiment in the notebook, as displayed in Fig.19 (a). Fig.19 (b) shows experimental conditions.



(a) Experiment condition written by student (in Japanese)

Date: 2020/3/23 (Monday)
Time: 12:33 (Tokyo)
Weather: Fine
Temperature: 20℃
Humidity: 37 %
Air pressure of regulator: 0.4 [MPa]
Plunger down speed: 30[mm]/2.5[s] = 12[mm/s]
Sampling rate (A-D converter): 25 [k Samples/s]
Measurement time: 10 [s]

(b) Summarize of the experimental condition

Figure 19 Experimental condition.

Fig.20 and 21 show the signals of brand A and B, respectively. The sound and load of brand A are somewhat higher than B. Note the extracted period is set to 2.0-[s] because the period is adequate for the apple experiment. Fig.22 (a) shows the mean of extracted 2.0-[s] period load signal average for 30 sample data for each bland. Fig.22 (b) shows the means of the integral of FFT results. It is found that physical features are different between two bland. Fig.23 shows the *characteristic images.*

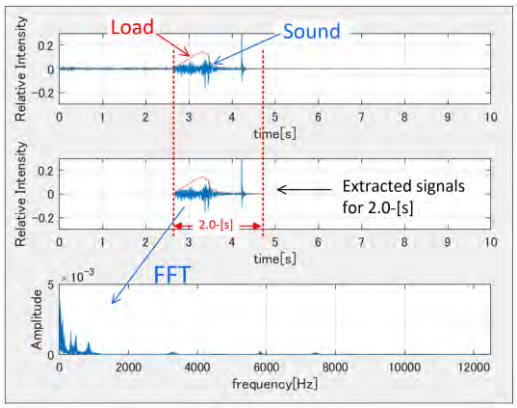


Figure 20 Signals of brand A (brand A: No.1).

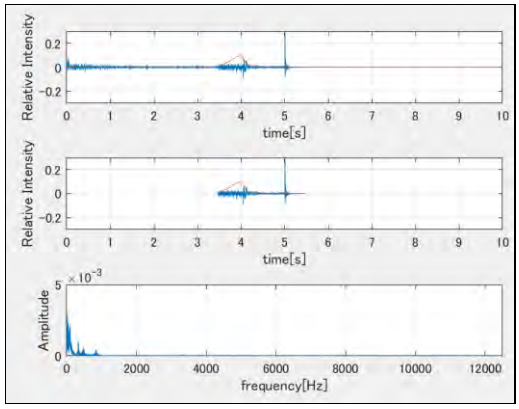
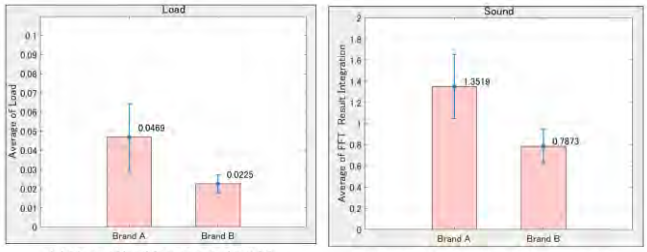


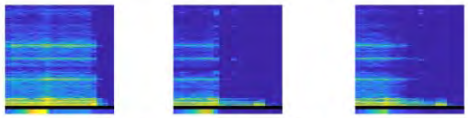
Figure 21 Signals of brand B (brand B: No.1).



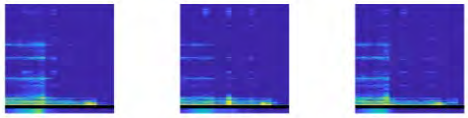
(a) Mean of load for extracted 2.0-[s]

(b) Mean of Integration of FFT amplitude

Figure 22 Mean of load and sound strength for each sample.



(a) Brand A (No.5, 10, 15)



(b) Brand B (No.5, 10, 15)

Figure 23 *Characteristic image* for each bland.

Fig.24 (a) shows the CNN for apple texture classification. The input of CNN is a *characteristic image*. CNN is the same construction as Fig.6 except for the output classification layer. CNN outputs the classification probability of the apple's bland.

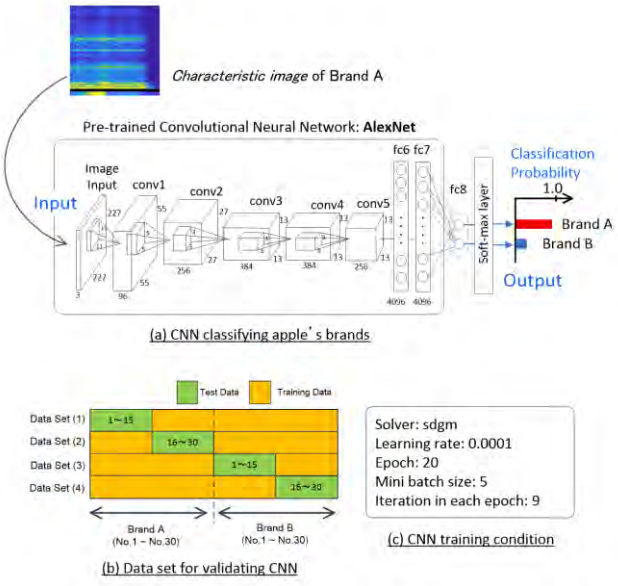


Figure 24 CNN and validation method.

CNN is validated by using the *characteristic images* shown in Fig.23. We have 60 *characteristic images* (Brand A: 30, Brand B: 30). Four-fold cross-validation, shown in Fig.24 (b), is conducted. As for Data Set (1), 45 data except for No.1-15 of Brand A are used for training CNN. After training CNN, the classification accuracy of CNN is confirmed by using No.1-15 of brand A. Training condition is shown in Fig.24 (c). For each Data Set, the accuracy was 93.33%, 93.33%, 93.33%, and 66.67%, respectively. The average accuracy was 86.67%. CNN can distinguish the texture pattern of two kinds of apples, even though the average of the physical features were dispersed as Fig.22 shows. The student would comprehend the flexibility of CNN.

Conclusions

We interviewed the student who assisted in the presented experiment. His remarks are described as follows.

- The student felt be interested in AI because CNN is very flexible, and the programming code written by Matlab is simple.
- He found the importance of memorizing experimental conditions such as date, time, temperature, humidity, and size of samples as evidence.
- The mechanical setting of the equipment by hand was interested because the mechanical condition affects the experimental results.
- He figured out the signal processing meaning, such as FFT and STFT, in order to recognize signal feature differences.

By continuing an experiment with the student, we would discover improvements in the equipment, experimental condition, food sample production, analytical method, and AI algorithm.

Acknowledgments

The authors would like to appreciate our student Shiozaki participating in our experiment, and Maeda in MathWorks for giving us technical advice.

References

David E. Rumelhart, Geoffrey E. Hinton & Ronald J. Williams (1983). Learning Representations by Back-propagating Errors. *Nature*, 323, 533-536.

S.Kato & N.Wada (2018). DEVELOPMENT OF NEURAL NETWORK EXPERIMENT USING FOOD TEXTURE ESTIMATION. *Proc. of 12th International Symposium on Advances in Technology Education (ISATE2018)*, 1-7.

Y. LeCun, L. Bottou, Y. Bengio & P. Haffner (1998). Gradient-based learning applied to document recognition. *Proceedings of the IEEE*, 86 (11), 2278-2324.

S.Kato, N.Wada, R.Ito, T.Shiozaki, Y.Nishiyama & T.Kagawa (2019). Snack Texture Estimation System Using a Simple Equipment and Neural Network Model. *Future Internet*, 11(3), 1-16.

S.Kato, R.Ito, T.Shiozaki, F.Kitano, N.Wada, T.Kagawa, H.Nobuhara, T.Hino & Yukinori Sato (2019). Apple Brand Classification Using CNN Aiming at Automatic Apple Texture Estimation. *Lecture Notes in Networks and Systems*, 96, 811-820.

S.Kato, T.Kagawa, N.Wada, T.Hino & H.Nobuhara (2020). Citrus Brand Classification by CNN Considering Load and Sound. *Advances in Intelligent Systems and Computing*, 1150, 1239-1249.

A. Krizhevsky, I. Sutskever & G. E. Hinton (2012). ImageNet classification with deep convolutional neural networks. *In Proceedings of the 25th International Conference on Neural Information Processing Systems (NIPS'12)*, 1097-1105.

Shin HC, et al. (2016). Deep Convolutional Neural Networks for Computer-Aided Detection: CNN Architectures, Dataset Characteristics and Transfer Learning. *IEEE Transactions on Medical Imaging*, 35(5), 1285-1298.

MathWorks (accessed on 20 April 2020). *Transfer Learning Using AlexNet*, Retrieved from https://www.mathworks.com/help/deeplearning/examples/transfer-learning-using-alexnet.html.

FOLLOW-UP REPORT: A CLASSROOM STUDY OF ONLINE TUDY ON TEST OF ENGLISH FOR INTERNATIONAL COMMUNICATION AT NATIONAL INSTITUTE OF TECHNOLOGY, HAKODATE COLLEGE

Mariko Okuzaki[*,a]

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

*okuzaki@hakodate-ct.ac.jp

Abstract

In 2018, Hakodate College commenced online study on Test of English for International Communication (TOEIC)[*1] a mandatory course for all fourth-year Japanese students. This classroom research focuses on a specific group of 36 students in the fourth year of mechanical engineering majors at the Production System Department in academic year 2019 (hereinafter referred to as 4SM2019). This study reflects on the process used for a previous group of 37 students in the fourth year of mechanical engineering majors at the Production System Department in academic year 2018 (4SM2018) to gain the following insights on improving e-learning for 4SM2019: (a) students with total score of 350 or lower tend to spend much less time on e-learning compared with those who scored 500 or more; (b) students with total score of 350 or lower tend to spend much less time on the TOEIC examination compared with those who scored 500 or more; (c) of the total number of students, 75% engaged in *inappropriate e-learning* because of improvisational attitudes towards learning; and (d) a teacher's face-to-face learning confirmation facilitates the self-efficacy of lower-level students. Based on the study results, the following measures were taken to improve the English learning of 4SM2019 using the learning management system (LMS): (a) conducting regular quizzes that expand vocabulary to prevent students from doing monotonous work or pretending to learn and (b) allowing students to set feasible learning goals, achievement objectives, and e-learning self-evaluation and to regularly monitor their learning status together. In terms of the frequency distribution of study time and reading score, the measures proved effective for 4SM2019. However, overall results indicate that the measures were not enough to help lower-level students in acquiring a total score of 400 in TOEIC.

Keywords: *TOEIC, e-learning, vocabulary quiz, monitoring learning status*

Introduction

The English department at the national Institute of Technology (NIT), Hakodate College, continuously undertook a TOEIC e-learning course for 36 students in the fourth year of mechanical engineering majors at the Production System Department for academic year 2019 (hereinafter referred to as 4SM2019). The course is aimed at helping 4SM2019 achieve the necessary TOEIC score for their future career through a self-learning program provided by the same learning management system (LMS) used for 37 students in the fourth year of mechanical engineering majors at the Production System Department for academic year 2018 (4SM2018). LMS enables students to practice TOEIC using the ALC NetAcademy NEXT: TOEIC®L&R test*[2]. The target scores of the TOEIC e-learning program were 350 points for the subject Practical English 1A in the first semester and 400 points for the subject Practical English 1B in the second semester. A total of 36 students were included in 4SM2019. Figure 1 shows a bar chart of the frequency distribution of the TOEIC scores of 4SM2019 in their third year of school (2018).

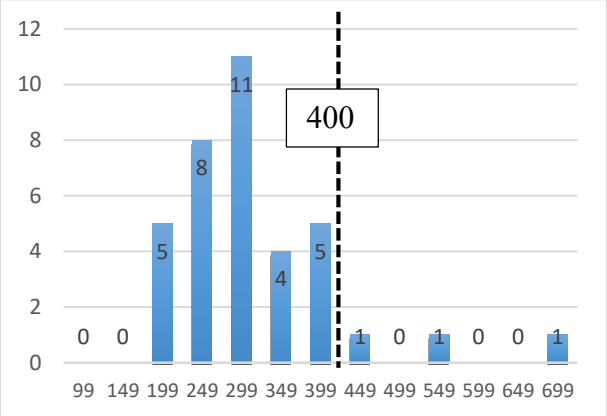


Figure 1 Frequency distribution of TOEIC IP scores of 4SM2019 in the third year of school (2018)

The horizontal axis indicates that the total TOEIC score ranges by 50 points, whereas the vertical axis indicates the number of students in each range. In 2018, the score was 287 on average, with the maximum and

minimum score being 665 and 170, respectively. In the beginning of academic year 2019, the learning goal of achieving 400 points or above within a year appeared relatively difficult for majority of the students.

Regular vocabulary quizzes to suppress the *inappropriate* e-learning behaviour of students

Watanabe and Aoki (2011) defined a case of inappropriate study wherein a student undergoes e-learning within a shorter time than that required for completion based on competence and task volume. Furthermore, Okuzaki, Hirano, and Maruyama (2019) focused on fourth-year students of NIT, Hakodate, and found that 75 % of the students engaged in *inappropriate* e-learning due to their improvisational attitudes towards learning in 2018. Therefore, to prevent the improvisational attitudes towards e-learning and to suppress the *inappropriate* e-learning behaviour of students, vocabulary quizzes were regulated for every lesson in Practical English 1A and 1B. The quizzes were generated using the LMS named GLEXA[*3] and produced by Version2[*3]. The vocabulary for a quiz was arranged based on the *TOEIC L&R TEST: Derutan-tokkyu-KinnoFurezu* (Asahi Press, 2018). The book presents approximately 1,400 English words and phrases frequently used in the TOEIC test. The students were informed in advance of the pages that will be covered by the quiz. Each vocabulary quiz consists of 100 words and phrases taken from a section and presented according to the order displayed in the textbook. As the textbook consists of 16 sections, students took a quiz on one or two sections for each lesson. The process was repeated 14 times for the first and the second semesters. At the beginning of each lesson, oral repetition of words and phrases was conducted in chorus and was led by a teacher. A multiple-choice quiz (Figure 2) was then given for the first semester, whereas a word order quiz was provided for the second semester (Figure 3).

Figure 2 Example of a multiple-choice quiz

Figure 3 Example of a word-order quiz

Each quiz was designed to complete within a few minutes. However, several students repeated the task and spent 20 to 30 minutes to complete the quizzes. Those students were deemed insufficiently prepared for a regular vocabulary quiz. The practice revealed students who had improvisational attitudes toward learning. Through the vocabulary quizzes, other students recognized that preparation can benefit learning and, thus, took steps to gradually prepare for and finish a quiz in the first attempt.

Comparing TOEIC reading conversion scores by examination

Figure 4 shows the differences in the average TOEIC reading conversion scores between 4SM2018 and 4SM2019 for each examination. Although 4M2018 marked the highest scores in the second midterm, the values dropped in the second final. Conversely, the average scores for 4SM2019 were slightly higher than those for 4SM2018 in three examinations, namely, first midterm, first final, and second final.

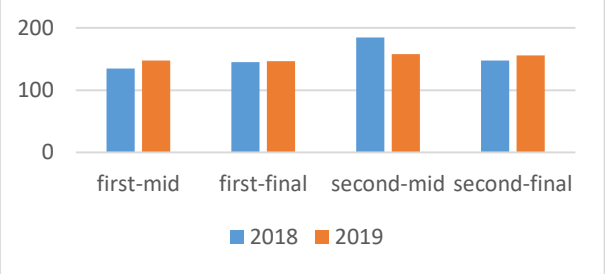


Figure 4 Comparison of average TOEIC reading scores of two classes by examination

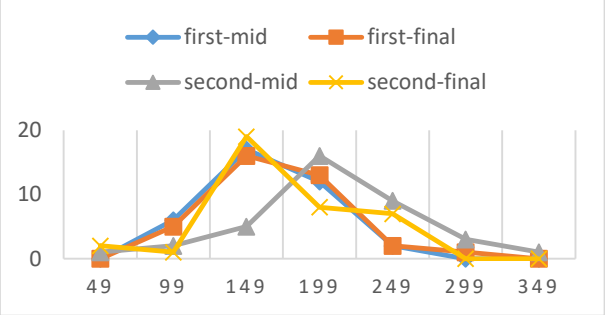


Figure 5 Frequency distribution of reading scores for 4SM2018

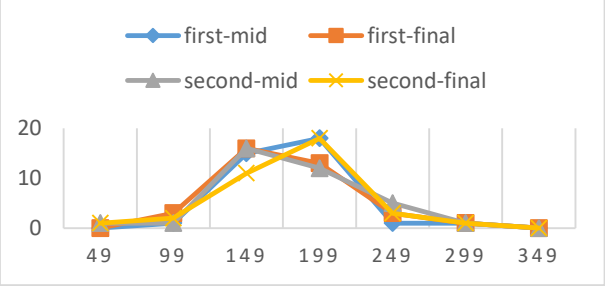


Figure 6 Frequency distribution of reading scores for 4SM2019

Regarding the frequency distribution data of the reading scores, the second final line for 4SM2018 indicates bipolarization (Figure 5). In contrast, each line for 4SM2019 in Figure 6 lacked bipolarization despite the peak differences. According to Fujita (2011), bipolarization occurs when a class divides into two groups, namely, motivated learners (those who study after class) and less motivated (those reluctant to study after class). Figure 7 shows that standard deviation increased in the second semester of 2018, whereas it slightly dropped by the end of 2019, although the first values were similar. This finding supports the notion that 4SM2019 maintained a learning community for a year.

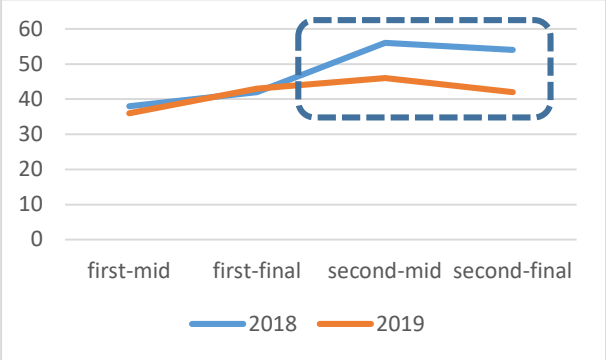


Figure 7 Comparison of the standard deviations of reading scores

***Inappropriate* e-Learning**

Figure 8 shows that in 2018, 90% of the students spent less than 35 hours on e-learning, which is the recommended study time for the ALC NetAcademy NEXT: Target 500/600/730 Course for the TOEIC®L&R TEST (Okuzaki, Hirano, and Maruyama, 2019).

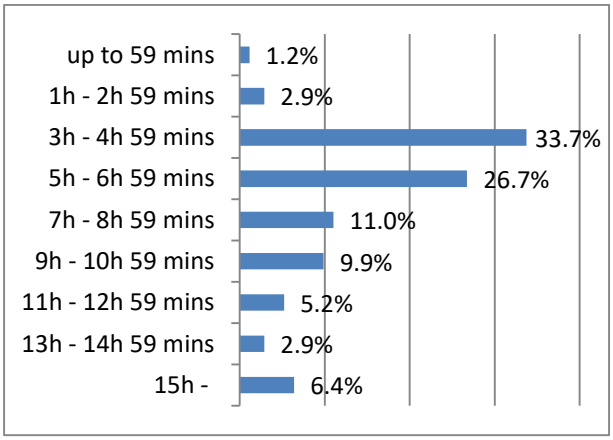


Figure 8 Total duration of the study time of fourth-year students for academic year 2018

Figure 9 shows the total duration of the study time of 4SM2019. The graph indicates that more students studied longer than 4SM2018.

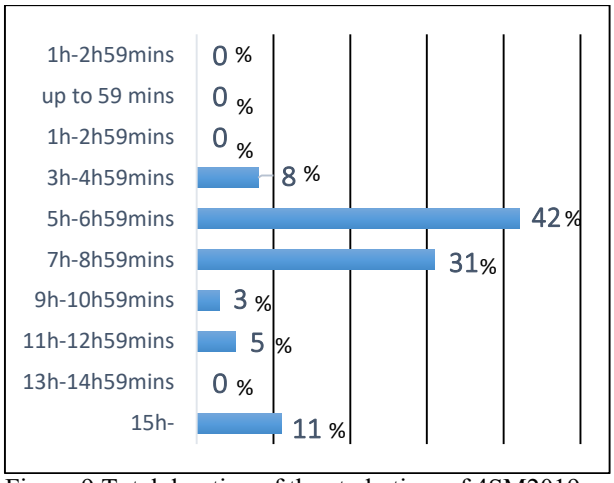


Figure 9 Total duration of the study time of 4SM2019 for academic year 2019

Comparing the average times in the entire TOEIC conversion tests between the first midterm and second final examinations for 2018, students who scored below 350 took the exam 30 minutes faster than those who scored more than 500 (Table 1). In 2019, the time difference between students who scored below 350 and those who scored more than 500 became less than 20 minutes (Table 2).

Table 1 Comparison of time spent to complete the TOEIC conversion tests (4SM2018)

examination period	overall mean	mean of scores of 345 and below	mean of scores of 500 and above
1st-mid (June 2018)	1:18:54	1:05:01	1:38:28
1st-final (August 2018)	1:32:10	1:22:41	1:54:35
2nd-mid (November 2018)	1:32:49	1:09:33	1:47:26
2nd-final(February 2019)	1:22:55	1:13:49	1:44:52
mean	1:26:42	1:12:46	1:46:20

Table 2 Comparison of time spent to complete the TOEIC conversion tests (4SM2019)

examination period	overall mean	mean of scores of 345 and below	mean of scores of 500 and above
1st-mid (June 2019)	1:43:51	1:33:00	1:50:28
1st-final (July 2019)	1:26:23	1:01:05	1:41:30
2nd-mid (November 2019)	1:28:22	1:26:00	1:35:12
2nd-final(February 2020)	1:06:16	1:01:54	1:07:20
mean	1:26:13	1:15:30	1:33:38

Table3 Comparison of total average scores of TOEIC conversion tests

	1st-mid	1st-final	2nd-mid	2nd-final
4SM2018	420	368	447	410
4SM2019	436	371	427	409

The total average scores for 4SM2019 were mostly similar to those for 4SM2018 (Table 3). Although most students of 4SM2019 were anticipated to achieve less than 400, the numbers of students were similar to those for 4SM2018 in each examination (Figure 10).

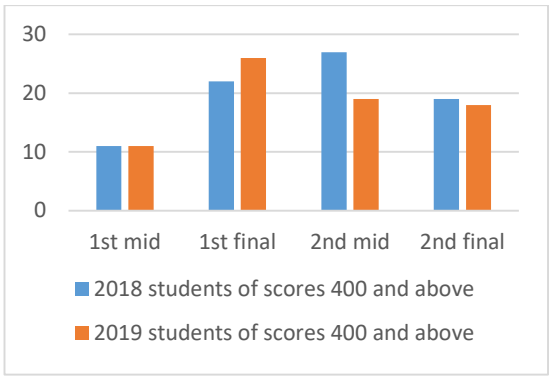


Figure 10 Comparison of number of students who achieved approximately 400 in TOEIC conversion scores

Results and Discussion

Based on the test results, examination times, study hours, and number of students who achieved a score of 400 and above the total TOEIC conversion scores as the learning goal, the vocabulary quiz functioned efficiently to prevent students from engaging in *inappropriate* e-learning. However, after allowing the students to set feasible learning goals, achievement objectives, e-learning self-evaluation and regular monitoring of their learning status with a teacher (the author), six students were unable to pass the second semester in 2019, the same case as in 2018. This indicates that the measures for improving the LMS for English were effective for facilitation of the entire class of 4SM2019 but insufficient for lower-level students. According to Ishihara (2016), providing other suitable instructions for lower-level students as early as possible based on their learning motivation and problems is necessary. Maeda (2008) points out that successful learners and unsuccessful learners in classroom should be aided by web-based training because of differences in learning aptitudes. The author claimed that instructions should be flexible so to maintain balance in the students' aptitude by investigating learner beliefs, learning motivations, and learning strategies, which are aspects that lack attention in the context of teaching 4SM2019.

Conclusions

Based on the previous study results, the two measures for improving the LMS for English for 4SM2019 were taken. Conducting regular quizzes that expand vocabulary was effective for preventing the class from undergoing monotonous work or pretending to learn. However, the measures were not enough to help lower-level students who were unable to achieve a total score of 400 in the TOEIC conversion tests. To support lower-level students, instruction should be flexible to suit their learning aptitudes. Inaddition, this aspect is an interesting angle for future studies.

Notes*

1. In the context of the current study, the TOEIC Listening and Reading (L&R) and Institutional Program (IP) tests are referred to as TOEIC tests.

2. In this research, the score attained in the examination of the ALC NETAcademy NEXT: Target 500/600/730 TOEIC®L&R TEST is referred to as the TOEIC conversion score. Takashima (2006) reported the quality and validity of questions in the ALC NetAcademy test.

3. Version2 is a company located in Sapporo, Hokkaido which facilitates *Blended Styled Education*, that is, a combination of classroom teaching and individualized learning using a computer. It provides an e-learning system wherein communication and a portfolio function are reinforced in a face-to-face classroom setting in addition to conventional LMS learning. GLEXA is one of the LMSs that facilitate English education inside and outside the classroom setting by providing e-learning functions for development of the reading, writing, listening and speaking skills of students.

Acknowledgments

I thank the students who allowed me to use their personal data for this research.

References

Ishihara, T. (2016). Implementation of e-learning based Tasks at TOEIC 1 Classes in 2014: Achievements and Future Issues, *Language and Culture Contents*, 61(34), 127-136.

Kato, T. (2018). *TOEIC L&R TEST: Derutan-tokkyu-KinnoFurezu.* Tokyo: Asahi Press

Maeda, H. (2008). Successful Learners and Unsuccessful Learners in Classroom Teaching Aided by Web-Based Training, *ARELE: Annual Review of English Language Education in Japan,* 19(0), 253-262.

Okuzaki, M., Hirano, T., & Maruyama, H. (2019). A Classroom Study of TOEIC E-Learning Involving Fourth-year Kosen Students at NIT, Hakodate College. *Transaction of The 13th International Symposium on Advances in Technology Education*, 216-219.

Takashima, H. (2006), An Attempt to Improve the Students' TOEIC® Test Scores, *Memoirs of the Kure National College of Technology,* 68, 35-44.

Watanabe, T.& Aoki, N. (2011), Effects of an English e-learning program: Task completion rate, time on task, and improper study based on TOEIC score gains, *Hiroshima Journal of International Studies*, 17, 105-119

Visualization of students' Generic Skills growth through Overseas Internship Programs

K. Yajima[*,a], K. Kawasaki[a], Y. Kubota[a], T. Shirane[a] and H. Fukumura[a]

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

*E-Mail yajima@sendai-nct.ac.jp

Abstract

National Institute of Technology, Sendai College (Sendai KOSEN) has been engaged in global education for students by offering internship programs at overseas universities since the early 2000s. On the other hand, a continuous survey of students' generic skills (GSs) by an objective method has been conducted from the academic year 2014. The GSs of Hirose campus students who participated in the 5-month overseas internship (OSI) program were analyzed, and the results are reported in this paper.

From the comparison of results between before and after OSI, it became clear that OSI program can efficiently enhance the participants' Competency abilities. This results are expected to make more effective and fulfilling OSI programs possible, and we will continue these surveys and analyze the effects of overseas internship by analyzing students' GS growth trends.

Keywords: *Quantitative evaluation of Generic Skills, Oversea Internship programs, A continuous survey of Generic Skills, Progress Report on Generic Skills*

Introduction

Sendai KOSEN has signed the academic agreements with 10 universities in the European region and 5 universities in the Asian region. In these agreements, exchanges of students are included. Sendai College has several overseas internship programs, for example, a program to dispatch 5th grade students of regular course to the partner universities in Finland, France or Thailand for about 5 months. Therefore, Sendai KOSEN is committed to fostering a global mindset of our students by dispatching our students to OSI and also accepting international students for our school programs.

As part of quality assurance of education, on the other hand, continuous surveys of students' GSs, abilities to comprehensively adjust to society, has been conducted since the academic year 2014. Through these continuous surveys, it is possible to know the GSs characteristics of the students who want to participate in OSI and the GSs growth between before and after the internship. The results of these surveys can be used to improve the contents of pre- and post- guidance on the programs and support to make OSI more effective.

In this paper, the differences of GSs growth characteristics between the students who participated in a 5-month OSI (longest program) and those of other students from Hirose campus are reported. By comparing the GSs of the students who participated in OSI with those of other students, some tendencies can be observed in the differences in the abilities of students before participating in the internship and the differences in growth characteristics with and without the participation in OSI. For the dispatched students in 2020, in addition, we measured their GSs immediately after dispatching, and compared their growth from 1st to 4th grade with that from 4th to 5th year (after dispatch). By analyzing these trends in detail, it is possible to achieve more effective overseas internships. For that purpose, we will introduce the results of the differences in GSs growth with and without overseas internship participation of our students.

Evaluation method of Generic Skills

In order to quantify GSs, there are two representative methods, that is, direct evaluation using rubrics, and indirect evaluation using external assessments. Progress Report on Generic Skills (PROG) [1], one of Japan's standard tests, was adopted in this survey because the test has advantages of eliminating evaluators' subjectivity and of being able to use for comparing our students' results with those of university students. Since Ito reported the assessment of PROG as a useful assessment tool [2], the results of PROG have been used in the evaluation of educational effects and proposals for new educational methods, for example, the proposal of A^3 Learning system by Takahashi et al. [3] and proposal of utilization of PROG for objective GSs assessment by Yajima et al. [4].

The PROG consists of two parts: Literacy part, which evaluates the examinee's ability to apply their knowledge to solve new or inexperienced problems, and Competency part, which evaluates the examinee's coping abilities with their surroundings, including decision making or action principle characteristics.

Literacy part consists of questions such as numerical reasoning and text comprehension. In Competency part, there are many questionnaire-type questions for examining behavioral characteristics. For example, to a question "When talking with a person you are new to, how do you act?" the answer should be in a five-scale rating from "Very friendly" to "Very politely." The evaluation of each component in this part is quantified by comparing the statistically processed exemplary answers of 4,000 Japanese businesspersons who were rated as "excellent". PROG test scores are rated either from 1 to 5, or from 1 to 7, depending on factors, in both Literacy and Competency parts, with larger numbers indicating better results.

Results of the Surveys

Information of the Surveys

Table 1 indicates the grades of students who took the PROG in each academic year. The target students in these surveys are those who were dispatched to a 5-month OSI program in their 5th grade and took the PROG in the academic years before and after the dispatch. Specifically, it targets 5th grade students in the academic years of 2015, 2016, 2017 and 2018. In 2015, eight students were dispatched to OSI, and all six of them took the PROG in their 4th grade and in the 1st grade of advanced course, respectively. Similarly, eight students were dispatched in 2016, and six and three of them took the test in 4th grade and in 1st grade of advanced course, respectively. In 2017, ten students were dispatched, and eight and four of them took the test in 4th grade and in 1st grade of advanced course. For 2018, three students were dispatched, and three and one of them took the test in 4th grade and in 1st grade of advanced course. (As for the PROG test, only those who are interested take the test, so the numbers of the dispatched students and the students who took the test do not match. In addition, since some students did not go on to the advanced course, the number of students who took the test in 1st grade of the course is further reduced. For the three dispatched students in 2019 who have no data for 1st grade of advanced course, on the other hand, we compared their GSs growth between that from 1st to 4th grade with that from 4th to 5th grade.

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

Grade	Academic Year					
	2014	2015	2016	2017	2018	2019
1st	○	○	○	○	○	○
2nd	○	○	○	○	○	○
3rd	○	△	○	○	○	○
4th	○	○	○	○	○	○
5th	○	△	○	×	○	△
1st	△	△	○	○	○	○
2nd	△	△	○	○	○	○

○ : All the students took the test
△ : Only some students of regular and advance course took the test
× : Students did not take the test.

R : Regular course
A : Advanced course

The students in the survey did not differ significantly in the curriculum compared to other students, except that they participated overseas internship in their 5th grade. Therefore, it is considered that the difference between the students who participated in the internship and other students is due to the difference whether or not they participated in overseas internship.

Generic Skills characteristics before dispatch : Comparison between students dispatched to OSI and others

Fig. 1 shows a ratio between the average value of the students who were dispatched to OSI and the value of other students (a value of average score of the students participated in OSI divided by the scores of other students) for the Literacy and Competency overall scores in PROG which they took in 4th grade. If this value exceeds 1.00, it means that the students who were dispatched to OSI have higher abilities at the time of their 4th grade before dispatch. As shown in Fig. 1, both of overall Literacy score and overall Competency score, the scattered results were observed and we can not say if there is a particular tendency. Fig. 1 tells us that the students who participated in OSI do not have particularly high Literacy and Competency abilities compared to other students.

Next, a comparison of "language processing skills" in Literacy part was shown in Fig. 2, since it is considered that students who wish to participate in overseas internship have higher language skills than others. The

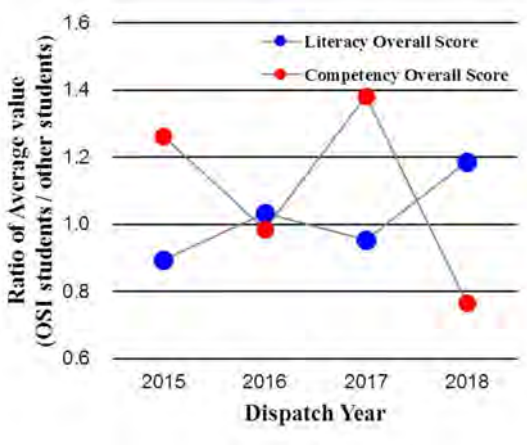


Figure 1. Comparison of Overall scores between OSI students and other students. ("OSI students" means the students who participated in the Overseas Internship.)

ratio of "language processing skills" showed a value of 0.96 to 0.99, which indicates that the students who want to participate OSI do not have high language processing ability in particular. Therefore, it became clear that the level of language processing skills did not match the desire to participate in OSI.

Finally, we compare scores for the elements of Competency main (3) categories to confirm if there are differences between students who want to participate in OSI and other students. Fig. 3 shows the results of a comparison of main categories' elements “Teamwork skills”, “Personal skills”, and “Problem solving skills”. Similar to Fig. 1, the results are also scattered among these elements. Even in the elements of the main Competency category, no particular tendency was found in the comparison between students who wish to participate in OSI and other students.

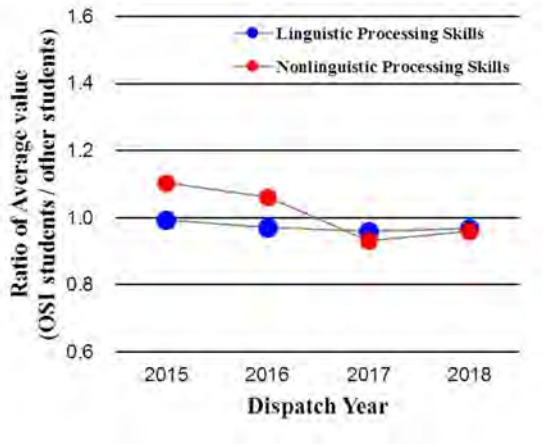


Figure 2. Comparison of Linguistic processing skills between OSI students and other students.

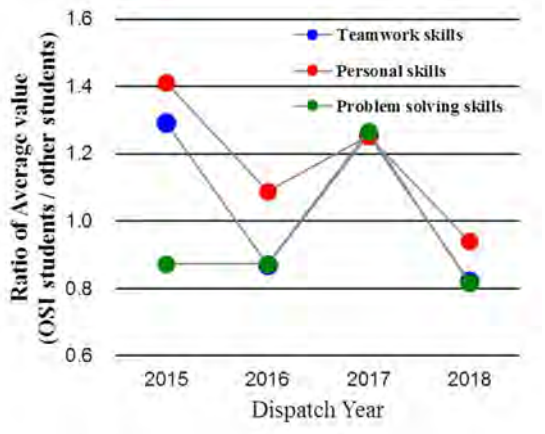


Figure 3. The elements of Competency main (3) categories between OSI students and other students.

GSs growth characteristics before and after OSI (Comparison between students were dispatched to OSI and others)

Fig. 4 shows GSs score improvement (the value obtained by subtracting the score in 4th grade before dispatch from the score in 1st grade of advanced course after dispatch) before and after OSI in the evaluation elements of Literacy part. From this point on, the growth of GSs was treated as the average of all dispatched years, due to the small number of students taking PROG in 1st grade of advanced course. It was found from Fig. 4 that the growth associated with the element of Literacy, whether or not participating in OSI, is relatively small in the range -0.2 to 0.8. This is caused since the Literacy growth tendency of Hirose campus students grows up to 4th grade of the regular course, and then shows a saturation tendency after 5th grade [5]. Furthermore, score improvement of those who participate in OSI is lower than those of other students. Therefore, regarding improvement of Literacy part skills, it is clear that studying at Sendai KOSEN is better than participating in OSI.

Next, GSs score improvement in each evaluation element of Competency part before and after OSI were shown in Fig. 5. In contrast to Literacy, students dispatched to OSI have higher scores for most elements of Competency than others. In the main (3) category, "Teamwork Skills" and "Personal Skills", the students dispatched to OSI scored about 0.6 points higher than before dispatch, while the score of students who did not participate in OSI is in the range of 0.1 to 0.2, that is, students dispatched to OSI grew more on the factor than others. On the other hand, it was found that the students who did not participate in OSI had higher score improvement for each element belonging to the "Problem solving skills". Therefore, it became clear that OSI program can efficiently enhance Competency abilities, which are considered to be difficult to improve by just attending lectures. In particular, every element of "Teamwork Skills" and "Personal Skills" grew efficiently.

Comparison of between GSs growths from 1st to 4th grade with from 4th to 5th grade

Since there are no data for 1st grade of advanced course for the three students who dispatched at 2019, we compared between their GSs growth in 3 years from 1st to 4th grade with their GSs growth in 1 year from 4th to 5th grade. The GSs score improvement in each evaluation element of Literacy and Competency part in 3 years before being despatched to OSI and in 1 year of the year of OSI were shown in Fig. 6 and 7, respectively. It is not possible to make a simple comparison because it is a comparison of growth over three years and one year, but from Fig. 6 it can be seen that each element of Literacy, except linguistic and nonliguistic processing skills, has grown remarkably in the three years prior to dispatch. On the other hand, regarding each element of competency, the growth during the one year participation in OSI is substantially higher in almost all the elements. However, regarding the factor of problem solving ability,

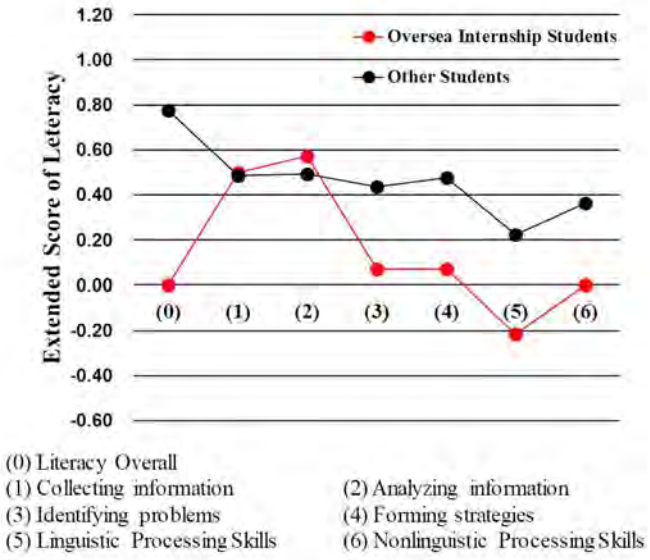


Figure 4. Comparison of scores improvement in Literacy between OSI students and other students.

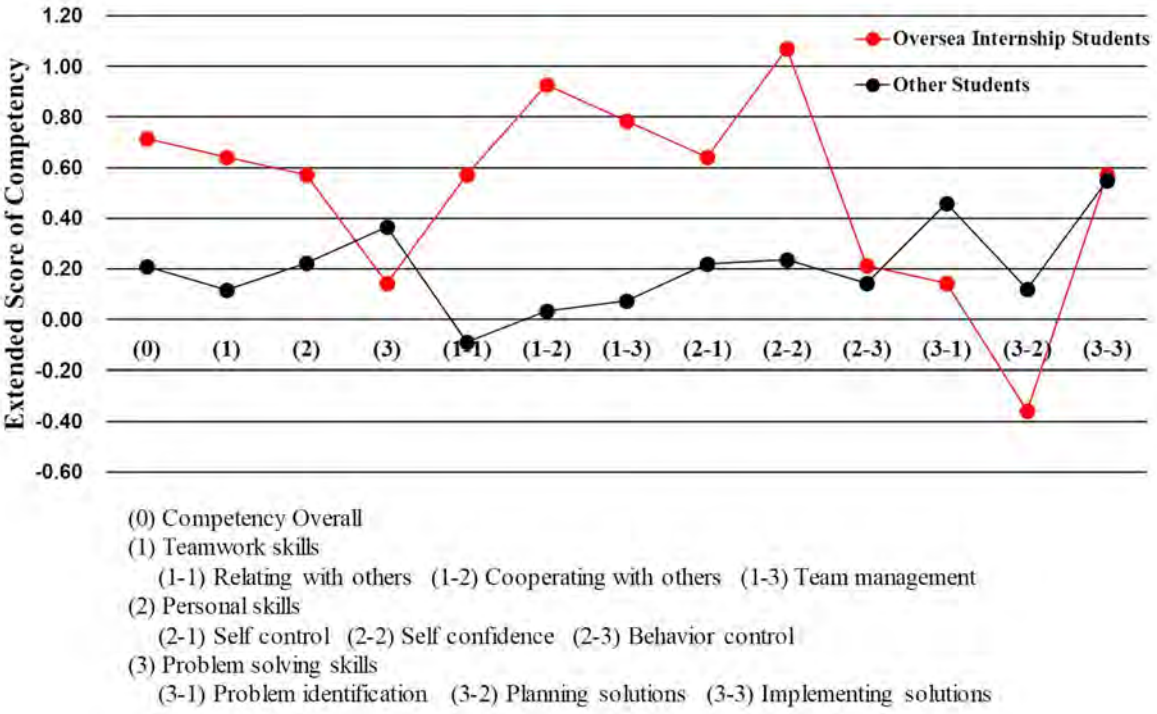


Figure 5. Comparison of score improvement in Competency between OSI students and other students.

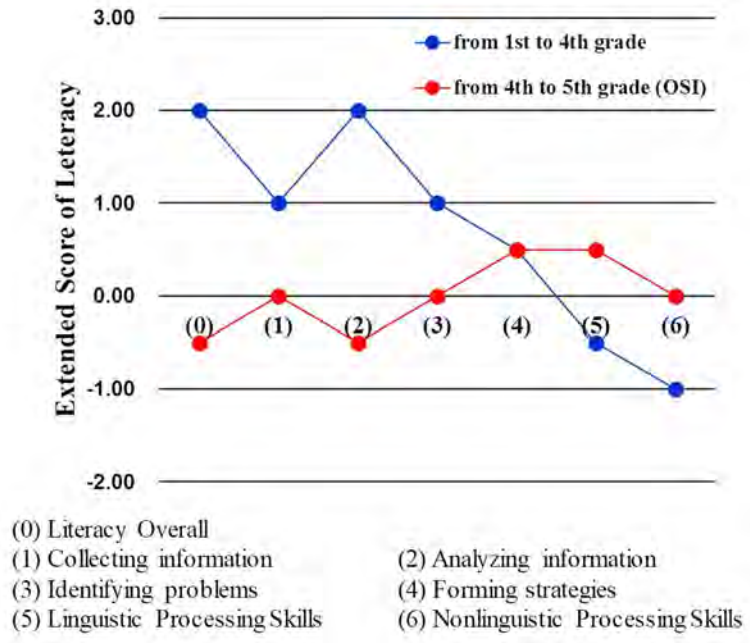


Figure 4. Comparison of scores improvement in Literacy between 3 years from 1st to 4th grade and 1 year from 4th to 5th grade.

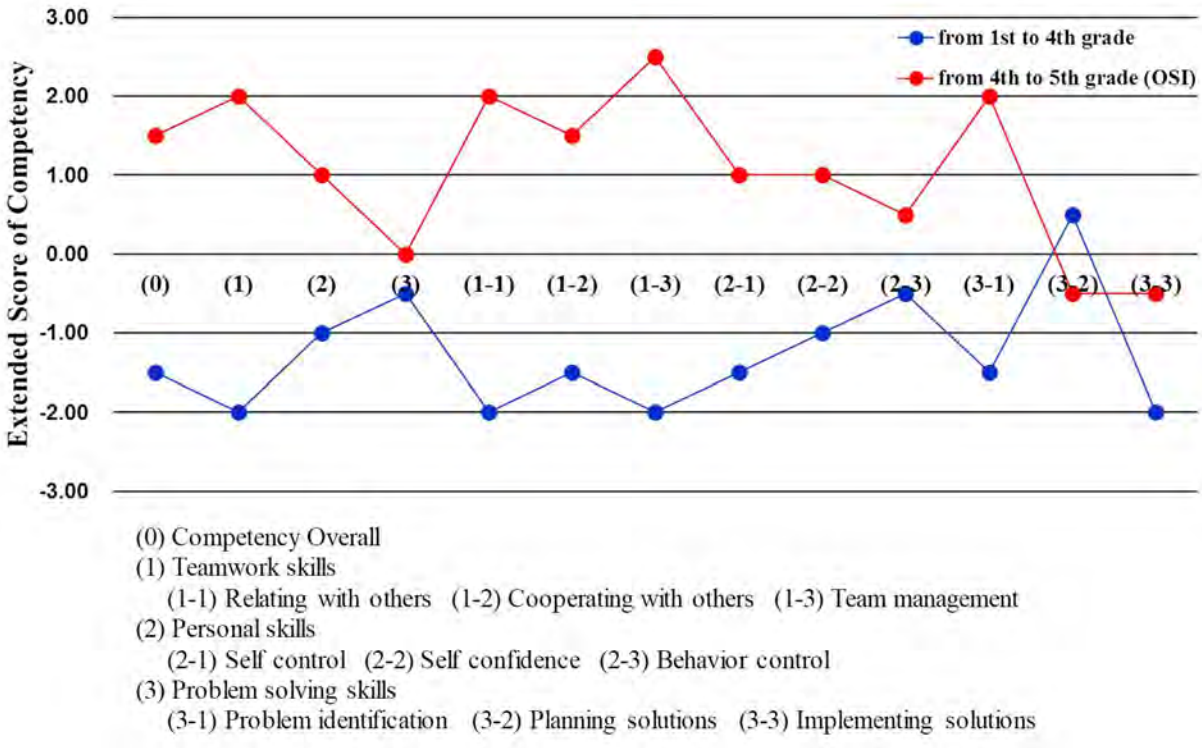


Figure 5. Comparison of score improvement in Competency between 3 years from 1st to 4th grade and 1 year from 4th to 5th grade.

the growth rate in one year when dispatched to OSI is smaller than other factors, and it is almost equal to or smaller than the value in three years before dispatch. These results show the same tendencies as the comparison before and after OSI dispatch in Fig. 4 and 5. Therefore, it became clear from these results that OSI programs can efficiently enhance the participants' Competency abilities, especially the elements of "Teamwork Skills" and "Personal Skills"

Conclusion

Sendai KOSEN has been engaged in global education for students by offering internship programs at overseas universities since the early 2000s. In this paper, the GSs of Hirose campus students who participated in the 5-month OSI program are surveyed before and after OSI by an objective method.

From the survey before OSI, remarkable tendencies were not observed in Literacy and Competency regardless of whether or not there was a desire to participate in OSI. Furthermore, the level of language processing skills did not match the desire to participate in OSI.

Moreover, from the comparison of results between before and after OSI (two different surveys), it became clear that OSI program can efficiently enhance participants' Competency abilities. Since Competency abilities, especially personal and teamwork skills, are considered to be difficult to improve in just attending lectures at school, the results of our survey seems to prove the educational effects of OSI (the training experience overseas).

It is considered possible to visualize the effects of the OSI program on GSs by continuing these surveys and conducting more detailed analysis. Since feedback of the visualized effects to the students participating in the internship is expected to make more effective and fulfilling OSI programs possible, we will continue these surveys and analyze the effects of overseas internship by analyzing students' GS growth trends.

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 staff of our college for their contribution to this project. In addition, we appreciate Professor N. Fujiki and Professor H. Matsueda of Sendai KOSEN for their helpful cooperation in the collection of data.

References

[1] About Progress Report on Generic Skills (PROG) test:https://www.kawaijuku.jp/jp/research/prog/ (URL: In Japanese)

[2] Ito, H. (2014). Assessing an Assessment Tool of Higher Education: Progress Report on Generic Skills (PROG) in Japan, International Journal of Evaluation and Research in Education (IJERE), Vol.3, No.1, pp. 1–10, 2014.

[3] Takahashi, A. et al. (2016). A3 Learning System: Advanced Active and Autonomous Learning System, International Journal of Engineering Pedagogy, Vol.6(2), pp.52-58, 2016: http://dx.doi.org/10.3991/ijep.v6i2.5645

[4] Yajima, K. et al. (2018). Objective Assessment of Students' Generic Skills, IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE2018) : https://www.tale2018.org/

[5] Kawasaki, K. et al. (2019). A Proposal of a students' voluntary improvement cycle method by visualization of Generic skills, Transactions of The 13th International Symposium on Advances in Technology Education (ISATE2019), 364-368

CAREER EDUCATION PROGRAMS IN NATIONAL INSTITUTE OF TECHNOLOGY, TOYOTA COLLEGE

T. Shimizu[*,a] and A. Kaneshige [a]

[a] National Institute of Technology, Toyota College/Department of Mechanical Engineering, Professor, Toyota, Japan

*shimizu@toyota-ct.ac.jp

Abstract

Career education includes wide varieties of educational activities such as improving communication skill, learning aptitude area of oneself and planning one's life as well as vocational guidance. The career education has been playing an important role in educational programs in National Institute of Technology, Toyota College since the Ministry of Education Culture, Sports, Science and Technology issued public message "Promotion of Career-oriented and Vocational Education" in October 2011. In 2012, project group for preparing the career-oriented education in Toyota College was organized and started working on making systematic unique career programs. The project group members listed up all existing extracurricular activities except club activities and classified them into several purposes. Then activities that efficiently meet each purpose carefully were picked up and program lists were reconstructed. Eventually, the career education programs in Toyota College introduced in 2013 have three unique features, such as, (1) residential training course for new students specialized to communicational training, (2) personal profile stock file book called T-file which is given to all new students every year and (3) vocational and social training e.g. self-present skills, job interview training by graduates. On April, new students of Toyota College submit their first homework assignments given in March (in advance) and enter the College. In these assignments, a filling form activity about their recollection of just graduated junior high schools and expectations for school lives starting in April 1, which is the first program of career education is included. With this form, a homeroom teacher can have useful information about their history and wish and will for their school lives. After entering school, they get their T-file at new student orientation guidance and then they start to keep handouts or forms described their thinking. After four years, the file will be a useful personal profile when they would like to know about their aptitude, way of thinking and growing history of themselves. It will be also a great help for deciding their new career course after leaving Toyota College.

Keywords: *career-education, residential-training, personal-profile-stock-file, job-interview-training-by-graduates, filling-form-activity-before-entering*

Introduction

The Ministry of Education Culture, Sports, Science and Technology has been promoting career education to Japanese educational institutes more than two decades. The career education promotion policies have been varied with social environments.

A strong awareness of the need to promote "career education" as a national policy matter arose in December 1999, when the Central Council for Education; the most comprehensive consultative agency to the Minister of Education called for the implementation of career education from elementary school level. It reads "there is a need to implement career education from the elementary school revel, in line with each stage of a child's development, in order to provide smooth transitions between school and society, and between different levels of schooling". This education should help students to gain a desirable perspective of employment and work, as well as knowledge and skills related to work itself, and at the same time, encourage them to understand their own personalities so as to foster their abilities and attitudes and allow them to select their own careers independently.

The main backdrops of the proposal were the increasing number of young people out of work, and those who spend their time on part-time, mostly unskilled work, who are known in Japan as "Freeters", and currently around 9% of senior high school graduates leave school without progressing to higher education or entering employment. In addition, according to a survey by the Ministry of Labor, 47% of new senior high school graduates and 32% of new university graduates leave their employment situation within three years. The reason why part-time work and high frequency of job changing drew serious attention from the government is the fact that so-called lifetime employment practices

were deeply rooted in Japan. It had always been assumed that young people would move from full-time study directly to full-time work.

However, after that, there was a new move in the direction of career education. That was the shift from Countermeasures against youth employment issues toward education initiatives. In January 2011, the Central Council for Education changed the definition of Career Education; education which encourages career development by cultivating the competencies and attitudes needed to raise the social and vocational independence of individuals. This definition is based on the understanding that all persons live their life while playing various roles, such as that of a professional, a family member, a member of the larger community; and that these roles change, accumulate, and interact over the period of lifetime. Also, the Council reconfirmed that career education program should be implemented at all school form pre-primary to tertiary levels, and the practices through each school's overall educational activities are crucial.

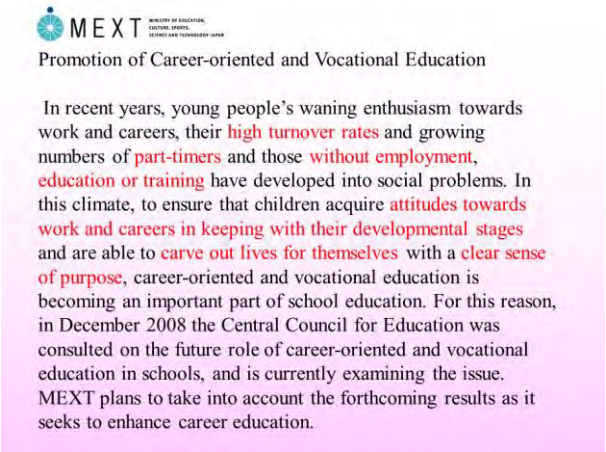
Also, the Council proposed a clear recommendation on the competencies to be fostered through career education as "the Basic and General Competencies consist of four group;

1. Competency to establish relationships and community.
2. Competency to manage and understand oneself.
3. Problem-solving Competency.
4. Career-planning Competency.

All of the competencies are indispensable in both life and professional career in the 21st century.

Promoting Career Education in Toyota College

The Ministry of Education Culture, Sports, Science and Technology issued public message "Promotion of Career-oriented and Vocational Education" in October 2011 as shown in Figure 1.


MEXT

Promotion of Career-oriented and Vocational Education

In recent years, young people's waning enthusiasm towards work and careers, their high turnover rates and growing numbers of part-timers and those without employment, education or training have developed into social problems. In this climate, to ensure that children acquire attitudes towards work and careers in keeping with their developmental stages and are able to carve out lives for themselves with a clear sense of purpose, career-oriented and vocational education is becoming an important part of school education. For this reason, in December 2008 the Central Council for Education was consulted on the future role of career-oriented and vocational education in schools, and is currently examining the issue. MEXT plans to take into account the forthcoming results as it seeks to enhance career education.

Figure 1. Statement of MEXT "Promotion of Career-oriented and Vocational Education" (Summary)

In 2012, project group for preparing the career-oriented education in Toyota College was voluntarily organized. The target of the project was established self-consistent programs to foster student's competency to self-realization. It is not only vocational education, which is often related to *career education* in limited meaning. The group was consisting of five teams for residential training, intercultural understanding, career planning, vocational educations and making T-file (personal profiles). Then, every team started to consider programs for career education to achieve their goals.

An educational activity known as "homeroom activity" or "classroom activity" takes place in first to third grade class room once a week in Toyota College as almost College of Technology. This involves group work and discussion-based activities, during which students learn how to form positive relationships, plan how to enjoy class and school activities, and think about their own futures. The person leading these activities is the class teacher. The project group needed help from class teachers because the career programs have to be implemented in those homeroom activities. Every class teacher has own skill and different way of class management so, it is not easy to persuade them to implement career activities as classroom activities. There had already existed some program such as a half day excursion, a seminar by outside of college lecturer, sports activity and so on. Those activities were one-off basis and managed my individual class teachers. So, the project group members listed up all existing extracurricular activities except club activities and classified them into four categories corresponding to the competencies the Council proposed as mentioned above.

Then activities that efficiently meet each purpose were newly planned and with carefully picked up from previous activities, new program lists were reconstructed.

1) Programs related to competency to establish relationships and community.

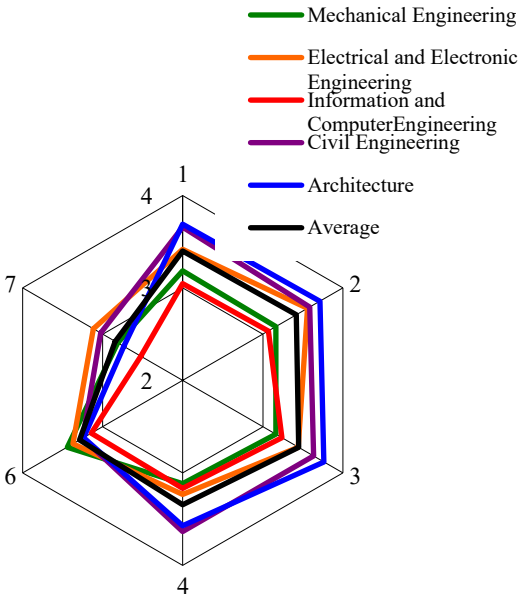
Competency to establish relationships and community is crucial in the social context in Japan today and it is the basis of all other competencies. Career education activities in Toyota college listed in this section is residential training course for new students specialized to communicational training, intercultural understanding, etc.

99% of new students of Toyota College are entering dormitory on entering school. Most of them start living in the dorm with their classmate. For most of the students the dormitory-life last two-years, but some students remain as senior residents of dormitory and lead younger residents. This boarder experience of Toyota College students have been highly rated by recruitment staff of company. However, in the routine daily life, the usual friends prone to be limited. And misunderstand between the groups in the class is going to happen. This causes because of lack of communication between the groups.

Figure 2. The theatre working activity in Residual Training Course

Career program: Residual Training Course was specially planned for new students' competency of communication. Residual training course is carried out in the middle of June every year from Friday to Saturday and which is an overnight training. It holds just after the first mid-term exam for new students and by that time, most of them have been making the group of their usual friends. The residual training course consists of roughly three activities i.e. theatre working by four students, group work in each class, and outdoor or sports activities. The theatre working which is directed by actors and scriptwriters of private theatrical groups. The task for the group with four students is for example, "stand up a person sitting chair and reding book with conversations only. They must convince the sitting person to stand up, so have to develop strategy within their groups. Four roles are assigned each student in the groups. One student in every groups cannot speak but have to join in the performance. Since the significance of this activity is communication competency, so four group members gathered from all department randomly. For most cases, they never talk nor even seen each other before the activity. Prior to the performance, each group has enough time for discuss their strategy within the discussion, students experience interaction with students from another department class. Subsequently, every group perform with their scheme in front of the audience of all other students. One of This performance scene is shown in Figure 2. Most situations, they fail to persuade the sitting person to stand up and found it difficult to have their own way. The group work in each class is discuss about good and bad subject of classroom activity in the school life, and makes three or more motto of the future classroom. The group members of this activity are carefully chosen by classroom teachers to promote interaction spreads among the classmates in the classes. Some classroom teacher said that trouble in the classroom around before the summer vacation decreased after this activity had took place in this period of school calendar.

After the series of activities, a survey was conducted to find out the level of satisfaction with the activities. Figure 3 describes the most recent results of the survey.



1	By and large, I enjoyed the Residual Training.
2	Two class room activities have improved my communication skill with classmates.
3	By the theatre role playing, I noticed importance of communication skill.
4	I enjoyed the sports activities.
6	No problem with having meals, taking a bath, and sleeping.
7	Are you refreshed after the Residual Training?
5	Cooking in the field was called off due to the bad weather.

Figure 3. Results of a questionnaire to students regarding the effectiveness of the Residual Training Course (The Rader chart of every class and the question item)

From this figure, most of the students satisfied with the activities, such as the theatre role playing, two classroom activities, and the sports activities. As will be described later, the large number of students regard the Residual Training Course as the most memorable activity in the school life.

Another activity in this category of competency to establish relationships and community is intercultural understanding programs which consist of from Toyota to the world programs and from world to Toyota programs. Every year, more than fifty students of Toyota College go abroad to study and around ten students from foreign countries are studying in the College. The target of these program is cultivating feeling for the wider world with attend lectures of a returned student from studying abroad and a student from outside of Japan. The lectures are focused on the different cultures, foods and annual school events to understand different way of thinking between foreign students and Japanese students. Recently, these programs are implemented in monthly dormitory meetings due to packed schedule of career programs.

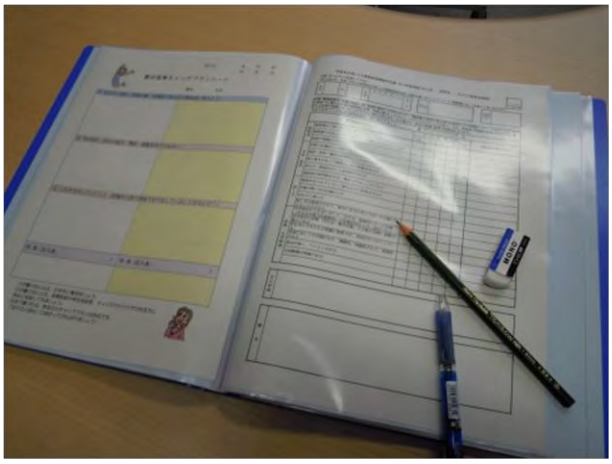


Figure 4. T-file (personal portfolio)

2) Programs related to competency to manage and understand oneself.

The competency to manage and understand oneself is significant for most new students of Toyota College because they must make their living in dormitory. The career programs listed in this category must be carried out at the same time their starting school lives. On April, new students of Toyota College submit their first homework assignments given in advance in March and enter the College. In these assignments, a filling form activity about their recollection of just graduated junior high schools and expectations for school lives starting in April 1, which is the first program of career education is included. With this form, a homeroom teacher can have useful information about their history and wish and will for their school lives. After entering school, they get their T-file which is personal portfolio shown in Figure 4, at new student orientation guidance and then they start to keep handouts or forms of subsequent career programs in which described their thinking. After four years, the file will be a useful personal profile when they would like to know about their aptitude, way of thinking and growing history of themselves. It will be also a great help for deciding their new career course after graduate Toyota College. There is another program "desired persons of talent" for third grade students to look back their lives so far and try to know themselves. The lecturer of this program comes from recruiting section of a company and who is a graduate student of Toyota College. In this program, students work on making own life plan and prepare for choosing their future paths.

3) Career-Planning Competency.

Prior to the career-planning programs set at the beginning of two semesters of third and fourth grade, the program for making plan of campus activity and looking back of the latest plan invoked in the head of every semester for first- and second-degree students. During the first and second grade, plans made by students were stored in their T-files and put efficient use of career planning. The career planning programs are designed to complete self-introducing part of application form. A class subject Japanese expression also setting one of the goals for students to make personal introducing form. Thus, career programs and a class subject go along to foster competency of career planning. Just before the submission of the entry sheets, fee-charging program "writing entry-sheet" held for forth grade students after the second semester examinations. This program is conducted by instructor outside the school and some forty students attend every year.

Concern about vocational education, in Finnish secondary schools' the activities centre on a career counsellor known as Opinto-Ohjaaja, in Europe, many countries provide career support through partnerships with organizations outside the schools. Examples of this are UU-centers (Ungdommens Uddannelsesvejledning: youth guidance centers) in Denmark. UU-centers are established across the country. Also in Germany, BIZ (Belufs Information Zentrum : job information centers) have been active in cooperation with the schools. On the other hand, Japanese schools give the responsibility for career guidance and counselling to the members of school teaching stuff, each of whom has their own subject to teach. As is usual with Japanese public school, most of National Institute of College have no special dedicated section for vocational education at the moment.

Getting through the company interview is one of the most concernedly thing for the job-hunting students. The guidance for the interview is usually made by classroom teachers of fourth grade students and teachers belong to the department of the students. In this kind of circumstances, some alumnus lends their hands to carry out "how to improve self-expression" seminar and realistic practical simulation of company interview (Figure 5). In the latter program, about sixteen alumnus act as interviewers. In the simulation, some students getting so nervous that cannot speak at all. This program is for about one hundred students and twenty-four students interviewed and get right into candidates of employee.

Figure 5. Job meeting training with alumnus

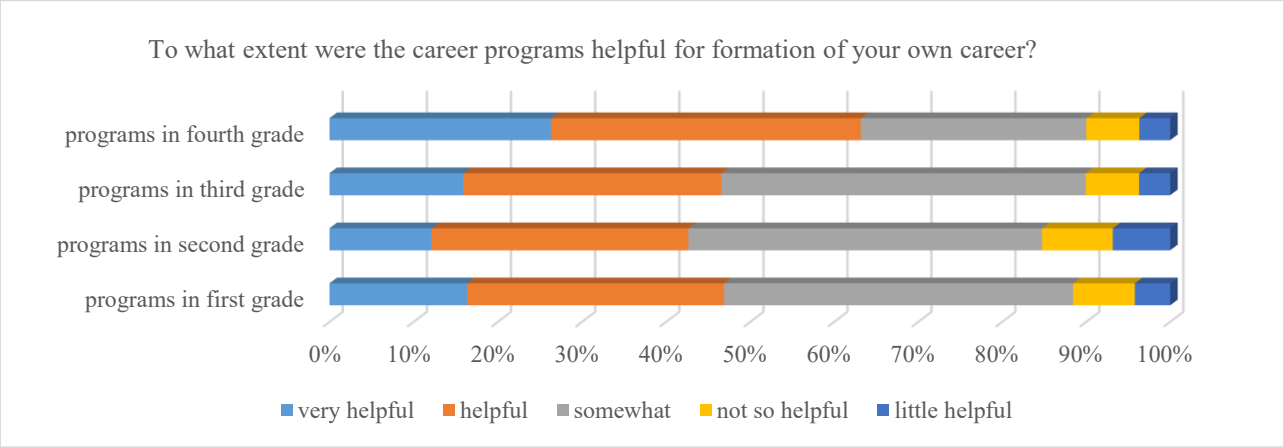


Figure 6. A questionnaire survey for graduated students

From late February in 2020, career programs were cancelled due to the spread of the coronavirus. Students were not allowed to go to school, and cannot practicing job meetings in the career programs. Most job-seeking students want to practice their job interviews. In this year, unlike in previous years, students talking about their anxious about having a job interview. Therefore, it can be said that systematic job search support is a valuable support for students. Due to the influence of the corona disaster, the number of remote interviews by companies has been increasing. The anxiety of students who go through such an unfamiliar experience without being adequately prepared is great. It may be necessary to think about how to deal with these new forms of job hunting in the future. The school's job-hunting support events include briefings by local small and medium-sized companies in booths, but there is insufficient time and space to hold individual company briefings separately. Our school has an effective job offer ratio of about 30 times. Therefore, individual company briefings are not conducted because they interfere with educational activities.

Results and Discussion

A questionnaire survey was conducted every year at the time of graduation in order to invesigate the overall satisfaction and effectiveness of the career education programs. The answers of the most recently graduated students to the question “To what extent were the career programs helpful for formation of your own career“ are summarized in the Figure 6. From the results, 80 to 90% of the students reflected the career education programs were effective. But the differences were found between programs in each grade. The programs in fourth grade is considered very effective, while the programs in second grade is not so effective. This is because, goal setting and reflection were not considered as important, while job preparation was desperate for them.

The questionnaire asks which initiatives have been effective. From the results, the residual training course received the most votes. In second and third place was a lecture on human power for second grade students and a business etiquette course for fourth grade students. Lectures by alumni followed, and job interviews training by alumni came in fifth place. On the other hand, many students did not pay much attention to the semiannual goal setting and review and career planning. These results led us to the idea that the growth of students is variable and cannot be controlled, and that it is inappropriate to consult with a uniform program and encourage their growth. Therefore, it was decided to leave the individual qualities of these students to their class teachers.

Conclusions

In Toyota College, a series of career oriented educational programs were introduced since 2013 and implemented for eight years. These programs have took root with the College. The programs consist of (1) residential training course for new students specialized to communicational training, (2) personal profile stock file book called T-file which is given to all new students every year and (3) vocational and social training e.g. self-present skills, job interview training by graduates. From the questionnaire survey by the graduated students, career education programs seem to have received a certain amount of recognition. On the other hand, however, the temperament of the students is changing, and it is also necessary to make changes accordingly. Also, this Corona disaster has shown the importance of support for job hunting. We would like to continue to support the growth of students without the high job offer ratio.

Acknowledgements

When the career program was introduced in 2013, the Career Education Support Office was created. Since then, many faculty members have made significant contributions to the career development of our students. The authors would like thanks our member of the Career Education Support Office spanning for eight years. Especially, we thank Ms. Numaguchi for her contribution for number of activities and administrative contact and procedure for years.

References

Ministry of Education, Culture, Sports, Science and Technology. (2010). *The Ideal Education to Support People for Lifelong Career Building. White Paper on Education, Culture, Sports, Science and Technology 2010.* Retrieved from https://www.mext.go.jp/b_menu/hakusho/html/hpab201001/detail/1326588_006.pdf.

Ministry of Education, Culture, Sports, Science and Technology. (2014a) Announcement on FY2013 School Basic Survey. [in Japanese]. Retrieved from http://www.mext.go.jp/component/b_menu/houdou/__icsFiles/afieldfile/2014/08/07/1350732_02.pdf (accessed August 29, 2014)

Ministry of Education, Culture, Sports, Science and Technology. (2015b). Statistics on Student Guidance (2014) [in Japanese]. Retrieved from http://www.mext.go.jp/b_menu/houdou/26/10/__icsFiles/afieldfile/2014/10/16/1351936_01_1.pdf.

Ministry of Education, Culture, Sports, Science and Technology, Guidance and Counseling Research Center, National Institute for Educational Policy Research of Japan. (2013c). The result of research of FY 2011 workplace experience and internship enforcement (summary). [in Japanese]. Retrieved from http://www.nier.go.jp/shido/centerhp/ishiip/h24iship.pdf.

Ministry of Education, Culture, Sports, Science and Technology, Guidance and Counseling Research Center, National Institute for Educational Policy Research of Japan, .(2013) Creating Career Education. November 2011(Translated in March 2013)

Ministry of Internal Affairs and Communication, Statistics Bureau(2013) Annual Report on the Labour Force Survey2012. [in Japanese]. Retrieved from http://www.stat.go.jp/data/roudou/sokuhou/nen/dt/pdf/index1.pdf.

Takao Mimura. (2016), Vocational Guidance, Career Guidance, and Career Education phases in Japan. *Bulletin of the Graduate School of Teacher Education, Waseda University* vol. 8, 19-34

Teruyuki Fujita. (2011). The Current State and Future Tasks of Japan's Career Education Promotion Policies-Embarking on the Road Less Traveled. *Japan Labor Review,* vol. 8, No. 1, 26-47.

A continuous survey of students' Generic Skills from pre-admission to post-graduation

K. Kawasaki[*,a], Y. Kubota[a] and K. Yajima[a]

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

*E-Mail kawasaki@sendai-nct.ac.jp

Abstract

A continuous survey of students' Generic Skills (GSs) has been conducted since the academic year of 2014 at National Institute of Technology, Sendai College (Sendai KOSEN). Since the survey from admission to graduation at Sendai KOSEN has been completed, the results are reported in this paper.

We conducted the five-year continuous survey during college and planned surveys of pre-admission and post-graduation. As a pre-admission survey, we conducted a competency test of PROG for prospective students in March 2020. On the other hand, for a survey for post-graduation, we attempted to conduct a PROG follow-up survey as a trial in March 2020 with the cooperation of three graduates who had entered a university. In this paper, we introduce the results of these surveys.

Keywords: *Quantitative evaluation of Generic Skills, A continuous survey of Generic Skills from pre-admission to post-graduation, Visualization method of Generic Skills*

Introduction

In addition to the expertise and technical skills acquired at colleges and universities, it is important to nurture students with GSs, which consist of fundamental competencies and literacy skills, to make good use of their expertise and skills. In order to nurture GSs, many educational institutions have begun to introduce active learning (AL) techniques and project/problem based Learning (PBL). Some problems, however, remain about evaluating GSs quantitatively, objectively and accurately.

A continuous survey of students' GSs in Sendai KOSEN started in the academic year of 2014 and has been conducted annually for 6 years. The results of these surveys clarified our students' GSs growth characteristics in the educational curriculum of Sendai KOSEN.

In order to quantify GSs, we adopted Progress Report on Generic Skills (PROG) [1], which is one of the standardized tests of GSs in Japan. PROG is an objective evaluation method, and has the advantage that the subjectivity of the evaluator is excluded from the results. In addition, its great advantage is that we are able to compare our students' test results with those of other examinees, for example, university students or company employees, who have taken the same test. It means that an extended continuous surveys of pre-admission or post-graduation students can be also possible by having them take the PROG test.

In this paper, we will report the students' GSs growth characteristics of Sendai Kosen, Hirose Campus from their admission to graduation found out by the previous surveys. In addition, as a development of continuous surveys, we will introduce a research plan from pre-admission to post-graduation. As a pre-admission survey, a PROG Competency Test was given in March 2020 to the prospective students who passed the Hirose Campus entrance examination. The measured results of prospective students were compared with those of the first grade students who are surveyed annually from 2014, so the comparative results are reported in this paper. In addition, the post-graduation survey for Sendai KOSEN graduates who entered Universities of Technology at Toyohashi and Nagaoka, both of which have strong ties with Kosen, is now being coordinated for the first time. Other post-graduation surveys are planned to be expanded to graduates who entered universities or got a job in a company. In this paper, we introduce the results for three graduates who cooperated with the trial survey conducted in March 2020. Through these surveys, we attempt to establish a visualization method of GSs growth for engineering students.

Objective Evaluation of Generic Skills

In order to quantify GSs, there are two representative methods, that is, direct evaluation by teachers and students using rubrics, and indirect evaluation using external assessments. We have conducted a six-year continuous survey of our college students' Generic Skills using PROG, which is an assessment of GSs. PROG is an objective test, so we can use it to compare the scores of an examinee with an average score of all examinees. It means that the examinees can recognize their own strong/weak points by comparing their scores to the average scores of their classmates at school (and also to

those of other university students). An outline of PROG is described below.

The PROG test was originally developed by KAWAI-JUKU [2] and the test consists of two parts: the Literacy part, which evaluates the examinee's ability to apply knowledge to solve new or inexperienced problems, and the Competency part, which evaluates the examinee's coping abilities with their surroundings, including decision making or action principle characteristics. Evaluation components of PROG test were defined by reference to key-competencies determined by DeSeCo project [3] of OECD. The evaluation items 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) [4], while, in the Competency part, a number of questions are given in a questionnaire format, to examine the characteristics of the examinee's behaviors. 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 the larger the numbers are, the better the results are.

In the 2019 test, about 134,000 university and college students took the Literacy part and about 613,000 university and college students took the Competency part. Therefore, a statistical comparison of GSs between our students and university students is possible. In this paper, we compared our students' average score of PROG with the score of university students who took the same test to confirm the educational effects.

Growth Characteristics of Generic Skills

Table 1 indicates the grades of students who took the PROG in each academic year. A continuous survey of students' GSs started from the academic year of 2014 and six years have passed since then. Now we can assess how the students' GSs change as their grade progresses in Sendai KOSEN, Hirose Campus.

Figure 1 shows yearly changes of overall scores of Literacy and Competency parts for the follow-up survey of the same students from their 1st year to 5th year and 1st year of advanced course (red arrow in Table 1). In Fig. 1, the results of the advanced course are shown with pink dots for reference. This is because the number of samples is very small compared with the number of the regular course, since only about 30% of the students go on to the advanced course and the PROG is not mandatory in the advanced course. The reduction in the number of samples can also be seen from the size of the error bar. It is obvious from Fig. 1 at first glance that their abilities of both Literacy and Competency steadily grew with the progress of their grade from 1st to 5th grade in regular coerce. The Competency scores increase as their grade progresses, with the exception of a decrease in one year between 2nd and 3rd grade. In the Literacy part, it was steadily increasing until 3rd grade, but a saturated tendency was observed after 3rd year. One of the reasons for the saturation after the 3rd grade is that the Literacy overall score is very high at about 5.4 compared to the competency overall score, and it is very difficult to obtain a score higher than this score. Therefore, it is considered

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

Grade	Academic Year 2014	2015	2016	2017	2018	2019
1st	○	○	○	○	○	○
2nd	○	○	○	○	○	○
3rd	○	△	○	○	○	○
4th	○	○	○	○	○	○
5th	○	△	○	×	○	×
1st	△	△	○	○	○	○
2nd	△	△	○	○	○	○

○ : All the students took the test
△ : Only some students of regular and advance course took the test
× : Students did not take the test.

Red:Regular course
Blue:Advanced course

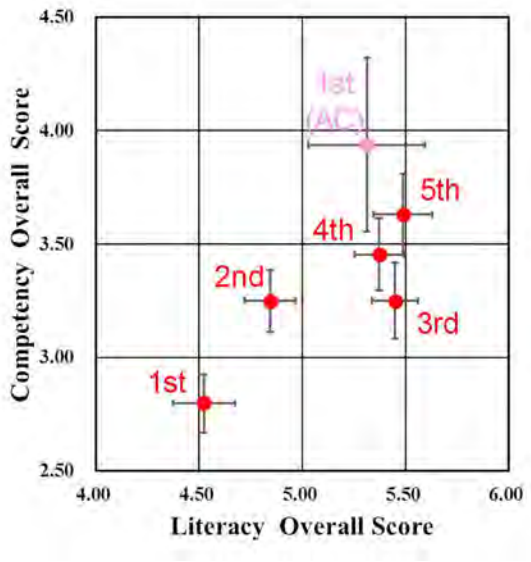


Fig. 1. Yearly changes of overall scores of Literacy and Competency parts for the follow-up survey of the same students from their 1st years of regular course to 1th years of advanced course.

that our students' literacy abilities have been sufficiently developed by the 3rd grade.

On the other hand, Figure 2 shows yearly changes of overall scores of Literacy and Competency parts for the comparative survey from 1st year students of regular course to 2nd year students of advanced course in the same year 2019 (blue arrow in Table 1). Here, since the 5th grade students of the regular course have not taken the PROG test in 2019, the result of the 5th grade is not described. The results of the advanced course are reference data for the same reason as in Fig. 1. Compared to the follow-up survey of the same students in Fig. 1, since the students surveyed in Fig. 2 were different in grades, more scattered results are expected to be measured. For the Competency part, it is observed that the overall score decreases slightly in one year from the 1st grade to the 2nd grade of the regular course, but the scores are totally increasing with the progress of the grade. As well as Figure 1, this results tells us that our students' competency abilities are growing steadily. The reason for the decrease in one year from 1st to 2nd grade can be considered as follows; since the competency abilities of the 1st grade students in recent years have been improved (as you can see from the results that come out later (Fig. 3)), it is considered that an effect of GSs education at elementary and junior high schools can be starting to appear. On the other hand, for the Literacy part, the overall score increased with the progress of the grade, with the exception of almost the same score of 1st and 2nd grade. In Fig. 2, the score of 2nd grade students in advanced course is very high (6.09). This result is possible to be considered to show that only students with high literacy ability took the examination, because the number of PROG examinees in the 2nd grade of the advanced course is very small (only 11 students took the PROG). The error-bar of Literacy is very narrow compared with the bar of Competency, and this suggests that the hypothesis is correct. Therefore, also in Fig. 2, the tendency that the literacy score is saturated at around 5.4 is observed.

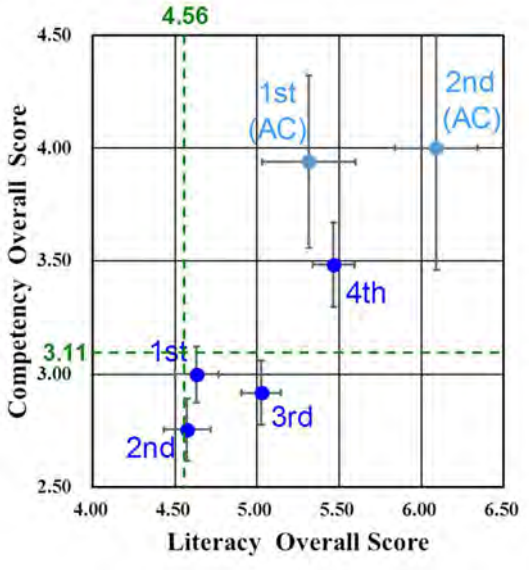


Fig. 2. Yearly changes of overall scores of Literacy and Competency parts from 1st year grades of regular course to 2nd year students of advanced course in the same year 2019.

On the other hand, the green dotted line in the figures represents the average value of university students who took the same test in 2019 (Literacy: 4.56, Competency: 3.11). The average of our college first-grade students' Literacy scores exceeds that of university students'. Regarding the Competency, the score of 4th grade of the regular course, which correspond to the 1st grade of university, greatly exceeds the average score of university students. From the results of comparison with the scores of university students, it is clear that our educations were also effective in terms of GSs.

Results of pre-admission competency survey

We are planning competency research from a pre-admission to post-graduation as a development of the 5-year continuous survey in Kosen. First, as a pre-admission survey, we conducted only the PROG Competency test for the prospective students of Hirose campus who passed the 2020 entrance examination. Since this is the first measurement, there is no comparable results. Therefore, we compared the result with the measurement results of the 1st grade students, which has been measured since 2014 (green arrow in Table 1). The result is shown in Fig. 3.

Fig. 3 shows the average of the Competency overall scores for 1st grade students from 2014 to 2019 with the green bar, and the average of the score for the prospective students in 2020 with the red bar. First, the measurement conditions will be explained. The examination conditions of 1st grade students are a paper-based written test in the classroom, examination about half a year after admission (midpoint of first-year) and 40 minutes of the time limit. Some students are unable to answer all the questions in 40 minutes because there are so many questions in the competency part of the questionnaire-style test. Meanwhile, the prospective students took PROG test online. Regarding the testing time, it is possible to extend if the students could not answer all questions in the 40 minutes. Regarding the completion time of the exam for prospective students, the percentage of those who completed the examination within 40 minutes, between from 40 to 60 minutes, and more than 60 minutes was 37.2%, 38.8% and 24.0% respectively.

From Fig. 3, the scores for the first year students in each year are in the range of 2.8 to 3.1, whereas the scores for the prospective students are as high as 3.62. The reason seems to be that the prospective students were able to spend enough time, and their motivation to take the test is considered to be very high because they took PROG test as part of the admission procedure. Furthermore, since the learning guidelines in Japan have been revised in 2008 -2009 [5] and partially revised at 2015 [6] to introduce AL techniques to foster GSs in all

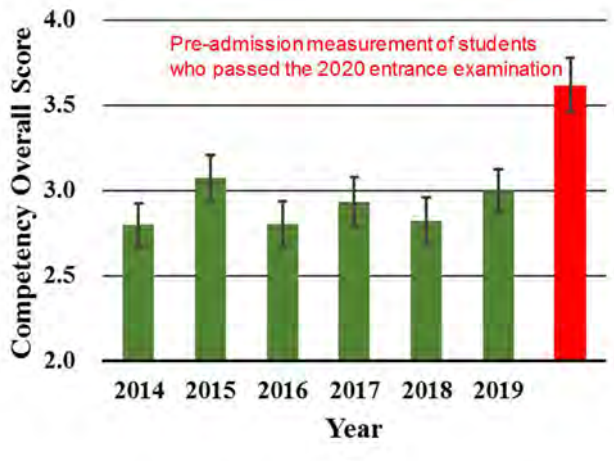


Figure. 3 The average of the competency overall scores for 1st grade students from 2014 to 2019 (green bar) and the average of the score for prospective students in 2020 (red bar).

educational institutions (the elementary and junior high schools are included), it is also possible that the introduced effects have come out.

The first measurement of pre-admission survey was completed in March 2020. While continuing this survey in the future, we are planning to improve education by thoroughly investigating the ability at the time of entering the school and the subsequent growth situation.

Results of trial post-graduation survey

Regarding the growth of generic skills, especially for the competency abilities, their own experience and their surrounding environments are considered important for the growth, unlike the knowledge acquisition and retention in the lecture. Furthermore, it is very meaningful to know how experience and changes in environment affect the competency abilities. Therefore, it is very important to know the growth of the abilities that the abilities have to be continually measured by the same method not only for the period of enrolment in Kosen, but also for the post-graduation. Continuing survey after graduation can evaluate and analyze the educational situations of Kosen by comparing the growth features of students after entering the companies and universities, which are more diverse. Therefore, it is possible to give useful feedback to the Kosen education. Now, we are starting to coordinate with both the University of Technology, Toyohashi and Nagaoka, which have many students from our college, to conduct a GSs survey of our students after entering the universities. After realization of post-graduation survey with universities of Technology, we plan to develop it into other universities and companies.

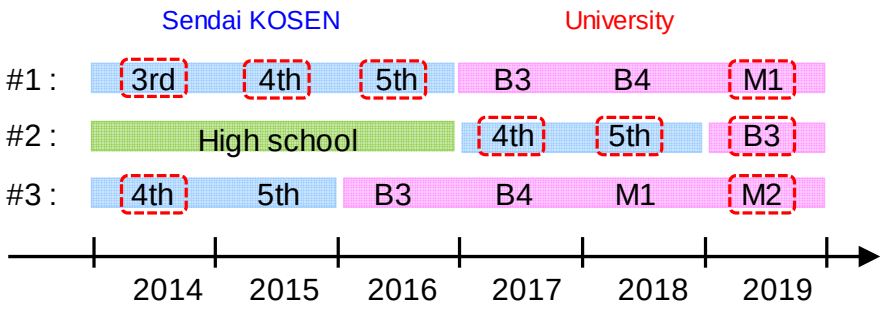
In this paper, we attempted to conduct a PROG follow-up survey in March 2020 with the cooperation of three graduates who had entered the university. The results are shown in Fig. 4. In figure (a), the PROG examinations' year of the graduates who cooperated to our survey are shown.

The student #1 transferred to the university after graduating from our school and is currently a 1st grade student of the master's course. #1 student took the PROG in 3rd, 4th, and 5th grade of our college and 1st grade of the master's course, and the change in the score is shown by the red triangles in (b). The results of the 3rd grade in Kosen, which is the first examination, are very high, as 7 for the Literacy overall score and 6 for the Competency overall score. However, since the second examination, both Literacy and Competency overall scores have decreased.

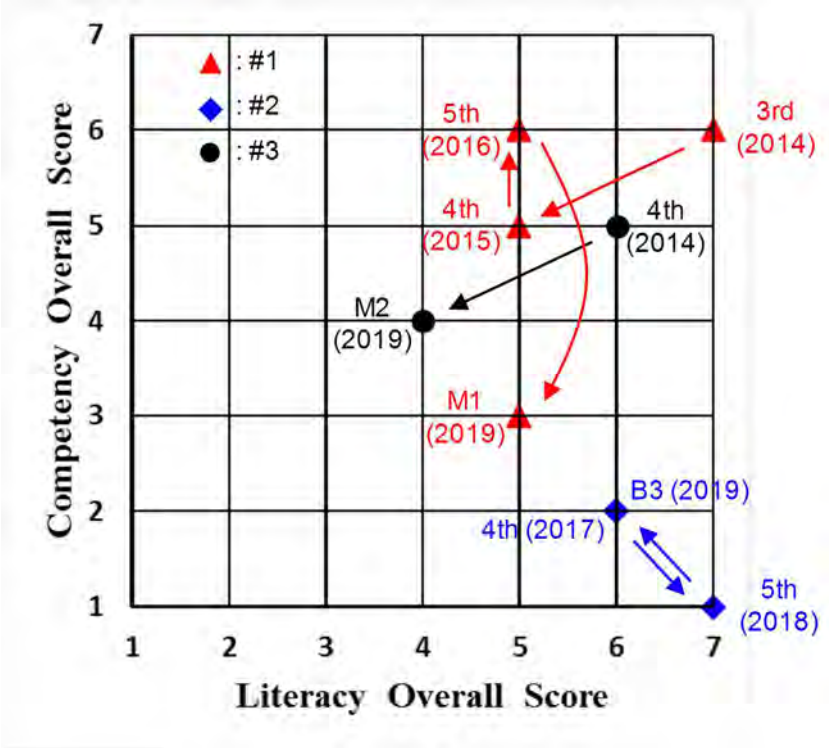
The student #2 is a student who transferred to 3rd grade of our college from high school, entered university after graduation of the regular course. The score change is shown by blue rhombus. No significant changes are seen in the PROG results for # 2 student.

Finally, the student #3 is a student who graduated the regular course, and then entered university, and now graduated with a master's degree in March 2020. Although #3 took the PROG only twice, in the 4th grade of Kosen and in the 2nd grade of the master's course, a decrease was observed in both the Literacy and the Competency, as shown black circle in figure (b).

The number of samples is extremely small, 3 students, which is just reference data, but the growth of GSs was not seen from the results of them who cooperated in the survey. There are several possible causes for this, as following. First, as shown in Fig. 1 and 2, both the literacy and the competency are seen to grow as the grade progresses in our college. These results are the average data of all students who go on to university or find employment at companies. A tendency is considered to be strong that students who go on to university or graduate school, prefer to develop their specialized skills and specialized research and development abilities than GSs. For that reason, they may have grown specialized in the required specialized skills and abilities. It is suggested that the analysis on the overall score was not sufficient, as some subdivided elements of competency growing in university were observed. Therefore, more detailed analysis is needed in the future. The second point is that the PROG evaluation method determines the score by comparing it with the statistical data of 4,000 excellent young businesspersons in various fields and industries of Japanese companies. It cannot be concluded at the moment that this evaluation method is absolutely correct as an evaluation standard for students who studying the engineering such as students of Kosen. We think that some answers will be given to these points by conducting a continuous survey of our graduate students in collaboration with universities and companies.



(a) the PROG examinations' year of the graduates who cooperated with our survey



(b) Results of a PROG follow-up survey with the cooperation of three graduates who had entered the university.

Figure 4. Results of trial post-graduation survey.

Conclusions

A continuous survey of students' Generic Skills has been conducted since the academic year of 2014 at Sendai KOSEN. Six years have passed since the survey started, and the survey from admission to graduation at Sendai KOSEN has been completed. The Competency scores increase steadily with grade. In the Literacy part, on the other hand, it was increasing until 3rd grade, but a saturated tendency was observed after 3rd year.

We conducted the five-year continuous survey during college and planned surveys of pre-admission and post-graduation. As a pre-admission survey, we conducted a Competency test of PROG for the prospective students in March 2020. The results of the Competency test of those students were found to be higher than the scores of 1st graders who took the test at midpoint of the first year. As a survey for post-graduation, we attempted to conduct a PROG follow-up survey in March 2020 with the cooperation of three graduates who had entered another university. As a follow-up survey after graduation, we plan to expand the scale of the survey to Toyohashi and Nagaoka Universities of Technology, other universities and companies. By conducting these surveys and continuing them, the

strengths and weaknesses of our college's education will be clarified, and effective and efficient improvement of education will be possible. Furthermore, we hope that these survey results will be useful for improving the students' voluntary GSs growth cycle [7] that started this academic year.

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 staff of our college for their contribution to this project, and 3 graduates who cooperated in this survey. In addition, we appreciate Mr. Kondo at RIASEC Inc. for his helpful cooperation in the analysis of data.

References

[1] About Progress Report on Generic Skills (PROG) test:https://www. kawaijuku.jp/jp/research/prog/ (URL: In Japanese)

[2] About KAWAI-JUKU:http://www.kawai-juku.ac.jp/ (URL: In Japanese)

[3] About DeSeCo Project at OECD: http://www.oecd. org/education/skillsbeyondschool/definitionandselectionofcompetenciesdeseco.htm (URL)

[4] About Synthetic Personality Inventory (SPI): https://www.spi.recruit. co.jp/ (URL: In Japanese)

[5] About Revision of learning guidelines at 2008-2009 in**J**apan:https://www.mext.go.jp/a_menu/shotou/new-cs/youryou/index.htm (URL: In Japanese)

[6] About Partial revision of learning guidelines at 2015 in Japan:https://www.mext.go.jp/a_menu/shotou/new-cs/youryou/1356248.htm (URL: In Japanese)

[7] K. Kawasaki, et al., Transactions of The 13th International Symposium on Advances in Technology Education (ISATE2019), 364-368, 2019

USING ENGLISH-MEDIUM INSTRUCTION FOR SPECIALIZED SUBJECTS IN A SECOND LANGUAGE: TEACHER TRAINING AND TRAIAL IMPLEMENTATION

Y. Nakajima[*, a] and H. Honma [a]

[a] Creative Engineering, National Institute of Technology, Kushiro College, Kushiro, Japan

*yoko@kushiro-ct.ac.jp

Abstract

The "Top Global University Project" is one of Japan's strategic approach to reform university education, focusing on the use of English as the medium to teach specialized subjects. Faculty members often teach without the awareness or the opportunities to learn English as a medium of teaching and assessments. Therefore, English as a medium of teaching, knowns as "English-Medium Instruction" (EMI), aims to bridge the gap in English proficiency levels among teachers and students, as well as the gap in skills and awareness. This has continued to be a subject of research. Acquiring the principles and teaching methods of EMI is crucial in bridging these gaps, and they serve to develop students' understanding. Studies on EMI have revealed that taking courses on specialized subjects in a second language helps to improve students' comprehension of their second language and that of the subject matter. One example of such a training program for teachers was the 100-Hour Customized Content Area Teacher Training Program at the University of Arizona's Center for English as a second language, which was based on five principles (theory of second language acquisition, methodology, classroom management, assessment, and teaching practice). Subsequent to participation in the course, this study details the observations of teaching a class of a small mixed-group of fifth-year international and Japanese students at the National Institute of Technology, Kushiro College. The teaching method of this class applies EMI, assessments, modifying materials, observations and second language acquisition theory. To develop specialized subject class materials, the theories of these subjects were considered. Describing the questionnaire, a student said, "The material is useful to understand, even for people with poor English skills." The survey found that 83.3% of the students felt that they understood 70% or more of the specialized subject matter regardless of their level of language proficiency. Therefore, the proposed method showed that teachers and students could reduce the difference in language skills and motivation.

Keywords: *English Medium Instruction, Second Language Acquisition, Content Area, TEFL, TESL*

Introduction

English is increasingly used as a lingua franca (ELF) in educational settings as a result of globalization. At the same time, English as a Medium of Instruction (hereinafter EMI) in which a specialized subject is taught in English, is on the rise, even in countries where English is not the first language. This development is especially prevalent in Europe, where efforts are being poured into the European Community Action Scheme for the Mobility of University Students (ERASMUS) program (2007-2013) since its early days and has become even more pronounced after the Bologna Declaration[1] , which promotes the "free mobility and employment of Europeans." However, EMI has been introduced in Asian countries as proactively as in Europe. Among the ASEAN countries where the official language is English, Brunei, Malaysia, Singapore, and other countries share a history of former British colonialism, which explains the prevalence of EMI in these places. In recent years, East Asian countries such as Korea and China have also started to encourage EMI in their education systems as a means of responding to the advancement of globalization, and to appeal to exchange students from overseas.

Japan's Ministry of Education, Culture, Sports, Science, and Technology has actively promoted globalization while participating in the SGH (Super Global High Schools Program) as part of its international education efforts.

In order to examine the state of EMI in Japan, (Murata, 2017) conducted a questionnaire survey at Waseda University which targeted students attending classes in several of the humanities faculties and graduate schools, where EMI is available, alongside the respective instructors of each class. The observations indicated that

[1] http://www.ehea.info/cid100210/ministerial-conference-bologna-1999.html

the current approach of the classes requires further consideration. Further, Nagai [2] states in the FY2018 Super Global Highschool examination report that both the development of teaching methods and further teacher training are urgent issues that need to be addressed prior to any other issues within global education.

In Southeast Asia, (Vu & Burns, 2014) reported that the failure of the foreign language system in Vietnam from 2008 to 2020 can be explained by the misuse of L1 in classes, the imbalance in dedicated teaching time for four different language skills (listening, speaking, reading and writing), the lack of teacher-student interactions, and the shortage of English language teaching equipment. (Nguye, 2017) additionally posited that teacher skills were one of the problems, and stated that there are still gaps between schools in terms of teaching ability and teaching environments.

While the aim is to foster global human resources by adopting EMI, the reality in many universities is that lecture materials may be given out in English, but many of the actual explanations remain in Japanese.

Brown notes that the rapid growth of global education has raised concerns that human resources and expertise are not sufficiently available to effectively plan and implement EMI. Further, he states that these universities often implement EMI as a survival strategy in the face of declining enrollment numbers, with levels of dedicated resources and commitment often not meeting those required to effectively implement EMI (Howard, 2018).

To realize the level of resources and commitment required to effectively implement EMI, the first step in terms of its implementation is to ensure that EMI is being approached with the correct mindset.

After conducting voluntary overseas research, (Abe & Oota, 2017).summarized that in order to foster global human resources to play an active role overseas, teachers need to have global education skills, and training for teachers in addition for students needs to be improved in the future.

The National Institute of Technology, Hachinohe College, to which Abe belongs, conducted a 100-Hours Customized Content Area Teacher Training Program (CATT) provided by the Arizona University Center for English as a Second Language, in which the Teacher Training Program courses were especially arranged for technical college teachers. This training program is conducted by the Center for English as a Second Language (CESL) which is a language training institution attached to the University of Arizona, a research-oriented public university that offers various programs that focus on English as a Second Language. Instructors have master's or doctoral degrees in related fields such as Teaching English as a Foreign Language (TEFL), Teaching English as a Second Language (TESL), and linguistics, and are generally experienced teachers that have been technically trained in English language education for international students.

The author participated in the CATT program in 2018, passed the CATT course, and conducted a demonstration class in line with the presented methods.

In this paper, the author details the CATT methods and summarizes and discusses the results of a questionnaire survey conducted after a demonstration class.

Materials and Methods

The CATT course that the author participated in consisted of a 100-hours Intensive TEFL/TESL Certificate Program that was arranged for technical college teachers by the National Institute of Technology, Hachinohe College.

The goal of this course was to acquire theories and techniques for teaching this specialized subject, where the teacher is responsible for English around students who use English as a second language. This 100-hour intensive a TEFL/TESL Certificate Program curriculum was developed around five content areas: second language acquisition theory, methodology, classroom management, evaluation, and teaching practice. The TEFL/TESL certificate is considered a basic entry-level qualification to the ESL/EFL education profession and allows graduates to work in international EFL education situations for short-term employment opportunities or volunteer work.

The program that the author participated in consisted of six subjects. During the first half of the 50 hours (from September 4–14), three subjects of EMI Theory, Assessments, and Modifying Materials were covered in a face-to-face context in the CESL classrooms and computer rooms at the University of Arizona. After the author returned to Japan, the remaining three subjects of Observations, Second Language Acquisition Theory, and Practicum were covered in an online format during the latter 50 hours (September 17–October 19).

We introduce to the purpose and content of each course.

1: English Medium Instruction Theory and Practice Module

Modules of this course teach about the history, theory, and practice of English as a Medium of Instruction (EMI) around the world. Trainees explore previous research and case studies pertaining to EMI to understand the motives and issues of EMI. Relevant papers have been selected to explore how other programs address EMI-specific issues pertaining to learning and teaching based on EMI, including specific education strategies. The following examples can be listed: Manh's paper (Manh, 2012) on the use of English as the medium of instruction in Asian higher education institutions (HEI) and (Roy L. , 2007) book that outlines a counterbalanced approach as an array of opportunities for learners to process language through content by means of comprehension, awareness, and production mechanisms. Trainees evaluate content

[2] https://www.mext.go.jp/a_menu/kokusai/sgh/1418622.htm

pertaining to their particular field of study or other EMI settings and develop an "EMI Best Practice Manual" for use after completing the course.

[Task] Best Practices for Effective English Medium Instruction.

2: Assessment

In terms of course assessment, basic principles of assessment, various types of assessment (format, summary, substitution), rubric design, as well as methods of balancing and prioritizing language and content assessment discussed in EMI theory are covered. Furthermore, plagiarism, its cultural importance in the research community, and its prevention are also covered. With regard to rubric design, we discussed Mertler's method (Mertler, 2001), and with regard to assessment methods, we discussed (Coombe, 2007).

By the end of this module, as learning outcomes trainees will be able to:

- Assess the effectiveness, reliability, and practical utility of a test
- Apply basic principles of assessment, design an assessment method suitable to a field of study (e.g., diagnosis, summary, test), and effectively design or modify rubrics
- Recognize and clarify the role of students' language when performing an assessment
- Trainees are given asks pertaining to each course to understand the cultural and social foundations of plagiarism. They perform the tasks and practice

[Task] Prepare a quiz for a specialized course, and design a rubric for the evaluation of the quiz.

3: Modifying and Developing Materials Module

The course primarily focuses on modifying material that was originally designed for native English speakers. The goal of such modification is to build on student learning (such as vocabulary support, long and difficult reading summaries, etc.,) and includes processes for developing new materials (such as the presentation of important information and written compilations, etc.). It also covers the preparation of field-specific English language teaching materials as well as the examination of study objectives, the development of effective learning achievements, classroom activities that are useful for various learning situations, and lesson plans. Behaviorism, constructivism, and cognitive learning processes are also discussed in reference to (Schunk, 1991) Further, the classification of educational goals, as based on Bloom's Taxonomy, is also discussed.

In regard to the learning achievements, by the end of this module, trainees will be able to:

1. Identify various methods for planning, modifying, and developing teaching materials.
2. Prepare newly developed material and modify the content or design of material to suit the respective field.

[Tasks] Development of a Lesson Plan.

4: Observations

During this course, trainees learn about reasons for observations, examine observation goals from various perspectives (such as from peers via equivalent positions, and mentors via good instructors and managers), learn about observation protocols, and learn how to effectively choose observation formats. Trainees learn to make observations using a variety of observation formats and present reports reflecting their results.

In regard to the learning achievements, by the end of this module, trainees will be able to:

1. Recognize the purpose of observation and choose an appropriate observation format.
2. Evaluate observational settings and determine if feedback needs to be global, formative, or both.
3. Conduct online course observations using appropriate formats to reflect EMI education practices.
4. Apply appropriate observation protocols in future face-to-face observations as follows:

[Tasks] Select observation tools from existing online classes and consider appropriate evaluation styles for class tours. Observe the selected classes (three courses) and evaluate them using an appropriate evaluation method. Present evaluation results within the group, receive questions and comments from the instructor or students in the group, and respond appropriately.

5: Second Language Acquisition Theory

The Second Language Acquisition (SLA) theory module provides introductory methods for the specialized field, and functions as a theoretical framework for effective language education. Trainees learn basic SLA concepts and frameworks that answer questions such as how people learn languages, and what factors affect language acquisition. Trainees will also challenge common assumptions about language education and learning, and read and discuss (Myles, 2013).

In regard to the learning achievements, by the end of this module, trainees will be able to:

1. Deepen their understanding of second language learning and acquisition.
2. Link second language learning concepts to EMI education practices.
3. Identify internal and external factors that influence a student's language learning process as follows:

[Tasks] Detail a significant incident experienced in the classroom in 300 to 500 words using MacAtreer's questions (McAteer, 2010). These are discussed and suggested within groups of two to three people. This method of suggestion raises the level of understanding by

raising opposing perspectives and arguments via the "How to play the 'Devil's Advocate'" technique. Discussions are conducted using D2L.

6: Practicum

This module includes explanations and demonstrations of teaching methods, approaches, and strategies related to English language media instruction and includes CLT approaches, task-based instructions, and SIOP strategies. Trainees create their own lessons and perform educational demonstrations. They provide effective EMI lessons in their respective field, incorporating the knowledge and strategies of all previous classes. Trainees observe each other's demonstrations and receive feedback from each other and from the CESL instructors.

In regard to the learning achievements, by the end of this module, trainees will be able to:

1. Recognize and evaluate various teaching methods and approaches related to EMI.
2. Choose from these methods to effectively design lessons and class activities as follows:

[Tasks] In this subject, students comprehensively practice what they have learned up to this point. First, they create lecture materials to be used for a demonstration class of about 15 minutes and upload a recording of the demonstration class to D2L. They then create a rubric for class evaluation and upload their lesson. They have discussions with the trainees in their group and with instructors and exchange answers with each other. Finally, they summarize what they have learned so far in a report. In regard to the evaluation, the instructor comprehensively evaluates the contents of the recording and discussion of the demonstration class, as well as in the final report.

Discussions follow along observation points of each student and the instructor. The observation points are shown below:

1. Are students and teachers interested and engaged?
2. Are teachers calling students by their names?
3. Is humor used properly?
4. Does the teacher embarrass or neglect students?
5. Are students actively participating in classroom activities?
6. Did the teacher make eye contact with the students?

Trial Implementation

The setting the author chose for their demonstration class is shown below.

[Class setting]

Lecture content: performance evaluation indexes for machine learning.
Lecture language: English.
Period: about 15 minutes.
Students with English as their Second Language: six fifth grade students in this department.
Content: explanation and quiz regarding precision, recall, and F1, which are indexes used in performance evaluation of data classifiers as constructed by machine learning.

The class structure was arranged with the following items in mind, and the class was conducted using slides and a VTR:

1. Review of the last class.
2. Today's objective.
3. Schedule.
4. Explanation of important English words.
5. Explanation of class content.
6. Simple quiz questions and answers on class content.
7. Class summary.
8. Preview of the next class.

Results

After the demonstration class had concluded, a questionnaire was handed out to the students. The purpose was to clarify the understanding of both the specialized subject and English language when attending classes on specialized subjects in English.

The questions and possible answers provided in the questionnaire are shown below:

Q1. What is your English level?
- Eiken[3] Semi-Level 2 ・ Eiken Level 2
- TOEIC[4] less than 400 points
- TOEIC 400 points or more ・Unknown

Q2. How much did you know about the content of the demonstration class?
- A little ・ Enough to understand the content
- Nothing

Q3. How much of the content did you understand?
- Less than 50% ・About 70% ・Almost everything

Q4. Did the initial explanation of important words help you understand the content?
- Very much ・OK ・ So-so

Q5. Please choose one of the following statements regarding the quiz that was conducted to re-confirm the content.
- I was able to re-confirm the targeted content
- I could not understand the question in English
- I could not fully understand the content, and it felt difficult

Q6. Please think of the words that were used in class and answer the following.
- I could understand most of the used words

[3] Test in Practical English Proficiency is provided by the Eiken Foundation of Japan.

[4] Assessment of English Proficiency is provided by the Institute for International Business Communication

・ The used words were difficult to understand the content

Q7. Did the slides aid understanding?

・ Yes ・ No

Q8. Did the class motivate you to take classes in your second language (English)?

・ Given the opportunity, I would like to try
・ I would definitely like to try
・ I would like to try after studying more English
・ No

Q9. If you have anything else you would like to share, or if you have advice for the teacher, feel free to write it here.

Figure1 shows the questionnaire results for Q1 to Q8 of six students who participated in the demonstration class. Regarding Q9, one student answered, "I am grateful that content was presented in a way that allowed understanding, despite my low English proficiency."

Discussion

According to the student questionnaire results (Figure 1), 83.3% of students felt that they understood 70% or more of the content regardless of their language proficiency, while 83.3% of students also stated that they would like to take specialized subjects in English in the future. These results suggest that taking classes in a second foreign language is effective for both understanding English and the specialized subject.

EMI theory states that breaking down English in order to convey the contents of a specialized subject is effective for deepening the understanding of both the topic at hand as well as promoting language acquisition.

Regarding Q9, one student answered, "I am grateful that content was presented in a way that allowed understanding, despite my low English proficiency."

Due to the limited number of students, the amount of data was not sufficient to analyze a trend but nevertheless serves as a reference for future studies.

The author's impression is that this method makes it easier for students to understand both English and specialized knowledge, while at the same time takes pressure off the instructor regarding the necessary level of English. It is necessary to prepare vocabulary explanations and theoretical explanation material, make use of quizzes, and so on, in order to aid students in progressively deepening their understanding step by step. Describing evaluation criteria early and in detail is important for both the students as well as the instructor, and eliminates unnecessary stress.

In addition, the author feels that the methods for class composition and modifying and developing materials are also useful for first-time learners of specialized subjects in Japanese at technical colleges.

Conclusions

In order to acquire the skills necessary to teach and evaluate in a specialized field in English (in front of students with English as their Second Language), the author conducted a demonstration class after learning about the related theoretical framework developed by CATT which consists of the five content areas of SLA theory: methodology, classroom management, evaluation, and practical training in an effective, logical, and systematic manner.

According to the student questionnaire, 83.3% felt that they understood 70% or more of the content regardless of their language proficiency, while 83.3% of students also stated that they would like to take specialized subjects in English in the future.

The author experienced first-hand that these skills in teaching a specialized subject in English can bridge the gap in the English proficiency differences between students and instructors, provided that classes and evaluations are prepared systematically and based on logical methods.

Amid a lack of human resources and expertise to effectively plan and implement EMI, and in order to solve the problem of teachers requiring global education skills for developing global human resources to become leaders abroad, visits to a course such as the one offered by CATT could be very helpful.

It is the author's intent to reproduce this study in a more continuous manner in the context of laboratory seminars, and to investigate changes in students over a longer period.

References

Abe,M. & Oota,T. (2017). Global Kosen Project. *National Institute of Technology, Hachinohe College*,145-148 (in Japanese).

Coombe,C & Folse,K &Hubley,N. (2007). Introduction to Issues in Language Assessment and Terminology. A Practical Guide to Assessing Language Learners. University of Michigan Press.

Howard,B. (2018). English-Medium Instruction in Japanese Universities: History and Perspectives. *LANGUAGE TEACHING IN A GLOBAL AGE, Publisher: JALT*, 273-278.

Manh,L. (2012). English as a Medium of Instruction in Asian Universities: The Case of Vietnam. *Language Education in Asia*, Volume 3, Issue 2.

McAteer,M. & Hallett,F. & Murtagh,L. & Turnbull,G. (2010). Achieving Your Masters in Teaching and Learning. *1st ed. Exeter: Learning Matters Ltd.*

Mertler,C,A. (2001). Practical Assessment Research & Evaluation. *A peer-reviewed electronic journal*, Volume 7.

Murata,K. & Iino,M. & Konakahara,K. (2017). An Investigation into the Use of and Attitudes toward ELF (English as a Lingua Franca) in English-medium

Instruction (EMI) Classes and its Implications for English Language Teaching. *Waseda review of education Vol.31(1)*, 21-38 (in Japanese).

Myles,F. (2013). Theoretical approaches. In Herschensohn,J. & Young-Scholten,M. The Cambridge Handbook of Second Language Acquisition. *Cambridge University Press.*

Nguyen,T. (2017). Vietnam's National Foreign Language 2020 Project after 9 years: A Difficult Stage. Conference Proceedings in *The Asian Conference on Education & International Development 2017 (ACEID2017)*

Roy,L. (2007). Learning and teaching languages through content:A counterbalanced approach. *Language Learning & Language*, Vol.18, Teaching Jhon Benjiamins Publishing.

Schunk,H,D. (1991). Learning theories: An educational perspective. *New York, NY, England: Macmillan Publishing Co, Inc.*

Vu,N. & Burns,A. (2014). English as a medium of instruction: Challenges for Vietnamese tertiary lecturers. *THE JOURNAL OF ASIA TEFL* Vol.11, No. 3, 1-31.

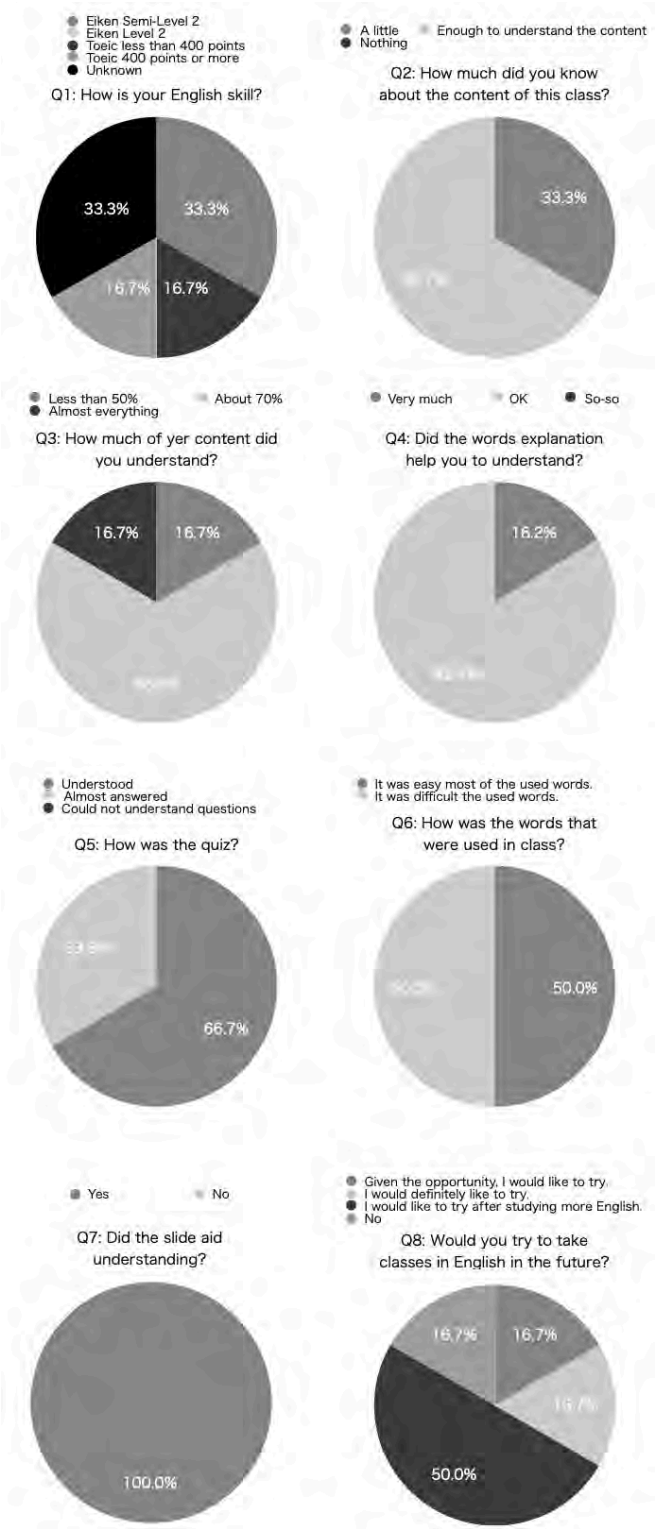


Figure 1: The student questionnaire results regarding the class in the second language (in English).

NANOTECH PLATFORM ESTABLISHED FOR AVERAGE TECHNICAL EDUCATION SCIENCE LABORATORIES

S. Nagaoka[*,a], M. Yamamoto[b], T.Tsuji[c], T. Shikama[b], T. Shimizu[a], R. W. Johnston[a], K. Matsuda[d], F. Shimokawa[e] and H. Horibe[f]

[a] NIT, Kagawa College/Dept. of Electronic System Engineering, Mitoyo, Kagawa, Japan
[b] NIT, Kagawa College/Dept. of Electrical &Computer Engineering, Takamatsu, Kagawa, Japan
[c] NIT, Suzuka College/Dept. of Electrical and Electronic Engineering, Suzuka, Mie, Japan
[d] Tokushima Bunri Univ., Dept. of Nano and Bio Material Engineering, Sanuki, Kagawa, Japan
[e] Kagawa Univ., Faculty of Engineering, Takamatsu, Kagawa, Japan
[f] Osaka City Univ., Graduate School of Engineering, Osaka, Osaka, Japan

*nagaoka@es.kagawa-nct.ac.jp

Abstract

Actual device fabrication experience is important for students to gain deep understanding. A nanotechnology platform established for the average science laboratory that makes the design, fabrication and evaluation possible is crucial to achieve this purpose. Simple methods for the following processes including impurity diffusion control depending on the type of silicon substrate surface, fabrication of silicon dioxide thin film for the insulation layer, fabrication of the thin film for the electrodes, and a lithography process to make the circuit pattern are required. In this study, we investigated the simplification of all these processes under a normal air environment with simple apparatus and in the limited environment of an average science laboratory. Thermal diffusions of phosphorous and boron, thermal oxidization of the surface of the silicon substrate and sintering of the silver contained material for the electrode prepared under a normal air environment were studied and successfully demonstrated to make and control p-n junctions which are the foundation for various kinds of semiconductor devices. In addition, a simplification of a photo lithography process was also studied by our original idea of the photo mask design making and revising process using a transparent plastic sheet without using special CAD soft. Approximately, 20μm line as the highest resolution and less than 10μm as the pattern alignment error was achieved without using XYZθ stage. Furthermore, a simple evaluation apparatus consisting of average PC and the analog & digital circuit design kit for the device evaluation also proposed and successfully demonstrated to measure the I-V characteristic of the p-n junction. As the result, the possibility to establish the design and fabrication processes required to make MOS and bipolar transistors, which are the basic devices of integrated circuit design was successfully demonstrated. It was confirmed that these results can contribute to establish a nanotechnology platform which is as same level as the early days of semiconductor research laboratory, at the average science laboratory level.

Keywords: *semiconductor, device, p-n junction, fabrication process, lithography*

Introduction

IoT is expanding in various fields. New device development is necessary to meet new demands due to the expansion of this field. The training of engineers who can work on the device development is an important issue even in educational institutions such as KOSEN. In order to achieve this aim, it is necessary to have the actual experiences of design, fabrication and evaluation of devices, with learning device physics from an early stage, the same as with the education of programming, experiments on electric and electronic circuits, etc. [1],[2]. However, it has been an obstacle to establish this educational circumstance in KOSEN, because the required cost for the equipment for the fabrication and evaluation for the device making is very high, and specialized knowledge is required for its operation. Therefore, one must make full use of the equipment around to design and manufacture semiconductor devices

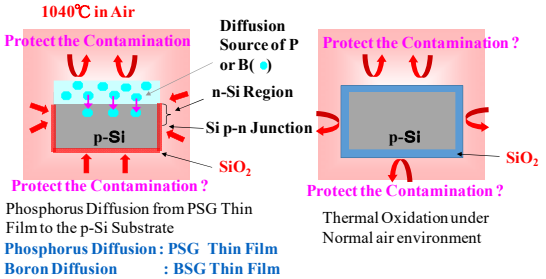


Fig.1 A hypothesis of the simplified fabrication of insulation layer and impurity diffusion

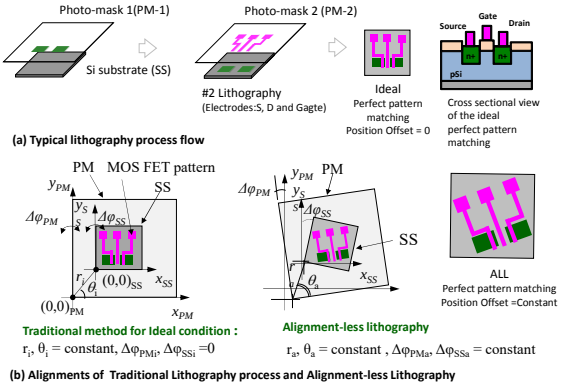


Fig.2 Principle of the simplified photo-lithography method without photomask alignment (ALL)

in an environment such as that of an average technical education science laboratory. And we have been working the basic and simplification studies to enable fundamental technology for device fabrication such as lithography, impurity diffusion, insulating layer fabrication, and electrode fabrication, and we finally achieved the simplification of each of these key processes and established a nanotech platform[3]-[5]. In this paper, we have demonstrated simplification of the elementary technologies for designing, manufacturing, and evaluating semiconductor devices, and to establish a nanotech platform in the average technical education science laboratory.

Hypothesis of the simplification of the Key Process

Insulation Layer and Impurity Diffusion

For impurity diffusion by heat treatment, we devised to simplify the process by using a PSG thin film prepared by the Sol-Gel method, which is safe and easy to handle, as a phosphorus diffusion source and thermally diffusing in an atmospheric environment. The outline is shown in Fig. 1. According to this method, the PSG thin film can function as an impurity diffusion source, and at the same time, the Si substrate surface can function as a protective film that prevents impurities from entering from the outside. Therefore, it is considered that the influence of the very small amount of gas contained in the atmosphere can be further reduced, and the performance equivalent to the heat treatment in the environment of high-purity inert gas can be realized. This makes it possible to simplify the thermal diffusion process in addition to simplifying the equipment. Moreover, in order to fabricate devices, it is necessary to fabricate a silicon oxide film SiO_2 to form element isolation and gate insulating layers. We considered that about 20% of oxygen contained in the atmosphere is used for the production of SiO_2 film. In addition to this, actual air contains a very small amount such as water vapor and CH_4, but if the effect of the substance on the insulating film characteristics and the silicon substrate is not large, It is expected that it will be possible to apply the thermal

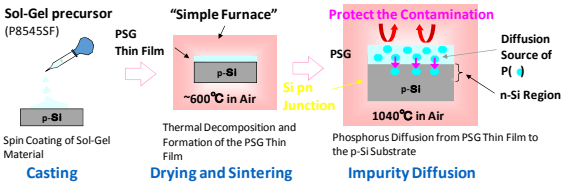


Fig.3 process flow of the simplified impurity diffusion under normal air environment

oxidization under atmospheric environment on the device fabrication process.

Lithography

～principle of the alignmentless lithography (ALL)～

The device is manufactured by the bottom up method by repeating the lithography process. It is necessary to achieve high alignment accuracy of circuit patterns and simplification of the lithography process at the same time. In the conventional fabrication process, in order to achieve the accurate positioning, the XYZθ stage was used. However, it may be a cause of the difficulty to introduce the process in the experimental program by the sophistication. Therefore, we proposed an Alignment-less Lithography method (hereinafter ALL), which is a lithography method that does not require mask alignment. Figure 2 shows the principle of alignment-less lithography. This method focuses on only the positional relationship between the photomask and the mask pattern formed on it, and makes the mask so that the positional relationship is the same among multiple masks. By using this method, it is possible to perform the exact pattern alignment by this mechanical pattern alignment without performing the mask alignment that was conventionally required. Furthermore, even if the pattern is difficult to see due to the reflectance of the substrate and alignment is not possible, it is possible to realize a feature that is not possible with the conventional method of aligning.

Fabrication of the Electrode

In order to achieve low resistance and ohmic contact, the thin film for the electrodes are usually prepared by vacuum evaporation system. However, thin film fabrication using a vacuum system is difficult because it requires special equipment, requires a high level of proficiency in handling, and requires lithography equipment. In order to satisfy the above requirements with the simplest device possible without using a vacuum device, a method that can be sintered under normal air environment with a material containing silver (Ag) to form an electrode was proposed. We proposed a method in which the electrode thin film is formed by, and the electrode pattern processing is made by using screen printing with no use of the lithography process. We also proposed the fabrication of embedded electrodes that do not require a screen printing method by forming a groove on a silicon substrate by using silicon anisotropic etching or Reactive Ion Etching (RIE), and embedding the above electrode material in the groove.

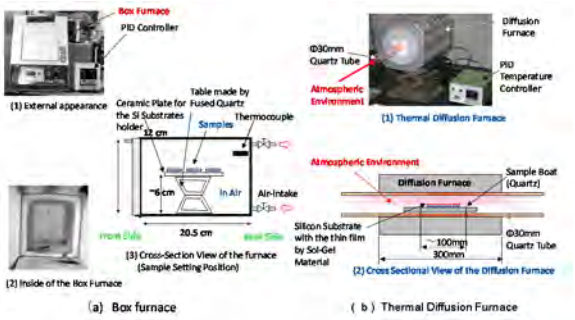


Fig.4 Photographs of the equipment for the thermal treatments

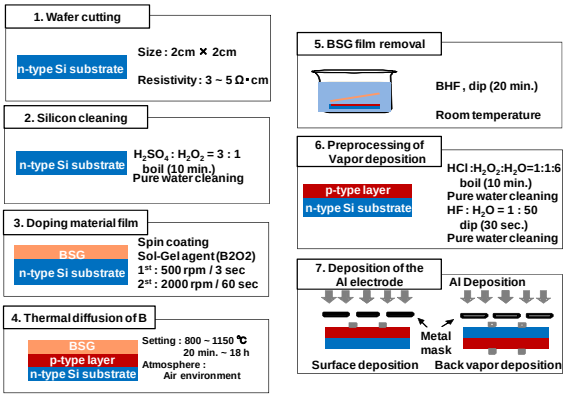


Fig.6 A simplified p-n junction fabrication process using Sol-Gel materials and thermal treatment under normal air environment

Experimental Method for Simplified Key Processes

Insulation Layer and Impurity Diffusion Processes

Figure 3 shows the thermal diffusion process of phosphorus (P) and boron (B) by PSG (Phosphorus Silicate Glass) thin film or BSG (Boro Silicate Glass) thin film prepared from Sol-Gel agent by heat treatment under atmospheric environment. First, the Sol-Gel agent is spin-coated on the substrate surface and sintered to produce PSG thin film and BSG thin film. Since the PSG film contains P and the BSG film contains B, it is considered that P or B can be diffused to the surface of the silicon substrate by using it as an impurity diffusion source and heat treatment.

Figure 4 shows the heat treatment equipment used in the experiment. Two types of apparatuses, which are a general box furnace and a simple thermal diffusion furnace were used. A ceramic plate for the box furnace and q quartz plate were used as the sample boat during thermal treatment. For the diffusion furnace, a quartz core tube was used, the temperature of both devices was PID controlled, and the soaking range was about 10 cm, and controlled at any temperature until 1100℃.

Photo Lithography (ALL)

Figure 5 shows an outline of the ALL photomask and the ALL process. Pin alignment method was applied to align the substrate and photomask for ALL process. Two step concavity was made on the aluminum(Al) plate to set the photomask and substrate shown in the figure 5(c)

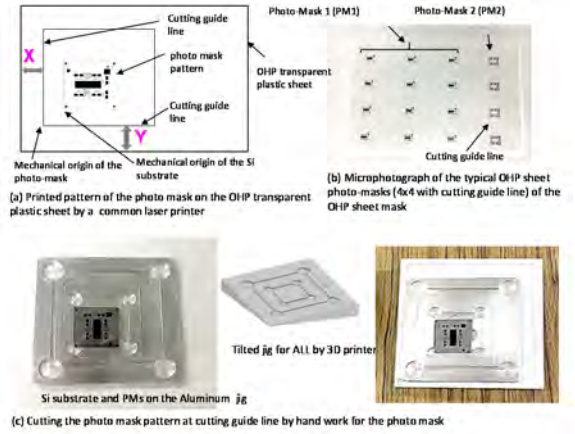


Fig.5 Schematic overview of ALL process

as the positioning jig. And the lower left corners are the "photomask origin" and "substrate origin", respectively. In each photomask, the photomask pattern is formed in exactly the same positional relationship from the photomask origin. Thereby, the position of the pattern in the photomask and the angle ψ (ψ = 0) can be accurately determined. If the positioning of Si substrate is handled as the same, the Si substrate can be arranged at the same position and angle Φ every time. This will enable accurate pattern alignment without using the XY stage. In the design and manufacture of photomasks used in lithography, a transparent plastic sheet (OHP sheet) for overhead projectors was used as a photomask to facilitate the design and manufacture and revision of masks.

Simplification of the device fabrication process

Figure 6 shows the p-n junction fabrication process. P type and n type, silicon ((100), 3-5 Ω・cm) are used as the substrate. They were cut into 20mm squares with a diamond pen. They were treated to create n type and p type regions by the method described about P and B diffusion in Fig. 3 after cleaning. A pair of Al comb-shaped electrodes with a film thickness of about 500 nm and a width of about 200 μm were formed on the

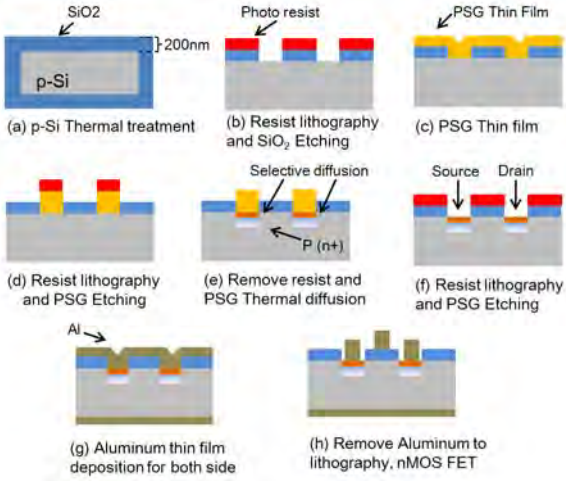


Fig.7 A simplified fabrication process of MOS FET using Sol-Gel materials and thermal treatment under normal air environment

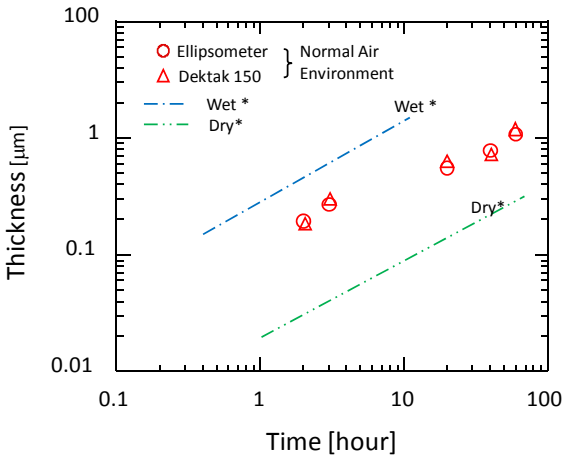


Fig.8 Time dependency of the thickness of the thermal oxidation layer prepared under normal air environment

surface, and plane Al thin film electrode was also formed on the entire back surface to a thickness of about 500 nm using a vacuum evaporation system.

Figure 7 shows a flowchart of the simplified nMOS FET fabrication process of the theoretical structure using simplified thermal oxidation, impurity diffusion and ALL process with 2 photo-masks. First, the surface of the Si substrate is thermally oxidized to form a SiO_2 thin film, and the first ALL process to prepare the n type region was applied. The diffusion area for P is determined by the first ALL and SiO_2 thin film etching processes. P is diffused only in a limited area of the surface of Si substrate by SiO_2 thin film, Al thin film is deposited on the entire surface of the substrate by a vacuum vapor deposition, and the Al thin film is processed in the same manner as the first ALL process which is the second ALL process to create electrodes. Finally, nMOS FET is obtained. The pMOS FET also can be prepared in the same manner by using an n-type silicon substrate and a BSG thin film with same photo-masks.

Experimental Result and Discussion

Figure 8 shows the results of thermal oxidation under a normal atmospheric environment. The results of wet oxidation and dry oxidation are also shown as a comparison. The thickness of the thermal oxide film

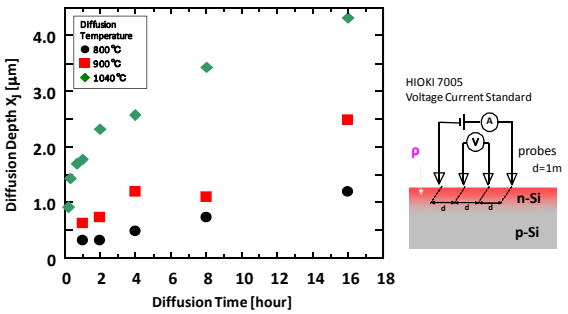


Fig.9 Time and temperature dependencies of the diffusion depth of Phosphorus by thermal treatment under normal air environment

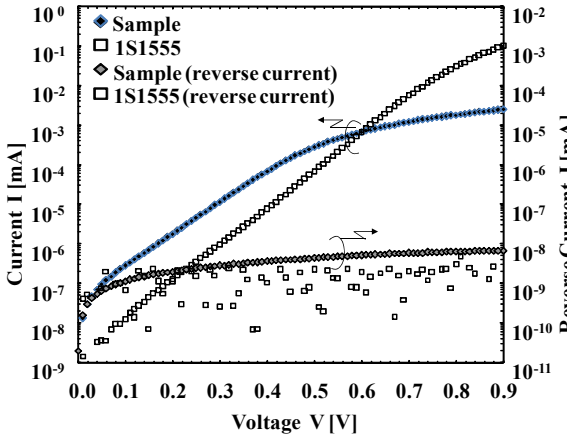


Fig.10 A typical current-voltage characteristic of the p-n junction prepared by Boron diffusion using Sol-Gel material on the n-type silicon substrate

produced was measured by an ellipsometer (Mizojiri Optical DV-36), and the surface profiler (DekTak150). It was found that the measured values by the two measuring methods showed good agreement. It was also found that the oxide film thickness increases in proportion to time, and the oxidation rate is intermediate in between wet oxidation and dry oxidation.

Figure 9 shows the time and temperature dependence of the diffusion depth in the thermal diffusion of P under atmospheric environment. The diffusion depth X_j was calculated from the measurement results of visualization method of the diffusion part using the spherical drilling and stain etching. From the results, it can be confirmed that the Si surface can be inverted to the n-type in all thermal diffusion treatments at 800℃ or higher. It can be seen that X_j becomes deeper as the diffusion time increases and the heat treatment temperature increases. From this result, it was found that X_j can be controlled by time and temperature even in the atmospheric environment.

Figure 10 shows the current-voltage characteristics of a p-n junction diode fabricated by diffusing B on the n-Si substrate. The characteristics of a commercially available diode (1S1555) are also shown for comparison. The typical ideal coefficient n were obtained about 2.2 of our

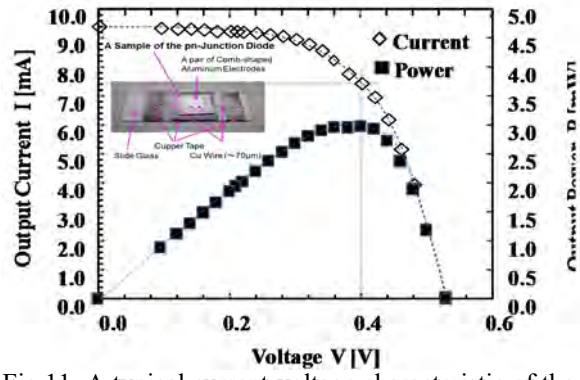


Fig.11 A typical current-voltage characteristic of the p-n junction prepared by Boron diffusion on n type silicon substrate using Sol-Gel material under normal air environment

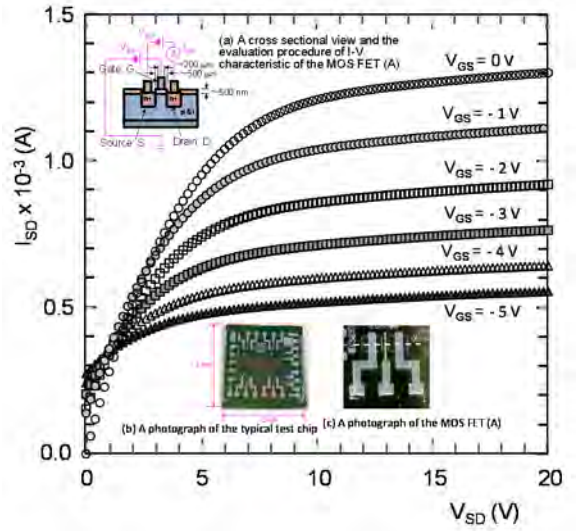


Fig.12 A typical current-voltage property of the nMOS FET prepared by the thermal treatment under normal air environment

p-n junction, 1.9 of 1S1555 respectively. From these results, it can be confirmed that the p-n junction diode fabricated by our proposed simplified process can obtain the same rectification characteristics as those on the market. The current-voltage characteristics of the solar cell were also evaluated.

Figure 11 shows the current-voltage characteristics of a p-n junction solar cell prepared by diffusing B on the n Si substrate prepared at the condition of the thermal diffusion treatment temperature of 1040℃, 3 hours, and the diffusion depth was about 3 μm. The area S of the element is 0.70 cm^2. F.F was about 0.6. It was confirmed that it performed well as a solar cell.

Figure 12 shows a typical result of the I_D-V_{SD} characteristics of an nMOS FET prepped by this method.

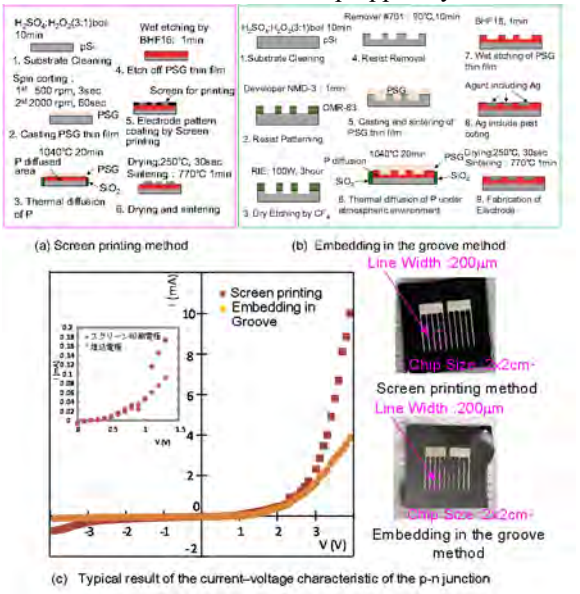


Fig.13 A typical current-voltage property of the p-n junction by Boron diffusion with sintered electrode prepared all under normal air environment

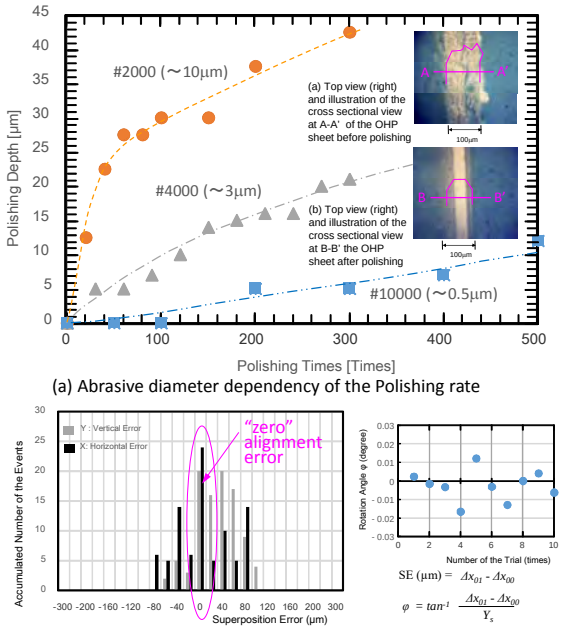


Fig.14 A typical edge polishing rate of the transparent plastic sheet for photo-mask

From the results, the drain current (I_D) is controlled by gate voltage (V_G). It was confirmed that it performed as a depletion type nMOS FET. "Selective Diffusion" in which patterned sintered PSG or BSG thin film is selectively placed on the substrate and to selectively diffuse P or B, like ion implantation, and "Simultaneous Diffusion" in which patterned sintered PSG and BSG thin films are selectively placed at any place on the same substrate and to simultaneously diffuse P and B were proposed, and the feasibility were investigated under a normal atmospheric environment.

Figure 13 shows the current-voltage characteristics of the p-n junction whose electrodes are the electrode fabricated by the sintering of the material containing Ag under an atmospheric environment. The screen printing method was used to prepare the electrode. In addition, the damascene interconnect method was also evaluated. The grooves to embed the electrode material were fabricated

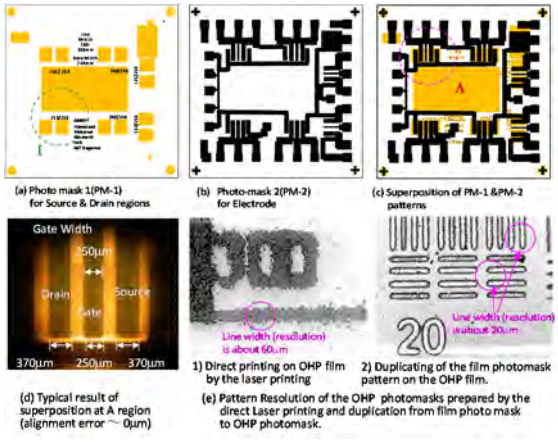


Fig.15 A typical alignment result by ALL process

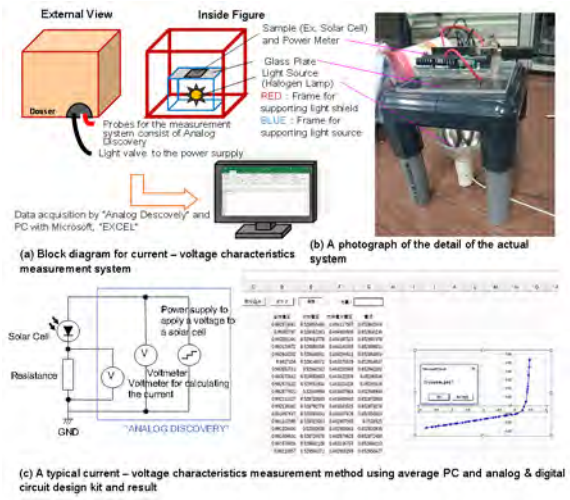


Fig.16 A simplified evaluation system using average equipment and analog & digital circuit design kit and its typical measurement result

by Si anisotropic etching. The good rectification characteristic were obtained by either structures. From this result, it was proofed that the electrodes fabricated under atmospheric environment can be used as the electrode for the devices. In order to improve the alignment accuracy of the mask pattern in the ALL process using the plastic sheet mask (OHP mask), we proposed the micro adjustment of the pattern position on the OHP mask by polishing the edge face of the OHP mask. Several polishing pads that have approximately 0.5 µm to 2 µm size of abrasive material were used for the polishing. The relationship between the number of times of polishing and the amount of polishing was investigated.

Figure 14 shows the result of the feasibility test. From the figure, it was found that the polishing rate was controlled the grain size of the abrasive material. The precise polishing rate control under Micro meter size can be achieved by the particle size of the polishing agent and the number of times of polishing. The accurate positioning of the Micro meter order of the can be performed by the Cut & Try compensation. The alignment error in the XY directions was evaluated by about 100 trials. The rotation error θ was also evaluated in addition to the alignment error in the XY directions. It was found that the resolution of the pattern was approximately 20µm by the duplicated film mask pattern on the OHP mask, standard deviation σ was about 40 µm and the rotation error was as small as 0.01°.

Figure 15 shows the alignment result of the mask set for MOSFET fabrication, which consists of three masks actually fabricated. From these results, it was demonstrated that by applying the polishing OHP mask set and the ALL process, it is possible to achieve alignment with almost no mask displacement and to achieve the purpose of ALL. From the above results, the usefulness of the ALL process was verified [6].

If it is possible to achieve an environment in which own made device can be evaluated by making full use of the measurement equipment in the average laboratories, simplification of the entire processes, device design, fabrication and evaluation will be made possible. Furthermore, the education and the research in a wide range of fields from basics to advanced contents are also made possible in a step-by-step by incorporating from the design to the evaluation of semiconductor devices. Therefore, we focused on the analog & digital circuit design kit, "Analog Discovery" and proposed an environment where the basic properties of p-n junction can be evaluated by combining it with a PC. Figure 16 shows the outline of the system. The feasibility of the measurement system including light source control and its programming for the solar cell characteristics was evaluate. The short circuit current and the open circuit voltage with the current-voltage characteristics of the solar cell was successfully measured with the applied voltage was continuously changed from negative to positive voltage. It was confirmed that the simple evaluation system can be established.

Conclusions

To create "Nanotech Plat Form Established in the Average Science Laboratory", we examined the simplification of all the key processes of device fabrication, which are oxide film fabrication, impurity diffusion, lithography, and electrode fabrication using general-purpose equipment and devising the process without using sophisticated apparatus under atmospheric environment. As a result, it was demonstrated that heat treatment under atmospheric environment enables oxide film fabrication, p-type and n-type fabrication, and electrode fabrication. We also proposed a new simplified lithography method "Alignmentless Lithography (ALL)" and successfully demonstrated the possibility of realizing pattern matching with less error by adjusting the mask. It was shown that this method can be expected to have the effect of deepening the understanding of the learning subjects of device physics through the lectures and experiments and fostering creativity, and also contribute to the learning of physical chemistry.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number JP16K00992, 19K0454301 and 20HT0207.

References

[1] S. Nakamura,JSEE,Vol.51,No.1,pp.115-18(2003)
[2] K. Shohno IEEE Trans. on Education. Vol.E-20, No.2, pp92-97 (1977)
[3] T. Tsuji, et al., Japanese Society for Engineering Education, Vol.64, No.6, pp127-130 (2016)
[4] T.Takahashi, et al., Advanced Material Research, Trans Tech Publications, ISSN:1662-8985, Vol.1109, pp625-630 (2015)
[5] K. Kai, et al., American Institute of Physics, Vol.1733, pp020094-1-020094-4 (2016)
[6] S. Nagaoka, et al., Transactions of ISATE 2017, The 11th International Symposium on Advances in Technology Education, Vol.1, pp275-279 (2017)

FOSTERING COLLABORATIVE LEARNING WITH HACKATHON

Linda William

Temasek Polytechnic / School of Informatics & IT, Singapore
Linda_William@tp.edu.sg

Abstract

In a teaching and learning environment, college hackathon has been introduced as a platform for collaborative learning by gathering the students to engage in intensive work to solve a problem and produce a solution to the problem in a highly constrained time frame. For student participants, this hackathon helps them to acquire and improve their programming skills, immerse and collaborate with like-minded people, and provide direct contact with potential employers. Although many recent studies have identified the benefits of using college hackathons as a collaborative learning platform, minimal works have been conducted to measure the effectiveness of hackathon for the pedagogical outcome. Hence, this paper aims to evaluate the effectiveness of the hackathon in fostering collaborative learning of IT students in Temasek Polytechnic. We worked together with one of our industry partners to design a specific format of college hackathon. In this hackathon, the students worked on various industry problems for one month. Our students formed a team with other students and the staff from our industry partner. The team members consisted of different types of specialist, educational background and interest in the hackathon. As a team, these individuals were tasked to solve the given industry problem and produce an innovative product or solution. We focus our study on the dynamic of the collaboration between the students and the staff. This dynamic would influence the students' motivation and learning. We collected data from observations, informal interviews and post-hackathon questionnaires. The data suggest that strong engagement between the students and staff would motivate the students to learn and refine their skill sets and knowledge to produce a decent product or solution. The collaboration also provides an excellent opportunity for the students to understand more about the working environment and work etiquette.

Keywords: *collaborative learning, hackathon, industry collaboration, industry problem, impacts of student-staff collaboration*

Introduction

Hackathon has emerged as a popular tool to gather individuals to engage in intensive collaborative work to produce an innovative product or solution in a highly constrained time frame (Aboab, et al., 2016; Komssi, Pichlis, Raatikainen, Kindström, & Järvinen, 2015; Lyndon, et al., 2018). It creates a focused working environment where the participants can assess their skills and exchange knowledge (Pe-Than & Herbsleb, 2019). Hackathon may require the participants to learn or refine skill sets or expertise (i.e. new programming language, new hardware, new strategies, and new business processes) in a limited amount of time. These skill sets and expertise are used to "hack" or design a new product or solution. Although the original idea of a hackathon is mostly exclusive to software development (Taylor & Clarke, 2018), it is now run to cover various topics. It includes retail (Nasser, 2017), business (Calco & Veeck, 2015; Komssi, Pichlis, Raatikainen, Kindström, & Järvinen, 2015), and health care (Lyndon, et al., 2018; Aungst, 2015).

One of the most distinct types of a hackathon is college hackathon (Warner & Guo, 2017). College hackathon is usually held in a college campus and involves the students as the participants to create a solution or a product and optionally compete for prizes. Several examples of college hackathon include hackathons sponsored by Major League Hacking in 200 colleges with over 65,000 student participants (Hacking Major League, 2020), and PennApps hackathon (PennApps, 2020).

Previous studies have identified the benefits of college hackathon. It includes promoting content mastery, developing technical and thinking skills, creating social networks and engaging individual students to take actions (Lyndon, et al., 2018). It is also believed that college hackathon can create an environment to encourage effective collaboration that would further improve the students' learning (de Toledo Piza, et al., 2018). Successful teams are associated with higher affective learning gains. However, these studies are mostly focusing on the hackathon benefits itself without considering it as a part of pedagogical methods for a particular subject in IT.

The primary purpose of this study is to evaluate the effectiveness of college hackathon to encourage

collaborative learning as part of a pedagogical method for a specific IT subject in Temasek Polytechnic. We designed a particular college hackathon format as one of the assessment methods for one IT subject. We collaborated with one of our industry partners to match their staff with our students to work on various "real-world" industry problems. Each team had one month to finish the solution or the product before they needed to present it to the teaching team and the company's senior management in the final hackathon day. The teaching team graded the solution or product by considering the feedback from the company's senior management.

We design a research model and hypotheses by focusing on the dynamic of the collaboration for students and staff. The research model considers five main aspects of collaborative learning to motivate the students to learn and refine their skill set and knowledge. These aspects are (1) mutual exploration of the issues/problems, (2) exchanging of ideas, (3) team formation, (4) social interaction, and (5) communication. Based on these aspects, we develop two questionnaires for the post-hackathon survey. One questionnaire is for the students, while another one is for the staff. Throughout the college hackathon duration, observation and informal interviews with the students and the staff were also conducted. These data complement the post-hackathon survey.

Based on the data from observation, informal interview and post-hackathon survey, the results show that students in a strong team are more motivated to learn and refine their skill set and knowledge. They would spend time and effort to produce a decent product or solution. The results also show the collaboration between the students and staff on college hackathon would help the students to understand more about the "real-world" problems, working environment and work etiquette.

Hackathon Design

A particular format of college hackathon was designed to encourage collaborative learning as well as to expose the students to real industry problems. This college hackathon was supported by one of our industry partners. Students from one class were divided into five teams. Each team had five to six students. Each team collaborated with two or more staff from the company. At the beginning of the hackathon duration, each team selected one problem to work. The problem was derived from company problems.

After forming the team and selecting the problem to work on, each team had one month to finish the solution or the product. The staff were able to provide the students with real-industry context as well as real company dataset. Each team was able to arrange meetings with the staff from the company within that one month. There was no limitation on the number of sessions that they can arrange.

At the end of the one month, each team needed to present their solution or product to the teaching team and the company's senior management in the final hackathon day. The company's senior manager would provide feedback regarding the feasibility to implement the solution or product in the company. Each team was graded based on the working processes and the solution by the teaching team. The teaching team would take into account the feedback from the company's senior manager. This grade is one of the assessments for a particular IT subject.

Research Model and Hypotheses

In this paper, we emphasize the benefits of college hackathon to foster collaborative learning as part of pedagogical methods for a particular IT subject. The skills and knowledge gained in the college hackathon are aligned with their IT subject and would be reflected in the students' grade. To evaluate these, we focus on the dynamic collaboration between the students and the staff to motivate self-learning (Anderman & Dawson, 2011).

We consider five main aspects of collaborative learning to motive the students to learn and refine their skill set and knowledge. These five main aspects are:

1. mutual exploration of the issues/problems (Harasim, 1989),
2. exchanging of ideas (Harasim, 1989)
3. team formation (Wessner & Pfister, 2001),
4. social interaction (Dillenbourg, 1999), and
5. communication (Dillenbourg, 1999).

We design our research model and hypotheses using these five main aspects, as illustrated in Figure 1. For this research model, we review the literature on collaborative learning and college hackathon to identify essential aspects for motivating students' self-learning. Using these aspects, we hypothesize the following:

Hypothesis 1: Mutual exploration of the problems (i.e. real-world or industry problems) would improve students' motivation for self-learning.

Hypothesis 2: Exchanging ideas during college hackathon improve students' motivation for self-learning.

Hypothesis 3: A good team formation would improve students' motivation for self-learning.

Hypothesis 4: Strong social interaction during college hackathon would improve students' motivation for self-learning.

Hypothesis 5: Good communication within the team would improve students' motivation for self-learning.

Based on this research model and hypotheses, we develop a questionnaire to collect feedback from students. The questionnaire comprises of nine items, as illustrated in Table 1. We use this questionnaire as the student's post-hackathon survey. In this questionnaire, we identify two items for mutual exploration of the issues/problems aspect, two items for exchanging of ideas aspect, two items for team formation aspect, one

item for social interaction aspect, and one item for communication aspect. We also add one item regarding their motivation to self-learn. The questionnaire uses the 5-point Likert scale (5=strongly agrees, 1=strongly disagrees).

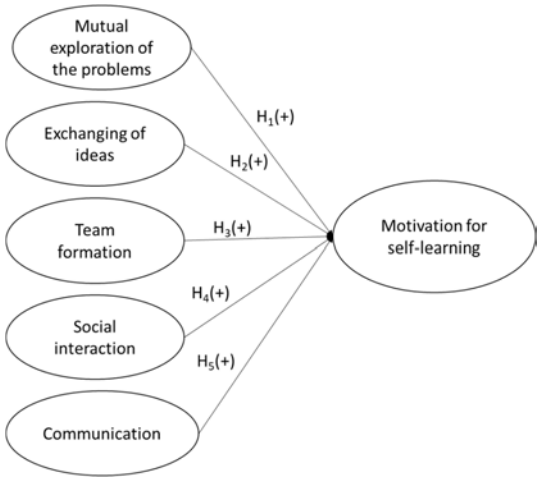


Figure 1. Research Model

Other than the questionnaire for the students, we also develop another questionnaire to collect feedback from the staff. To emphasize the team interaction in college hackathon, the staff questionnaire does not include all the five main aspects for collaborative learning. It only includes mutual exploration of the issues/problems, exchanging of ideas and team formation aspects. We identify one item for mutual exploration of the issues/problems aspect, three items for exchanging of ideas, and two items for team formation. We also add one item regarding the student's motivation. The questionnaire also uses the 5-point Likert scale (5=strongly agrees, 1=strongly disagrees).

Evaluation Method

The college hackathon was held from mid October to mid November 2019. During the one-month period, we met the students twice a week to observe their interactions with the staff. We also conducted five informal interviews with the students and two informal interviews with the staff. In addition to that, we discussed the progress for each team with the company's senior management.

After the college hackathon, we asked the students and the staff to fill in the post-hackathon questionnaires. We received 19 valid responses from the students and 12 valid responses from the staff. Other than the post-hackathon questionnaires, we also gathered feedback from both students and staff on the overall hackathon in an open-ended question. We received 19 valid responses from the students and 12 valid responses from the staff.

Table 1. Questionnaire for the student's post-hackathon survey

Items	Aspects
1. Do you feel that the staff from the company help you to understand the problem?	mutual exploration of the issues/problems
2. Do you feel that the staff from the company helps you to understand real world problem?	mutual exploration of the issues/problems
3. Do you feel that the staff from the company help you to develop the solutions?	exchanging of ideas
4. Do you feel that the staff from the company allow you to use your knowledge and skills?	exchanging of ideas
5. Do you feel that you can work together with the staff from the company?	team formation
6. Do you feel that the hackathon arrangement (including team arrangement) meet your expectations?	team formation
7. Do you feel that you can work together with the staff?	interaction
8. Do you feel that the hackathon helps you to build your confidence to communicate your solutions to other people?	communication
9. Do you feel that you are motivated to learn new skills for the hackathon?	motivation

Table 2. Questionnaire for the staff post-hackathon survey

Items	Aspects
1. Do you feel that the students understand the problem?	mutual exploration of the issues/problems
2. Do you feel that the students help you to develop the solutions?	exchanging of ideas
3. Do you feel that the students have the knowledge and skills to solve the problem?	exchanging of ideas
4. Do you feel that the students learn new knowledge or skills by solving the problem?	exchanging of ideas
5. Do you feel that you can work together with the students to come up with the solutions?	team formation
6. Do you like to work with the students?	team formation
7. Do you feel that the students are motivated to solve the problem?	motivation

Findings

From the observations and informal interviews during the one-month hackathon period, we observe the following:

1. Two teams out of five student teams were having communication problems with the staff the company. They only met the staff two times over the period of one month.
2. One team out of five student teams were interacting and communicating very well. The staff encouraged the students to push their own limits and produce a well-thought solution.

Based on the valid post-hackathon questionnaire responses, we illustrate the summary as shown in Figure 2 and Figure 3 for the students and staff questionnaire respectively. Figure 2 shows that the students' average scores for all the five aspects are above 3.5, but the minimum score for communication aspect is 1 and the minimum score for exchange ideas and team formation aspects are 1.5. The results suggest that few students do not feel that they can communicate, exchange and form a solid team. These may affect their motivation to self-learning.

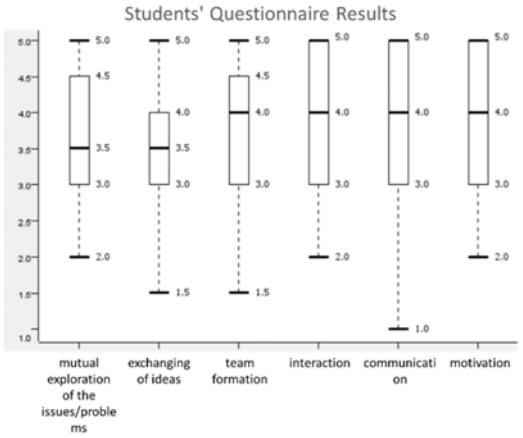


Figure 2. Students questionnaire result for each aspect

Figure 3 shows the average scores for the aspects from the staff questionnaire are above 4.8. The results suggest that the staff are happy with the students' performance. Do note that not all staff involved with the students respond to the questionnaire.

The research model and hypotheses are calculated using linear regression. The linear regression result for both students and staff questionnaires are summarized in Table 3 and Table 4 respectively. Table 3 shows significant relationship between team formation aspect with motivation for self-learning ($p<0.01$). While the other aspects do not have significant influence ($p> 0.05$). This indicates that the team formation in college hackathon provides motivation for the students to perform self-learning to improve their skill set and knowledge.

Table 4 shows significant relations between all the three aspects with motivation for self-learning ($p<0.01$). This indicates that from the staff perspective all the three aspects in college hackathon would provide motivation for the students to perform self-learning ($p<0.01$). Since, both Table 3 and Table 4 indicate that significant influence of team formation to motivate self-learning, we conclude Hypothesis 3 is supported.

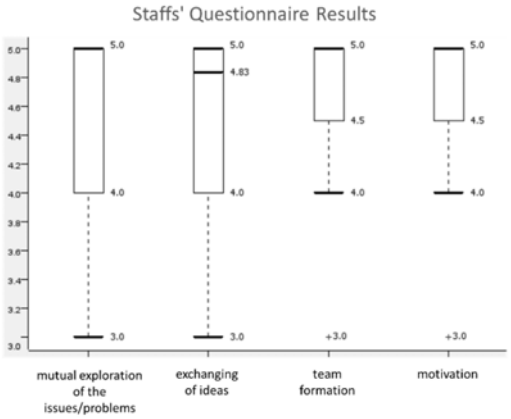


Figure 3. Staff questionnaire result for each aspect

Table 3. Linear Regression Result for Students' Questionnaire

Model	Coefficient
Aspect 1. Mutual exploration of the issues/problems	0.5728
Aspect 2. Exchanging of ideas	0.7586
Aspect 3. Team formation	0.6828**
Aspect 4. Interaction	0.7157
Aspect 5. Communication	0.4175

* $p < 0.05$
** $p < 0.01$

Table 4. Linear Regression Result for Staff Questionnaire

Model	Coefficient
Aspect 1. Mutual exploration of the issues/problems	0.9176**
Aspect 2. Exchanging of ideas	0.9168**
Aspect 3. Team formation	1**

* $p < 0.05$
** $p < 0.01$

We also extract the overall feedback in an open-ended question and identify the topics that they mentioned in

their responses. The topics are: coding, visualization (dashboarding), communication and team work. These topics indicate four main students' learning points.

The grades from the teaching team for all the teams in this college hackathon are also extracted. The grades are considered as one of the assessment methods in the particular IT subject. One team gets A+ grade, two teams get A, one team gets B and the last team gets B-.

Discussion

The results show a significant correlation between team formation aspects and student's motivation to self-learning. It indicates that the college hackathon is able to motivate students to form a team and interact with other students and the staff. The interactions would then motivate the students to learn specific concepts (i.e. programming or coding). This finding is aligned with the prior studies on collaborative learning aspects (Wessner & Pfister, 2001).

Our results from observation and informal interviews suggest that the students engage in their team differently. Some students were able to communicate in the team well. While some students may have difficulty to understand the problem and communicate their proposed solutions. It is effecting their motivation to self-learning and eventually effecting their grades for the particular subject. We summarize the observation and the grades in Table 4.

Table 4. Students' Grade for the Subject

Team	Grade	Observation
1	A	Shown a very good team dynamic and produced a well-though solution. The staff also complimented the students.
2	A	Shown a good team dynamic and produced a good solution.
3	A	Shown a good team dynamic and produced a good solution.
4	B	Had a small misunderstanding about the problem and the solution. It can only be rectify nearing the end of the hackathon.
5	B-	Had a serious communication problems with the staff the company.

Conclusion

In this paper, we focus our work on the dynamic of the collaboration between the students and the staff in college hackathon. We design the research model and hypotheses based on five collaborative learning aspects, namely: (1) mutual exploration of the issues/problems, (2) exchanging of ideas, (3) team formation, (4) social interaction, and (5) communication. We use this research model to evaluate the impact of college hackathon to motivate the students to learn and refine their skill sets and knowledge.

The results collected from observation, informal interview and post-hackathon questionnaires indicate that there is a strong relationship between the team formation aspects with the students' motivation to self-learning. It suggests that good team dynamic between the students and the staff would motivate the students to learn new skill sets and knowledge to produce a decent product or solution. The newly gained skill sets and knowledge includes coding, visualization (dashboarding), communication and teamwork. Hence, the college hackathon would also provide a good opportunity for the students to understand the working team dynamic and work etiquette in the company.

Nonetheless, we see two possible extensions that we would like to study in near future. First, we would like to evaluate our research model and hypotheses for students in different schools. We would like to evaluate if the collaborative learning platform can be developed in non-technology college hackathon. Second, we would like to involve more companies in the college hackathon. It would help us to understand the impact of company's environment and work etiquette to the collaborative learning environment.

References

Aboab, J., Celi, L., Charlton, P., Feng, M., Ghassemi, M., Marshall, D., . . . Pollard, T. (2016). A "datathon" model to support cross-disciplinary collaboration. *Science Translational Medicine, 8*(333), 333ps8.

Anderman, E., & Dawson, H. (2011). Learning with Motivation. In R. Mayers, & P. Alexander, *Handbook of Research on Learning and Instruction* (pp. 219-241). New York: Routledge.

Aungst, T. (2015). Using a hackathon for interprofessional health education opportunities. *Journal of Medical Systems, 39*(5), 60.

Calco, M., & Veeck, A. (2015). The markathon: Adapting the hackathon model for an introductory marketing class project. *Marketing Education Review, 25*(1), 33-38.

de Toledo Piza, F., Celi, L., Deliberato, R., Bulgarelli, L., de Carvalho, F., Rabello Filho, R., . . . Cohn Kesselheim, J. (2018). Assessing team effectiveness and affective learning in a datathon. *International Journal of Medical Informatics, 112*, 40-44.

Dillenbourg, P. (1999). What do you mean by collaborative leraning? In P. Dillenbourg, *Collaborative-learning: Cognitive and Computational* (pp. 1-19). Oxford: Elsevier.

Hacking Major League. (2020). *https://mlh.io/about*. Retrieved May 1, 2020, from https://mlh.io/: https://mlh.io/about

Harasim, L. (1989). Online Education. A new domain. . In R. Mason, & A. Kaye, *Mindweave. Communication, Computers, and Distance Education* (pp. 50-62). Oxford: Pergamon Press.

Komssi, M., Pichlis, D., Raatikainen, M., Kindström, K., & Järvinen, J. (2015). What are hackathons for? *IEEE Software, 32*(5), 60-67.

Lyndon, M., Cassidy, M., Celi, L., Hendrik, L., Kim, Y., Gomez, N., . . . Dagan, A. (2018). Hacking hackathons: preparing the next generation for the multidisciplinary world of healthcare technology. *International Journal of Medical Informatics, 112*, 1-5.

Nasser, K. (2017, August 3). *Retail Innovation Shout Out: The Rise of Fashion Hackathons.* Retrieved May 1, 2020, from www.semanticscholar.org: https://pdfs.semanticscholar.org/bf97/c88b6d71380ce75066e5907779d0604d08da.pdf

PennApps. (2020). *https://pennapps.com/*. Retrieved May 1, 2020, from https://pennapps.com/: https://pennapps.com/

Pe-Than, E., & Herbsleb, J. (2019). Understanding hackathons for science: collaboration, affordances, and outcomes. *International Conference on Information* (pp. 27-37). Washington, DC: Springer.

Taylor, N., & Clarke, L. (2018). Everybody's Hacking: Participation and the Mainstreaming of Hackathons. *Conference on Human Factors in Computing Systems (CHI)* (p. 172). Montréal, QC, Canada: ACM.

Warner, J., & Guo, P. (2017). Hack. edu: Examining how college hackathons are perceived by student attendees and non-attendees. *Proceedings of the 2017 ACM Conference on International Computing Education Research* (pp. 254-262). Tacoma, WA: ACM Digital Library.

Wessner, M., & Pfister, H. (2001). Group formation in computer-supported collaborative learning. *International ACM SIGGROUP Conference on Supporting Group Work* (pp. 24-31). Colorado : Association for Computing Machinery.

ASSIGNMENT CHATBOT

W.S.K. Percy

School of Informatics & IT / Diploma in Big Data & Analytics, Singapore

percywon@tp.edu.sg

Abstract

It is common for students to ask their lecturers or tutors about the deadline for the assignment report submission and other report related administrative details repeatedly. The administrative type questions can take up precious time from the lecturers/tutors, which can otherwise be spent on students that have urgent and non-administrative needs from the same subject. In this paper, we explore the use of chatbot in the context of student assignments and measure its effectiveness in reducing the educator's load on administrative questions. Our current approach is separated into two phases. The first phase is identifying the types of administrative queries that are typical among a pilot batch of students that are doing their assignments. The second phase is implementing the chatbot to handle the queries with the appropriate answers during the critical periods for the assignment, which is typically about two weeks from the assignment due date to the group of pilot students. After the assignment deadline, we reviewed the results of this pilot group of students using the chatbot. We started by examining the queries by the students for any other questions that might be common but were not in the chatbot's database. These are then added to our chatbot's database of queries with the corresponding answers. Next, we look at the number of administrative queries from the students and compare that with the number of similar queries that their lecturers received both before and after the implementation of the chatbot. The results from this experiment clearly demonstrated the effectiveness of the chatbot based on this pilot group of students. In the next experiment, the chatbot will be rolled out to a bigger group of students throughout the assignment term in the semester. The research will be focusing on validating the impact of the chatbot. This includes reducing the administrative workload on lecturers involved and providing just-in-time information for the students.

Keywords: *Chatbot, artificial intelligence, administrative assignment queries, DialogFlow*

Introduction

Self-help implementations have become a common thing in the recent decade, from automatic top-up kiosk for metro tickets to fully autonomous flight check-in. More recently, virtual assistants are found, not only on mobile phones but anything from also in computer systems all over the world. A scaled-down version of virtual assistants with specific purposes can also be found anywhere from government services to library assistants; these are typically known as chatbots. Chatbots are becoming very popular not only in big organizations but also in smaller companies. In our school, many of the first tier advisories for subject/course choices provided to potential students are done through our chatbots. The above, together with the drive towards reducing the administrative load for educators, became the motivation for the assignment chatbot project.

The assignment chatbot project aims to reduce the administrative load of the educator without removing meaning content-based interactions with students. Within this context, the administrative load will be defined as work that does not have a direct impact on the student's learning of the subject. Students with doubts about the content of the topics would still be able to seek help with a tutor face to face, thus not losing the human element in education.

In this paper, we will describe our Assignment Chatbot, starting with the technology used, followed by the process of implementation, a brief overview of its setup using DialogFlow (Google, 2020), the outcomes, and finally, the challenges encountered.

Platform Architecture

The Assignment Chatbot was implemented using the DialogFlow platform (Google, 2020). The features that are needed in implementing the basic Assignment Chatbot are available in other chatbot platforms; the choice of Dialogflow is because it is available, relatively simple to use, and free for a small rollout with unsophisticated requirements like the Assignment Chatbot. However, DialogFlow does offer attractive features for our future enhancement through its simple integration with Google Assistant.

The diagram shown in Figure 1 depicts the essential chatbot components of DialogFlow.

Figure 1. Basic DialogFlow chatbot components.

As illustrated in the diagram in Figure 1, central to creating a chatbot will be the *agent*. The agent is the component that handles the conversations with the end-users and interprets their utterances. Next, we would describe the *intent*. This is the mapping between the utterance from the user and how the system response. There is more than one way in which the user can ask the same question. *Training phrases* allow the Dialogflow engine to be exposed to different ways in which a query can be requested. There is no need to list all the possible phrases exhaustively; however, there should be sufficient numbers to allow the machine learning capability of the DialogFlow engine to train itself. Next would be the *Entities*, and these are keywords within the training phrases that can be matched to some actions. An example of it would be "I want a T-shirt", the word "T-shirt" could be matched to a particular entity for the clothing intent. Based on the keyword/entity value, the DialogFlow platform can activate the *action and parameters* segment of the DialofFlow setup. The entity can be matched to a parameter value, which will, in turn, trigger a particular action. Finally, the *response* section creates the chatbot's response to the intent. Different responses can be set up for one intent based on the output destinations. There is also a default response is set up as a universal response to all output destinations.

There are some other components/terminologies that are useful in knowing this platform, and that includes,

1. **Prebuilt agent / Small-talk** – These are prebuilt agents provided by Dialogflow for common use cases. These agents can be used to establish a base for building conversations for dining out, hotel booking, navigation, etc. "Small Talk "is a prebuilt agent that handles casual conversation automatically, without the need to add such intents to your agent, when it is enabled.
2. **WebDemo** – This application from the DialogFlow platform provides the user with a simple text-based URL for the chatbot user to interact with the agent. It eliminates the need to set up websites just to test the chatbot.
3. **Publish** – Once the agent has been created, it can be published for use. Each time an agent is published, the system allows the agent to be published in a separate environment. Multiple versions of your agent can be published in different environments for different applications.

Implementation Process of the Chatbot

While it is not difficult to learn the mechanics of the chatbot platform, trying to implement a chatbot effectively is another thing altogether. Predicting the type of questions from students and setting up the chatbot to answer it is not an easy task.

For this purpose, an empirical study is done to understand the non-content-based critical questions that are of concern for the students. These non-content-based questions shall be defined as administrative queries from hence. Of the students surveyed, most agreed that the deadline is of great concern to them as they do not want to submit their assignments late and have marks deducted. Besides that, they would also be quite concerned about the format of the report. The report format is where most students could follow the rules and obtain "easy" marks.

With the basic questions needed, the prototype for the Assignment Chatbot is built. Each of the questions corresponds to an intent in the DialogFlow platform. For each of the intents, a list of training phrases will be created. Training phrases are different ways of asking the same question. A example in this context would be, "When is the assignment due?", "When is the deadline for the assignment?", or even "When do we need to submit our report?". When building the training phrases, it was noted that people from different cultural backgrounds tend to ask the same question differently; their language preference and language ability also contribute to the difference. To ensure that the students of varying backgrounds were accommodated, the training phrases should not only capture the different ways the questions could be asked in proper language but include those colloquial equivalents as well. This would prove to be useful during the chatbot pilot.

Another intent that was built in the initial phase was the official report submission format. The intent build around this is appropriately named *AssignmentFormat*. Its purpose is to answer assignment format queries such as the length of the report, font size, line spacing as well as the presentation (if any) duration are included in the training phrases to build the intent. The appropriate entities containing the different variations of the keywords are also created for this intent.

Once the initial group of intents is created, the pilot stage of the Assignment Chatbot project is launched. The "Small Talk" agent - one of the Dialogflow prebuild agent is also included to make the chatbot more interesting. The small-talk agent allows students to hold a casual but probably innovative conversation with the chatbot; this eliminates the dryness attached to testing a

chatbot. Moreover, the prebuilt agent requires no implementation effort other than enabling that agent.

The interaction with students begins with the students being told its objectives. One of these objectives is to help the students with the answers to their administrative queries for their assignment. They are allowed to access the chatbot at any time during this pilot, and the chatbot's response will be the source of truth. The students in the group were also excited to find out that they are not limited to queries relating to the assignment, but are also allowed to ask the chatbot other casual questions. The novelty of the chatbot to answer their assignment questions and the excitement of interacting with the small-talk agent propelled the students' participation rate to 100% for this pilot group of students.

The queries from the students are recorded as part of the history in DialogFlow. By reviewing the history panel in DialogFlow, some excellent questions that have not been captured in the chatbot were discovered. This results in more intents being created. The next few intents were built as a result of these new findings.

One of these intents was built around the assignment submission location/media. As part of the Polytechnic's go green initiatives to discourage hardcopy report submission, most assignment report submissions within the school are made through electronic media. Typically, reports are submitted through the Learning Management System (LMS), where the students will log in to their LMS account and submit their report via assignment submission link. However, due to constraints such as space availability, other electronic means such as CD or even hard disks are used as alternatives occasionally. These can create confusion among students as to where or how to submit their assignment reports. The intent on the submission location was established to answer the submission media/location question. The chatbot will respond by providing the student with a textual answer to the submission location.

Another excellent intent created from unanswered queries of students was one of performance. The chatbot was asked how a student could get an 'A' for the assignment. That was definitely a great question and should be of concern to every student that wanted to do well. However, it can be challenging to provide a universal answer for such a query. The difficulty of answering such a question lies in that all assignments are different, and there could also be potential moderation in any assignments; thus, it would be tricky to provide a standard answer for the query. Assignments for some courses can also have some level of subjectivity in grading. This query was answered by providing students with the marking rubrics for the assignment. There are no better ways to give the student tips on doing well than by showing them the marking rubrics. Marking rubrics should be universal across all subjects and assignments within the Polytechnic. To implement the solution, a page on the LMS to display the rubrics for the assignment was created. Next, an intent with the necessary training phrases is built. Finally, the default text response for the intent was created. The text response includes a link pointing to the web page of the LMS that shows the rubrics. Though most students know the rubrics as part of the institution's policy, the link to the LMS was nevertheless a good reminder on the criterion for doing well. Furthermore, the rubrics could easily have slipped their mind amid the rush to finish the assignment. All students welcomed this intent, although some prefer a little more tips over and above the rubrics.

After describing the implementation process of the Assignment chatbot and highlighting some useful insights in adopting chatbot to answer administrative queries of a given assignment, the next stage is to describe it was set up in DialogFlow, our chosen platform.

Setting up the chatbot in DialogFlow

In the earlier section on platform architecture, we mentioned that one of the reasons DialogFlow was selected was because of the ease of setting up. In this section, we will describe the process of setting up the assignment chatbot. There are several significant steps in creating and deploying our assignment chatbot, and they are listed below,

1. Create a login account for DialogFlow.
2. Create an agent, the highest level object in our chatbot.
3. Create an entity of each of the keywords that we will use in our intents.
4. Create an intent for each of the categories of questions that we plan to answer.
5. Create or include all other intents, including prebuild agents, and default response intent.
6. Publish the agent in the deployment environment.
7. Share the agent with the intended users/students.
8. Test the agent, enable Web-Demo app, and share the Web-Demo URL with our intended users.
9. Review the log frequently and look out for any exciting findings, such as an excellent unanswered question.
10. Collect some data for future studies into the Assignment Chatbot.

Step 1: Sign in to a DialogFlow account with your Google account credentials. This can be done as DialogFlow is part of Google.

Step 2: From the DialogFlow environment, the dropdown list below the DialogFlow logo has the option to create a new agent, select this option, and create the agent.

Step 3: The left panel in Figure 2 shows the option to create new entities (marked with a red box). Each new entity created will allow users to create a list of synonymous keywords that will be used by the corresponding intents. This intent will be defined at a later stage. For example, in the AssignmentDue entity,

keywords such as Assignment Deadline will be linked to "Deadline", "submission date", "Project Deadline" to list a few. As the new entities are created, the platform engine will use its machine learning ability to train the agent to recognized these keywords and link it to other synonyms found in its database. There is also an option to create different sets of keywords for different parameters and actions within an entity; however, this feature of DialogFlow is currently not used in our Assignment Chatbot.

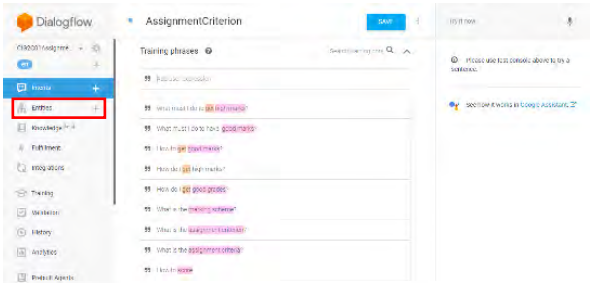


Figure 2. Training phrases in DialogFlow

Step 4: Intents are created in this step by clicking on the "+" option of the left panel in Figure 2 marked with the blue box. As in Figure 1, there are three main specifications to be defined when creating an intent. Firstly, create the training phrases needed. Following that, the actions and parameters section and finally build the response for the intent. We will begin by exploring the training phrases. Like the keywords in entities, training phrases in intent allows the DialogFlow platform engine to use its machine learning capability to training the agent with the different ways in which the users may ask the question. Though there is no need to exhaustively mention all possibilities (as this might not be possible), there should be sufficient phrases. The training phrases in Figure 1 are what we use to train our agent for *AssignmentCriterion* intent. When the training phrases are defined for the intent, action, and parameters panel can be populated with the appropriate information. As the assignment chatbot is a very simple chatbot, there is no need to create a separate action for each synonym group; thus, verifying that the entities are correctly assigned are the only tasks needed for the actions and parameters section. The final stage in creating the intent will be to define the default text response for the intent. In the case of *AssignmentCriterion* in Figure 1, we will define how the students will be graded by providing them with the URL to the rubrics.

All other intents in our assignment chatbot to answer the assignment related administrative questions are done in the same way as above.

Step 5: Other intents, including the small-talk and default fallback response, will be discussed in this section. The small-talk agent can simply be turned on by clicking on the small-talk option in the left panel of the DialogFlow console, and this is just below the prebuilt agent option. When turned on, our agent will be able to use its capability to answer casual questions from students. No additional actions are required to create our assignment chatbot, as unless we need to modify its default response or training phrases. On the other hand, the default fallback response is an intent created by default for every agent. The purpose of the default fallback intent is to answer queries that do not match any of the intents created. The example of the default fallback response that is created in the assignment chatbot is, "That's a good question! Please email me at myemailaddress@tp.edu.sg with the question and its details, and we will discuss it in class". This default fallback response would provide students that have queries on the contents of the assignment an avenue to approach the tutor for help. The default fallback intent and small-talk are the only additional features that were used for the current version of the assignment chatbot.

Step 6: When all intents are created, the chatbot is ready to be published for deployment. Publishing is accomplished by clicking on the setting button, followed by the environment tab, and finally clicking on the "PUBLISH A VERSION" button on the environment tab. This can be found in Figure 3

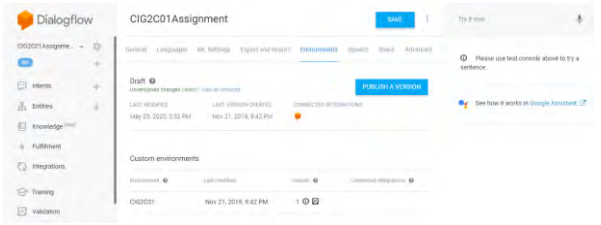


Figure 3. Publishing the Chatbot

Step 7: Once the chatbot has been published, the access to the chatbot can be shared with the users. This is done in the Share Tab, as in Figure 4. The email of each user will be entered into the system via this interface.

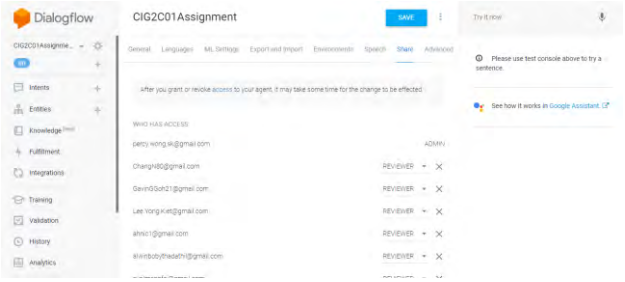


Figure 4. Sharing Chatbot Access and Testing

Step 8: The Chatbot is now ready for testing. Testing can be done through the right panel, as shown in Figure 4. However, this option of testing the chatbot is only available on the console. The chatbot needs to be deployed on a web server if testing is to be done outside the console. Setting up a web server can be a tedious task both from the administrative and technical perspective. On this front, DialogFlow has created a simulator for deployment known as WebDemo. This application of DialogFlow simplifies the process of the testing or even implementation of a small scale chatbot deployment. The WebDemo can be found in the Integration Option on the

left panel of Dialogflow, as indicated by the blue box in Figure 5. To enable the application, scroll down to the text-based section, and turn on the WebDemo app by sliding the button. WebDemo provides an URL that can be shared with any reviewer to test the chatbot. To retrieve the URL used for testing the chatbot, click on the WebDemo option. From the WebDemo application interface, copy the URL provided, as depicted in Figure 5. This URL can be shared with users that need to access the chatbot.

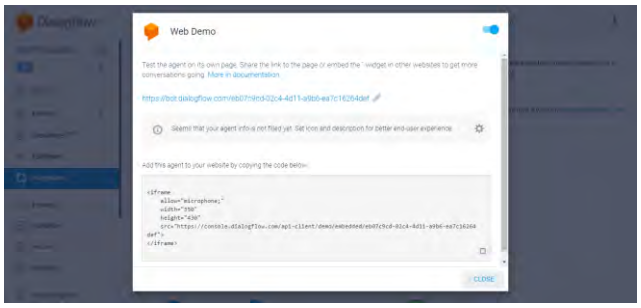


Figure 5. Getting the WebDemo URL

Step 9: The log or history of our agent can be accessed via the left panel of the DialogFlow console under the "History" option. It records all the interactions between the student and the agent. The interactions are organized into conversations and timestamped. DialogFlow also provides an option to limit the output to those of the selected dates.

Step 10: Analytical information about the agent can be retrieved via the "Analytics" option on the left panel of the DialogFlow console. Simple analytical data will be provided, such as the distribution of sessions/queries over the last 1-30 days, the distribution of the utilization of each intent is also available.

By using the ten steps listed above, the Assignment Chatbot can easily be set up on the DialogFlow platform. These steps can also be adapted for any other chatbot platform.

Results

The empirical feedback gathered from users indicates that the chatbot is well accepted by the students. The five reasons stated were,

1. The chatbot is available all the time and the replies are instantaneous. Without the chatbot, when the students query their tutors beyond certain hours, they will only get a response the next day or after the weekend. For the case of the chatbot, the students can get their answers instantly at any time of the day.
2. The chatbot provides the source of truth. Unlike checking with fellow students who may not have accurate information, the chatbot will always be able to provide the source of truth information.
3. Chatbot has no emotion, and as a result, it is not sarcastic, nor critical. Students can ask the chatbot questions deemed by themselves as "stupid" knowing that the chatbot will answer them squarely without any added emotions.
4. The chatbot does not take away the ability to ask the tutor, given that we have set up the default fallback response statement. Should there be a need for them to discuss their work with their tutors, they'll still be able to do so. The chatbot is not designed to prevent tutors from interacting with them.
5. The chatbot is a fun and convenient way of getting information about the assignment. The chatbot is another window on their laptop, and as such, when they encounter some administrative doubts while working on their task, they can get the answer right away on the same screen, for most of the users, this is construed as very convenient. Further, the small-talk agent allows users to get some fun interactions when they are bored. It is evident in the high level of interactions that the students have with the small-talk agent depicted in Figure 6.

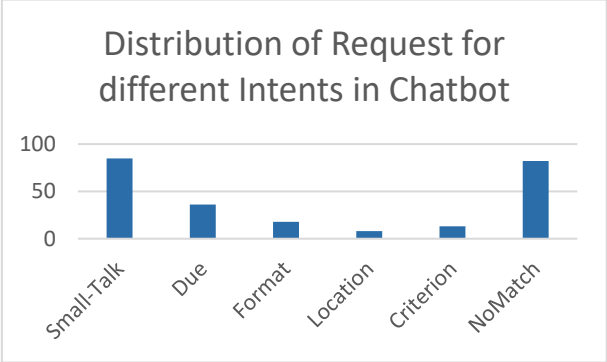


Figure 6. Distribution of Request for different Intents in Chatbot

The data collected during the chatbot pilot also highlight the potential of the chatbot. The pilot was rolled out to a group of twenty-five above average students. During this pilot stage, there were forty-two different conversations with the agent. Each conversation has an average of 5.76 interaction from the students to the chatbot. Since the launch of the chatbot, no more administrative questions for the tutors were being asked except one question on WhatsApp about the trustworthiness of the chatbot – "Can I trust the chatbot?".

Tutors typically spend five to ten minutes managing a conversation with students, forty-two conversations would imply that by using the chatbot, about 3.5-7 hours of the tutor's time was saved. At first glance, this may not be significant, but if the chatbot is deployed to an entire cohort, it could be phenomenal. There are twenty classes of twenty-five students in each cohort, and each student have to complete five assignments on average per semester over a two-semester academic year. By using the chatbot, the potential savings could be over a thousand hours of tutor time!

Besides the performance of our Assignment Chatbot, another handy feature of the chatbot is that the entire chatbot can be exported from the DialogFlow platform and re-imported to another account created for a different assignment. No additional training of setup of the chatbot is needed except the default response, which is specific to the assignment required to be modified. The new agent can be ready for its deployment to a different subject/assignment within minutes. The transferability of the agent is significant as the agent need only to be created once and can be reused many times.

Discussion

There were also some challenges in the chatbot pilot. Firstly, this is the first time the experiment was conducted, there was a significant number of unmatched requests initially, as can be seen from Figure 6. While this was to be expected, more could be done in creating more training phrases and entities to match the student queries. There was also some significant drawback to the DialogFlow platform; the analytics function of the platform only works for data collected over the last 30 days, and it will not compute beyond that. As the pilot was active over a month, the initial data will be excluded should the analytics function of the platform be used. Fortunately, there were only twenty-five students and forty-two conversations, and it was still possible to manually entered the data into an excel spreadsheet for analysis. Finally, the number of students participating in the experiment could be increased to allow for more accurate statistical analysis. Increasing the size of the group will undoubtedly be the consideration for our next operation for the chatbot.

Conclusions

The assignment chatbot experiment aims to answer the administrative assignment queries from students that often took up much of the tutor's time. From the results of the pilot, the potential for the chatbot looks promising. Over a thousand hours of savings on the tutor's time is undoubtedly a significant figure. On top of that, the assignment chatbot can easily be deployed to different courses/subjects by merely exporting it and re-importing it for the relevant subject tutor. Only minimum modifications are required to get the chatbot working for the new course. Based on the first pilot, there is also potential that administrative queries for tutors could be eliminated and become historical.

More experiments are currently in the pipeline with a bigger group of students, as well as adding more exciting features. The results of these experiments will be shared once it becomes available.

References

Gannon, D. [(2018, August). Building a "ChatBot" for Scientific Research. Researchgate. https://www.researchgate.net/

Google Inc. (2020, March 27). DialogFlow Documentation. DialogFlow. https://www.dialogflow.com

Vergadia, M. (2019, February 11). Deconstructing Chatbots: Getting Started with Dialogflow. Medium. https://medium.com/

Vergadia, M. [Priyanka Vergadia] (2019, February 5). Getting started with DialogFlow (Deconstructing Chatbots). [Video]. Youtube. **https://www.youtube.com**

TOWARD THE NEXT GENERATION EDUCATION WHICH CONTRIBUTES TO REGIONAL REVITALIZATION WITH "KOSEN 4.0" INITIATIVE PROJECT

S. Toyama[*,a], S. Akazawa[b], Y. Tawara[c], F. Ikeda[d] and Y. Murakami[e]

[a] Department of Electronic Control Engineering,
National Institute of Technology, Nagaoka College, Nagaoka, Japan
[b] Department of Materials Engineering,
National Institute of Technology, Nagaoka College, Nagaoka, Japan
[c] Division of General Education,
National Institute of Technology, Nagaoka College, Nagaoka, Japan
[d] Department of Mechanical Engineering,
National Institute of Technology, Nagaoka College, Nagaoka, Japan
[e] Department of Civil Engineering,
National Institute of Technology, Nagaoka College, Nagaoka, Japan

*toyama@nagaoka-ct.ac.jp

Abstract

NIT (National Institute of Technology, Japan) is expected to contribute following directions. The first direction is development of human resource to support new industries. The second direction is contribution to each region, such as education based on distinctive industries. The third direction is acceleration and promotion of internationalization. For those directions, the "KOSEN 4.0" Initiative, which is competitive funds for strengthening of education in each NIT college, has founded. NIT, Nagaoka college suggested three education programs: Vanguard engineer program for global engineers to develop regional industry worldwide, NaDeC Entrepreneur program to create new industry in our region, and AIR Tech engineer education program. This paper reports those three education programs towards the next generation education. In the first program, the new subjects "Global PBL I & II" cultivate challenge sprits, communication ability and understanding of different cultures through problem-solving exercise with international students from various countries. In the second program, NaDeC means the concept of Nagaoka Delta Cone. Four vertexes corresponding to the locations of four universities and one college in Nagaoka City make a shape of delta cone on the map. These five institutes arranged a consortium and named it NaDeC. The consortium can produce various educational opportunities for fostering of entrepreneur. In the third program, the term "AIR" represents the new technologies of AI, IoT and Robot. This education program aims to foster AIR Tech engineers who can fluently apply such new technologies like breathing air. Literacy education of AIR Tech has been begun in all departments of our college. Those three education programs can lead our students to develop their global awareness, entrepreneurship and AIR Tech. This paper reports three good educational efforts brought by those programs. The first example is a venture company started by a student who makes a core technology useful for robot products. The second example are some students who proposed an AI business model, which is evaluated as the market value of JPY 400 million in an AI business contest. And the third example are some students who have developed the creative equipment to solve a problem of a Kenyan start-up company.

Keywords: *Global Engineer, Entrepreneur, AI, IoT, Robot Technology*

Introduction

In a VUCA world, Japan's higher education has entered a period of great change, as well as other countries. As a higher educational institution, all universities and colleges in Japan are further required to upgrade their functions, such as knowledge accumulation, research promotion, cooperation with local industries and regional contribution (Japanese Central Council for Education, 2018). Toward the next generation education, National Institute of Technology (NIT) implemented the "KOSEN 4.0" Initiative in 2017 and 2018, aiming to expand the strengths and characteristics of each NIT college in the three directions of "human resource development to drive new industries", "contribution to regional community" and "acceleration and promotion of internationalization".

Each college of NIT is located in almost every prefecture in Japan. NIT, Nagaoka College is located in Nagaoka City, Niigata Prefecture, where it takes less than two hours from Tokyo by the Shinkansen. Nagaoka City is the second largest city in Niigata Prefecture with about 270,000 inhabitants. With a successful oil exploration of the Higashiyama moutain range in 1888, Nagaoka City started its history as an industrial city. Because electronics and precision machinery industries have also accumulated in addition to the ironworking and casting industries which have been cultivated by machine tools for oil drilling, Nagaoka City is home to one of the largest machine industry groups in Niigata Prefecture (Nagaoka City, 2020). The Nagaoka area is the birthplace of a famous story of the "100 bales of rice" about the education of Mr. Torasaburo Kobayashi, who is a samurai of the Nagaoka clan in the late Edo period. This story is often cited as a symbolic story of how patience in the present can benefit in the future like education. That is the reason why Nagaoka City is very enthusiastic about human resource development in techinical fields. Therefore, the first technical high school in the prefecture, Faculty of Engineering of Niigata University (moved to Niigata City in 1980), and Nagaoka University of Technology have been established in this area.

Under such a historical background, NIT, Nagaoka College was established by the strong demand and enthusiasm of the community as Nagaoka National College of Technology in 1961. Initially, NIT, Nagaoka College consisted of three departments: Department of Mechanical Engineering, Department of Electrical Engineering and Department of Industrial Chemistry. Only Department of Mechanical Engineering had two classes, which means twice the number of students compared to other departments. In 1968 during the period of Japanese high economic growth, Department of Civil Engineering was expanded. In 1990, one class in the Department of Mechanical Engineering was reorganized into Department of Electronic Control Engineering to accommodate the spread of the Internet. In 2000, Advanced Courses in Electrical and Mechanical Engineering, Materials Engineering and Civil Engineering were established to provide more advanced education for engineers. And NIT, Nagaoka College now has five departments and three majors of the advanced courses, which have been modified to meet the needs of the times.

For the “KOSEN 4.0“ initiative, the direction of regional development in Nagaoka City was investigated to deterimine how education reform of NIT, Nagaoka College will proceed in the future. "Nagaoka Rejuvenation Strategy" formulated as a comprehensive strategy for Nagaoka (Nagaoka City, 2015) says that it is necessary for young people, who will lead the future as the main players, to develop a strategy of today's Japanese society in which the population and vitality are expected to decline in the future, with a long-term perspective. Then, the basic action plans of the comprehensive strategy were designed: (1) to create a system in which young people themselves can participate, plan, and realize their own attractive city, (2) to create a high-quality educational environment to nurture children who will be the future leaders of Nagaoka, and (3) to support the business development of present companies and to promote new startups and attraction of enterprise. Furthermore, Mr. Tatsuhiro Isoda, who is the mayor of Nagaoka, says that it is important to revitalize the regional industry, retain young people and promote U/I turnover. And he advocates "Nagaoka Version of Innovation" that makes cross-disciplinary innovation by taking advantage of the concentration of various higher education institutions of four universities and one college in Nagaoka City, and by adding new technologies such as AI, IoT and Robot Technology (Nagaoka, 2018). It is also recognized that it is necessary to develop a base for globalizing Nagaoka's industry and to develop global human resources, as well as to develop innovative human resources with a background in technology, design and business (Isoda, 2018).

In the direction of Nagaoka City, NIT, Nagaoka College has proposed three projects as the “KOSEN 4.0” initiative. Two of those proposed projects: the global human resources development and the entrepreneurship development, have been adopted in 2017. In addition to those two projects, another new project of advanced technologies that contribute to Industry 4.0 also has been adopted in 2018. NIT, Nagaoka College has built a human resource development platform that fuses these projects to create and accelerate local industries and expand globally. This paper reports on each project, which was established by NIT, Nagaoka College through the “KOSEN 4.0” initiative.

Methods

Prior to the “KOSEN 4.0“ initiative, NIT, Nagaoka College has established "System Design Education Program" to produce interdisciplinary innovator through solving various problems of regional companies (Tsuchida et al, 2015). The Education program is one of the multidisciplinary education program of NIT, Nagaoka College, which was established in 2013. The multidisciplinary education program consists of the Basic Course, which is completed in two years of four and five years of the main course, and the Expert Course, which is an integrated four-year course from the fourth year of the main course to the second year of the advanced course as shown in Fig. 1. Since each course program mainly consists of common classes to all departments, students can take courses regardless of their department, and receive educational and research guidance from multiple department staffs. "System Design Education Program" is designed to develop generic skills that enables students to derive solutions to multidisciplinary problems. The core educational method is JSCOOP (Job contents Search for local companies based on COOPerative education). In JSCOOP, cross-disciplinary teams consisting of students from various departments are organized and they visit local companies for interviews. Through those interviews, students learn

about the history of local companies, consider what it means to work for local companies, and get information on the problems of local companies. After the interview, students formulate the problems and proposed their soluations in each cross-disciplinary team.

Through a series of learning experiences such as information gathering, problem finding and problem solving, students develop cross-disciplinary skills in the Model Core Curriculum. The Model Core Curriculum developed by NIT presents "Core", which is the minimum level of ability and content to be achieved by all students of NIT, and "Model", which is a guideline for further advancement of technical college education. On the other hand, the cooperating companies of JSCOOP can get flexible ideas from students for their problems. A good example of how collaboration can lead to recruitment activities has begun to emerge. Exactly, it is an educational program that can lead to innovation that will accelerate local industry. Under the direction of regional development in Nagaoka City, NIT, Nagaoka College discussed the direction of educational reform on the occasion of the "KOSEN 4.0" initiative. As mentioned in Introduction of this paper, we decided to build a human resource development platform that contributes regional revitalization by adding new educatonal projects into the multidisciplinary education program as shown in Fig. 2. The added new projects are Entrepreneurship program to create local industries, Global human resource development program to develop local industries internationally and Education program for new technologies such as AI, IoT and RT for realizing an super smart society from the lower grades.

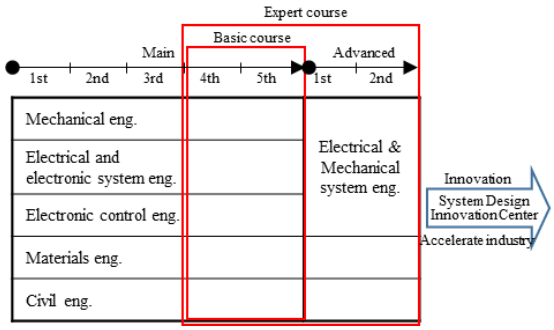


Figure 1 Multidisciplinary education program

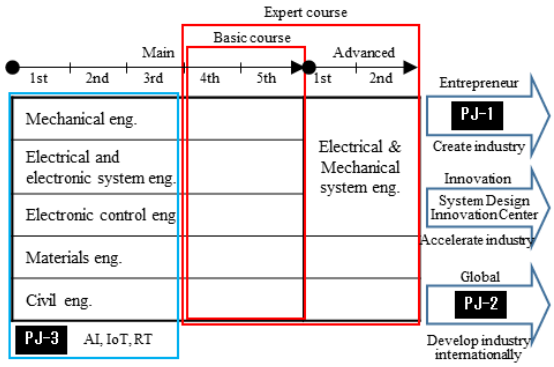


Figure 2 Platform of Human resource development to contribute regional revitalization

A new project PJ-1 shown in Fig. 2 is "NaDeC Entrepreneurship Development Based on Nagaoka Rejuvenation" project, which was adopted as a human resource development program to create local industries in the "KOSEN 4.0" initiative. Based on "System Design Education Program" which aims to produce innovative human resources, the entrepreneurship education program adds education on commercialization and on entrepreneurship. It is essential to secure teachers with diverse expertise, experience and backgrounds for commercialization education and for entrepreneurship development. Therefore, the NaDeC (Nagaoka Delta Cone) concept shown in Fig. 3 was established in collaboration with four universities (Nagaoka University of Technology, Nagaoka Institute of Design, Nagaoka University and Nagaoka Sutoku University) and one college (NIT, Nagaoka College) located within an 8 km radius. In order to foster entrepreneurship, NIT, Nagaoka College has entered into a comprehensive partnership agreement with a prominent venture company, FULLER Inc. as shown in Fig. 4. The president and CEO of Fuller Inc. is Mr. Shuta Shibuya, who is an alumnus of NIT, Nagaoka College. Since he and his colleagues organize a lot of lectures and app development seminars under the comprehensive collaborative agreement, the entrepreneurial mindset has been gradually fostered among the students. For example, the entrepreneur Club of NIT, Nagaoka College was launched in 2017.

Figure 3 NaDeC concept based on collaboration with Nagaoka four universities and one college (The photo is provided by Nagaoka City Office)

Figure 4 Comprehensive partnership agreement with a prominent venture company, FULLER Inc. (The photo is privided by Nagaoka City Office)

A new project PJ-2 shown in Fig. 2 is "Vanguard Engineer Development Program for Driving the International Expansion of Regional Industries" project,

which was adopted as a global human resource development program for the global expansion of local industries in the “KOSEN 4.0“ initiative. The new education program will produce global human resources who will lead local industries in cooperation with other institutes under the NaDeC concept and the overseas academic exchange agreements. The students of NIT, Nagaoka College are encouraged to establish "Nagaoka Identity" and to cultivate international and diversified perspectives. And they can form an international network of the next generation engineers with the students of our overseas partner universities by making them "Nagaoka fans" through the Vanguard Engineer Development Program. In this project, new subjects "Global PBL I", "Global PBL II" and “Global Debate“ have been established. “ Global PBL I“ is JSCOOP with various students under the NaDeC Concept and the overseas academic exchange agreements. "Global PBL II" is held in overseas as an international JSCOOP as shown in Fig. 5. “Global Debate“ is a debate class in English to promote cross-cultural understanding as shown in Fig. 6. This program is expected to produce engineers who love local industry and play a leading role in the international development of local industry.


(a) Groupwork (b) Presentation of concept

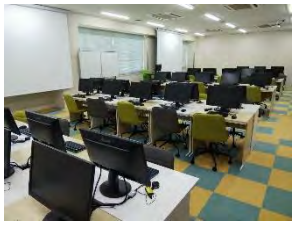
Figure 5 Global PBL II in Guanajuato, Mexico (2017)

Figure 6 Glabal debate

A new project PJ-3 shown in Fig. 2 is "Development of AIR Tech Engineers who will be the source of Nagaoka Version of Innovation" project, which is a literacy education of the lower grades for new technologies such as AI, IoT and RT to realize super smart society “Society 5.0“ suggested by Cabinet Office of Japanese government. The purpose of the new project is to train engineers who can naturally use AI, IoT and RT to support the "Nagaoka Version of Innovation". NIT, Nagaoka College calls AI, IoT and RT, which are essential for the next generation engineers, AIR technology, whose registered trademark is shown in Fig. 7. Some literacy education and some social implementation projects on AIR Technology develops the next generation engineers who can naturally use such technologies like breathing air. The curriculum organization policy of this program is as follows: (1) To introduce literacy classes for all departments in lower grades of the main course as shown in Fig. 8 (a) to make all students understand AIR technology as a familiar and indispensable technology. (2) To establish some Pre-Labs on AIR Technology for students in the middle grades of the main course. The Pre-Lab system is one of the extracurricular activities of NIT, Nagaoka College, and the system can provide some opportunities of self-directed practical activity to foster a spirit of inquiry for students. The established Pre-Labs hire some students with outstanding skills of AIR Technology as teaching assistants. Candidates for such students can be found among those who have participated in some technical contests, such as NIT robot contests, NIT programming contests and other events. Through such Pre-Labs, the fundamental know-how and skills for social implementation of AIR Technology will be imparted to a wide range of participating students. In the future, other Pre-Labs for mathematical science and data analysys are planned to open. And (3) To create some opportunities to practice AIR Technology for students in the upper grade of the main course and the advanced course. Some examples of such opprtunities are social implementation projects by an interdisciplinary team based on the NaDeC concept, or solving the local issues identified by JSCOOP in collaboration with the IoT Promotion Lab of Nagaoka City. In order to promote this educational project, the AI room, which has 45 AI workstations, has been set up in 2019 as shown in Fig. 8 (b), and some IoT literacy materials to provide a base for the above activities have been developed.

AIR Tech

Figure 7 Registered trademark of AIR Technology

(a) Class on image recognition (b) 45 AI workstations

Figure 8 AI literacy class in AI room

Results and Discussion

This section reports three good educational efforts brought by those programs. The first example is a venture company started by a student who makes a core technology useful for robot products. Fig. 9 shows the opening event for the incubation facility "Tech Luncher" managed by the venture company. Mayor Isoda of Nagaoka also came as a guest of honor at the press conference of the opening event. Since “Tech Luncher“ has a great facility with a good selection of

machine tools, they will pump fresh blood into the industry of Nagaoka City. The second example are some students who proposed an AI business model, which is evaluated as the market value of JPY 400 million in the NIT Deep Learning Contest 2019 (DCON 2019). The students participated in a Pre-Lab Team, and they won the Grand Prize as shown in Fig. 10. In the contest, NIT students compete feasibility of their business plan with deep learning technique. And the third example are some students who has developed the creative equipment to solve a problem of a Kenyan start-up company in the new subject " Global PBL II" as show in Fig. 11. Our students proposed a machine that would solve a problem, which is faced by a Kenyan local company, to sort insects by size for livestock feed. They actually built the machine and took the machine into the field to prove it in Kenya.

Thus, various ripple effects of the platform of human resource development shown in Fig. 2 are beginning to appear. The next task is to design a curriculum that fosters the ability to think and act more effectively in the global era of the SDGs.

Figure 9 Opening event for incubation facility "Tech Luncher" managed by Mr. Oishi, who started his own business while he was a student of NIT, Nagaoka College

Figure 10 Pre-Lab Teams of NIT, Nagaoka College won the Grand Prize in DCON 2019 (Business contest with deep learning technique)

Figure 11 An example of Global PBL II (JSCOOP in Kenya)

Conclusions

In this paper, we explained the direction of the educational reform of NIT, Nagaoka College based on the analysis of the current situation of regional development in Nagaoka City. In order to build a human resource development platform for creating, accelerating, and expanding local industries globally, the "KOSEN 4.0" initiative has established a system that complements the entrepreneurship and global human resource development projects and education for new technologies such as AI, IoT, and RT from the lower grades.

Acknowledgements

Those projects by the "KOSEN 4.0" initiative have been promoted with the cooperation of not only NIT, Nagaoka College staff but also many other parties outside the college. We hereby express our gratitude to all parties involved.

References

Isoda, T. (2018). Nagaoka version of innovation, begins., https://www.city.nagaoka.niigata.jp/sangyou/cate14/nagaoka-start.html.

Japanese Central Council for Education. (2018). Grand Design of Higher Education for the Year 2040 (Report), Ministry of Education, Culture, Sports, Science and Technology (MEXT), Review of Japanese Central Council for Education, No. 211.

Nagaoka City. (2015). Nagaoka Rejuvenation Strategy - FY 2015 - FY 2017 [Nagaoka City Comprehensive Strategy for the Creation of Town, People and Work / Population Vision].

Nagaoka City. (2018). Challenges from Nagaoka - Innovation -, News from Nagaoka municipal administration.

Nagaoka City. (2020). Corporate location guide in Nagaoka City, https://www.nagaoka-kigyoritchi.jp /nagaoka /history.html.

Tsuchida, Y., Toyama, S., Murakami, Y., Akazawa, S., Kiryu, T., Ikeda, F., Iyama, T., and Tokoi, Y., (2015). Cross-disciplinary education and research promotion activities by System Design Innovation Center, Bullen of NIT, Nagaoka College, Vol. 51, 87/96.

Tsuchida, Y., Murakami, Y., Toyama, S., Ikeda, F., Iyama, T., Tokoyama, Y., Tokoi, Y., Akazawa, S., Kiryu, T., (2017). Innovation Human Resource Education through Regional Collaboration JSCOOP, Engineering Education, Vol. 65, No. 4, p. 4_45/4_50.

THE NATURE OF SCIENCE AND ITS IMPACT ON THE IMPROVEMENT OF SCIENTIFIC EDUCATION

J.A. Sánchez-Márquez[*, a],

[a] Universidad de Guanajuato, CNMS, ENMS Salamanca, Salamanca, México

*ja.sanchez@ugto.mx , samj02@hotmail.com

Abstract

This project focused on the study of the nature of science through readings described as historically accurate narratives of great contributions and scientific developments in the fields of Chemistry, Physics, Biology, Astronomy and Geology. The introduction of the study of the nature of science had an impact on the humanization of scientific work and, in general, on the improvement of scientific education in students of the upper middle level. The phrase Nature of Science (NOS, for its acronym in English, Nature of Science) is commonly used to refer to issues such as: What is Science ?, How does science work ?, What principles or foundations are Science supports ?, How do scientists operate as a social group? And how does society itself influence and react to scientific efforts? The answer to these questions is key in order to eliminate the widespread idea that science is complex or exclusive to a single group of people. Understanding the principles of the nature of science allowed for a stronger scientific literacy in students and motivated them to advance their scientific education. The study of the nature of science was carried out through small readings developed in the form of historically accurate narratives about scientific facts and developments highlighted in multiple areas of science. These readings included topics such as: The calculation of the age of the earth, the formation of the elements in the universe, the development of the Bing Bang theory, the conception of dark matter, the recognition of evolution, among others. At the end of the project it was observed that a better understanding of the nature of science allows students to understand that science can be recognized as human behavior, increasing interest in science and science classes and improving the learning of scientific topics. It is important to note that the study of the nature of science is the most important component of scientific literacy because that knowledge is what citizens use when evaluating public problems that involve science and technology.

Keywords: *nature, science, scientific, knowledge, narratives*

Introduction

Currently, in most countries we can see that a higher percentage of students choose to avoid studying careers in the area of science or engineering. This trend is linked to the current belief that science majors are reserved for a select class of students. However, a less obvious cause for this phenomenon may be linked to a null or misunderstanding of the principles on which science is based. In this sense, in countries like the United States, the term Nature of Science (NOS) has been used to refer to the concepts that allow us to answer questions such as: what is science? How does science work? Are their foundations? Is it a human behavior, a set of knowledge or a group of methods? How do scientists operate as a social group? And how does society itself influence and react to scientific efforts?

The answer to these questions is undoubtedly the key to achieving scientific literacy and to attracting students to the areas of experimental and exact science. Knowledge of how science works will allow students to recognize science as a human effort; thereby increasing interest in science classes; improving the learning of scientific content; and promoting better social decision making based on science and technology. The NOS principles are the most important component of scientific literacy because that knowledge is what citizens use when evaluating public issues involving science and technology. Proof of the above can be found in recent discussions about whether we should act on global warming or whether we should do something about the anti-vaccine movement in various countries. Another important point to note is the fact that many brilliant high school students choose to leave science as soon as possible, in part because of misguided notions about the nature of science. Unfortunately, studies of students' and public's understanding of nature are extremely scarce and, in many cases, only limited to evaluating value judgments about whether science is important or not, but never delving into the People's idea of science and what science really is.

Today, most people think of science as complex and dehumanized. This fact is not surprising given that science books, laboratory activities, and most audiovisual materials minimize the influences in the research processes that eventually result in knowledge and portray science as a complex rhetoric of conclusions. Accurately and effectively conveying the foundations of the nature of science plays an important role in making introductory science courses more intelligible and meaningful to all students. Seymour and Hewitt (1997), in an extensive study of why students drop out of science, wrote that "a serious cause of loss of interest was disappointment with the perceived narrowness of their [science, math, and engineering] specializations as an educational experience ... ". Tobias (1990) reported that several talented students in his study reported that they were disillusioned with science classes and chose different majors, in part, because science courses ignored the historical, philosophical, and sociological foundations of science. Eccles (2005), summarizing several previous studies, noted that we do a very poor job of accurately conveying to scientists what scientists do. This lack of effectiveness in transmitting the foundations of the nature of science in the curricular materials is due mainly to two reasons: the lack of bibliography referring to the foundations and principles of the nature of science and the little interest of the editors incorporating these fundamentals into textbooks for fear of losing market share.

A solution to this problem would be in the development of materials that teach both the scientific content and the nature of science, so that they can be used when and where teachers consider appropriate. It would also be desirable for these materials to allow in-depth analysis of important questions about how students interpret instructional materials, and how they learn aspects of the nature of science more generally. These materials must emphasize that science and its construction do not escape the historical context in which the theories are generated and that, in fact, they are affected by the values of the time. This is framed in the premise that the teaching of the terms related to technoscientific knowledge is not neutral, because the conceptions about the way science is constructed are affected by ethical and moral factors of the scientists themselves. In this way, values are present in pedagogical practice and in the way that concepts about the nature of science are adapted to a didactic dimension, to be taught. It should be noted that for several authors, the term NOS specifically alludes to the epistemology of science and refers fundamentally to intrinsic values and assumptions of scientific knowledge, while for other specialists, the concept suggests broader aspects such as how science works, what science is, how the knowledge it generates is developed and built, and the methodology that used to disseminate and validate such knowledge, among other issues. However, in both positions it is possible to recognize that the NOS seeks recognition of the implicit values in the elaboration of theories and statements, taking into account that science is not neutral, it depends on socio-economic interests and historical aspects, in addition to being subject under permanent review. This implies considering science beyond the static and unalterable body of knowledge contemplated in the scientific method. It supposes a conception linked to the social and epistemological, without neglecting the environment of the scientific community where their hypotheses and theories are developed. It is essential to encourage students to ask themselves questions such as: what is science? How does it work? What are its foundations? Is it a human behavior, a set of knowledge or a group of methods? How do scientists operate as a social group? And how does society itself influence and react to scientific efforts? The answer to these questions will allow to achieve scientific literacy within institutions and will attract students to the study of science. Additionally, understanding how science works will allow students to recognize science as a human endeavor; thereby increasing interest in science classes; improving the learning of scientific content; and promoting better social decision making based on science and technology. Studying the nature of science will prevent many bright high school students from choosing to leave science as soon as possible, in part because of misconceptions about the nature of science. Finally, the completion of this study will contribute to support other teachers in the absence of bibliographic material on the subject in our country. This study should contribute to eliminating at the root the idea that science is complex, dehumanized and reserved for a select group of people. Given this, it is necessary to build a broader vision of science that goes beyond the static and unalterable body of knowledge contemplated in the scientific method.

Materials and/or Methods and/or Pedagogy

During the realization of this project, four methodologies were applied to incorporate the principles of the NOS in the courses:

Methodology A

Take readings about the principles of the nature of science outside of class time. The students carry out the readings at home and reflect on the principles on which the nature of science is based on the questions included in the body of the readings. It is important to emphasize to students that it is important to carefully read the readings and reflect on the questions posed. The teacher can use two or three slides that refer to the reading and key ideas of the presentation during the class in order to retrieve the content.

Methodology B

Do the reading at home and analysis in small groups inside the classroom. Students take the readings, individually, outside of class, but complete the comprehension questions in small groups in the classroom. In this methodology, the instructor has fewer responses from the students to review and evaluate since the reflection questions are agreed within the group.

However, this approach may be deficient in capturing aspects of students' individual vision that are not included in the final group responses. In order to reduce this aspect, the teacher must ensure that all students participate in the activity and that the point of view of each student is considered in the group.

Methodology C

Reading is done at home and the discussion is carried out with the whole group in class. Students take the tasks that the instructor directs during class time more seriously. This approach allows the teacher to emphasize the nature content of science in the readings. In this approach students share their ideas and the instructor can evaluate the contributions and interactions of the students in order to improve their understanding of the fundamentals of the nature of science.

Methodology D

Reading and questions are done interactively in class. The instructor reads a small section of the reading until reaching the first reflection question embedded in the body of the reading. At this point, he asks the group to reflect on the proposed question and gives them enough time to put their ideas into writing. The teacher can accompany the reflection question with a practical demonstration associated with the element of the nature of the science under study. The key to the success of this approach is not to leave the entire document in advance to the students and to have clear and instructional activities ready that follow the same timeline of thought that was modelled in the story. This approach is ideal to be carried in demonstration classes or laboratory sessions.

Methodology to create effective class discussions.

Class discussion is one way that teachers can determine how students process information. Under this scheme students raise many misconceptions about the nature of science that can cause students to misinterpret the readings and draw conclusions wrong about what science is and does. In this sense, class discussion helps students develop more precise points of view about science. Here are some strategies to promote effective class discussion:

a) Use open-ended questions to frame the discussion. IF your question can be answered with just a few words or it is a Yes / No question, reframe the question so that it requires extended answers.
b) The questions included in the readings are all examples of open questions. These questions can be used to provide a starting point for class discussion, but you should be prepared to hear answers that include misinterpretations of science.
c) Refrain from judging student response. If you want students to share their thoughts and ideas, you should avoid immediately evaluating the answers as correct or incorrect. Instead, he recognizes his ideas and works to get ideas from other students.
d) Build new questions from the students' answers to previous questions.

The concepts of the nature of science will be introduced in groups of first, third and fifth semester of the bivalent program in three different geographical location (Salamanca, León and Guanajuato). The readings will be included in the curriculum of subjects such as Chemistry, Physics and Calculus.

Results and Discussion

Fundamentally, the following aspects were analyzed in each methodology: the impact of each methodology on reading comprehension (reflection) and knowledge acquisition, the execution of the activity as indicated, the impact on student learning, contemplated when making the content retrieval by the teacher. Finally, the observation was made by the teacher about the relational dimension student-student, student-teacher and student perceptions (Figure 1).

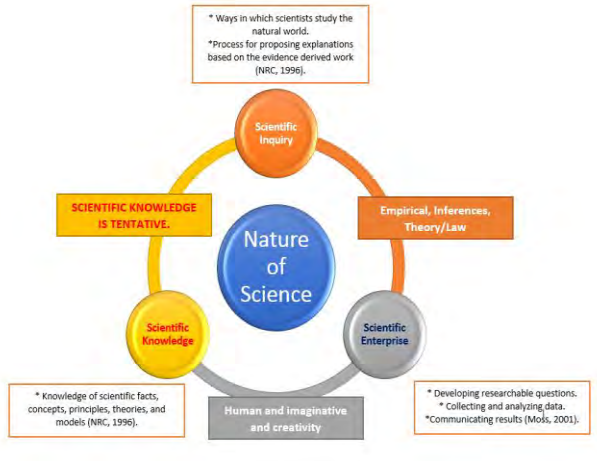


Figure 1. A Conceptual Representation of NOS (NRC, 1996; Moss, 2001).

Methodology A

It consisted of students reading the principles of the nature of science outside of class time. For this methodology, three readings were chosen, which were provided to high school science students. The introduction of the study of the nature of science (NOS), was made with the following readings:

1. "Understanding Earth´s Age Early Efforts by Naturalists and Chronologists"
2. “A Puzzle with many pieces Development of the Periodic Table”
3. “Personalities and Pride Understanding the Origins of Elements”

The students who followed the reflection questions suggested in the reading by nature if science, showed a greater mastery of the knowledge acquired, understanding the contributions of scientists, vision of science, advances and importance of science in humanity and progress of technology. They were provided with comprehension reading, also commenting that the inclusion of graphics made reading more enjoyable, despite being in another language.

In addition, the students showed greater mastery and understanding of the subject, commenting that it was easier to understand it and how the readings were left in their classes. Students considered science readings tedious, long, and heavy content. The articles provided were not considered in this way, and the results demonstrate this, as most of the students achieved a very good knowledge acquisition and discussion from all three readings. The students expressed that the scientific topics shown in this way were more interesting for them, due to the way the story was presented, as a talk as in their daily life but with scientific data.

Methodology B

This methodology consisted of the students doing the reading at home and the analysis of the questions in the classroom in small teams. The introduction to the study of the nature of science was made with the following readings:

1. "Understanding Earth´s Age Early Efforts by Naturalists and Chronologists"
2. "A Puzzle with many pieces Development of the Periodic Table"
3. "Personalities and Pride Understanding the Origins of Elements"
4. "The Realization of Global Warming"

By applying this methodology for the nature of science readings, a greater interaction between students could be observed. They had very good discussions about the topics presented in the readings. The English language of the readings presented difficulties for some students, but when working as a team they were supported by their peers and improved understanding of the topics. Some practiced their English language skills fluently. By working in work groups and sharing experiences, they interacted to help each other and complete the reflections, showing respect for the opinions of others. Reflection questions included in the readings made it easier for students to gain a better understanding of the scientific topics presented. In this sense, the students showed a better understanding of the subjects of science and the human nature of scientific work.

Methodology C

This methodology consisted of the students doing the reading at home and the discussion was carried out with the whole group in the class. The teacher led the discussion and reflections of each of the readings made, emphasizing the nature content of science in the readings. The introduction to the study of the nature of science was made with the following readings:

1. "Understanding Earth´s Age Early Efforts by Naturalists and Chronologists"
2. "A Puzzle with many pieces Development of the Periodic Table"
3. "Personalities and Pride Understanding the Origins of Elements"
4. "The Realization of Global Warming"

In carrying out this methodology, it was observed that the students when expressing their opinions were more critical and more eloquent when expressing their reflections. The student-student interaction was good, as some completed the comment made by another classmate. The advisor's direction was greater, and that allowed for directing the reflections in a concrete way and achieving more meaningful knowledge. The opinions of the students about these readings were as follows:

a) The topics covered had already been seen in some of their UDA, and they did not avoid making a comparison, the readings that refer to fundamental aspects of the nature of science seemed easier to read and understand, compared to the way in which information is traditionally given to them in class.
b) The moments in which they shared their opinions encouraged the shy students to express their opinions.
c) They found the readings of the nature of science more interesting than looking for knowledge in books with specific scientific topics.
d) They identified this activity as a valuable opportunity to practice their English while learning scientific knowledge.

Methodology D

In this methodology, reading and questions were asked in class. Using this methodology, it was observed that the students showed less interest in the activity compared to those methodologies where the students had previously done the reading at home. It was also possible to observe that the time of the activity gets too long, and the rhythm of the class becomes slower. In relation to the fundamental concepts of the nature of science, it was observed that a more superficial understanding of these subjects was achieved and that the learning was less significant for the students. The introduction to the study of the nature of science was made with the following readings:

1. "Understanding Earth´s Age Early Efforts by Naturalists and Chronologists"
2. "A Puzzle with many pieces Development of the Periodic Table"
3. "Personalities and Pride Understanding the Origins of Elements"
4. "The Realization of Global Warming"

Conclusions

At the end of this project, the following conclusions could be established:

- The introduction of scientific concepts through the nature of science approach turns out to be more efficient, entertaining and motivating for students.

- By including reflection questions in the scientific readings, the acquisition of more significant knowledge by students is favored.
- Do the reading at home and analysis the questions in small groups inside the classroom allowed a better student-student interaction that help students with less command of the English language to understand and reflect better on the topics. The student-advisor relationship was good and favored the learning and understanding of the students' knowledge.
- The inclusion of concepts of the nature of science enables students to achieve better scientific literacy and a more comprehensive view of science. Science was recognized as part of its environment and as an essential element in understanding the world around us.
- Readings that included a nature-based approach to science were liked by students; since the way of relating the facts in these readings seemed fun and "easier" to understand.
- Students showed interest in these readings being included in other courses.
- When applying methodology C, the student-teacher relationship was more effective and led to meaningful learning of each of the topics of the readings. It is clear from analyzing the results that in order to carry out scientific literacy and awaken scientific curiosity in the students, it is required that they follow directions and participate in the activities.
- When the methodology D was used, it was observed that the students showed less interest in the activities compared to those methodologies where the students had previously done the reading at home.

Acknowledgements

I would like to express my appreciation for the support extended by the University of Guanajuato for doing the research work.

References

Abd-El-Khalick, F. & Lederman, N.G. (2000). Improving Science Teachers' Conceptions of Nature of Science: A Critical Review of the Literature, International Journal of Science Education, 22(7), 665-701.

Clough, M.P. (1995). Longitudinal Understanding of the Nature of Science as Facilitated by an Introductory High School Biology Course. Proceedings of the Third International History, Philosophy, and Science Teaching Conference, pp. 212-221. University of Minnesota.

Clough, M. P. (2006). Learners' Responses to the Demands of Conceptual Change: Considerations for Effective Nature of Science Instruction. Science & Education, 15(5), 463-494.

Clough, M. P., Olson, J. K., Vanderlinden, D. W. & Bruxvoort, C. N. (2007). The Impact of Historical Short Stories on Post-Secondary Biology and Geology Students' Understanding of Science Content and the Nature of Science. Paper presented at the Association for Science Teacher Education (ASTE) National Conference in Clearwater Beach, FL, January 3-7.

Cromer, A. (1993). Uncommon Sense: The Heretical Nature of Science. New York: Oxford University Press.

ENHANCING LECTURER TEACHING COMPETENCE IN CDIO VIA WORKPLACE LEARNING

Sin-Moh CHEAH

Singapore Polytechnic, School of Chemical & Life Sciences, SINGAPORE

smcheah@sp.edu.sg

Abstract

This paper shares how the Course Management Team of the Diploma in Chemical Engineering of Singapore Polytechnic uses workplace learning based on the 70:20:10 Model of Learning and Development to develop the teaching competency of its lecturers based on the CDIO Framework to deliver its new spiral curriculum course structure. The aim of the spiral curriculum is to enhance student learning and retention of core chemical engineering knowledge, laboratory skills, and skills process operations (i.e. skills in operating chemical plants). This paper first briefly outlines what is meant by workplace learning, and explains why it is important for lecturers in today's context. It then shares the unique features of our spiral curriculum, namely in terms of using "cross-cutting" modules that integrate with core modules taught using "block teaching" approach. This creates a unique learning needs for the teaching team, because such a course structure requires that more lecturers to be well-versed in teaching more modules in a more intensive manner. This is a stark departure from earlier teaching arrangement whereby one lecturer teaches only 2 or 3 modules. There is thus an urgent need to prepare our lecturers in a timely manner to support the new spiral curriculum course structure. The paper then presents the 70:20:10 Model as an approach that portrays a more realistic approach towards learning, whereby bulk of the learning actually took place in the course of carrying out various jobs at the workplace (about 70% of the time). This is followed by an introduction to the Adding, Embedding, Extracting Model (AEEM) to derive learning from work at each of the three stages. The paper shares the author's experience with AEEM and provides examples at each stage on how to develop lecturers' competency to teach the "cross-cutting" modules and/or core modules using "block teaching". This paper concludes with a discussion of main challenges faced and key learning points gained.

Keywords: *Workplace Learning, Spiral Curriculum, Teaching Competence, CDIO*

Introduction

The Diploma in Chemical Engineering (DCHE) course of Singapore Polytechnic (SP) adopted the CDIO framework (www.cdio.org) as the basis for its 3-year curriculum since 2007 to produce the next generation of engineers. The framework provides students with an education stressing engineering fundamental set in the context of Conceiving, Designing, Implementing, Operating real-world systems and products. More recently, we introduced a new course structure based on spiral curriculum (Bruner, 1960) that took effect from April 2018 for Semester 1, Academic Year 2018/2019 (Cheah & Yang, 2018). It is an approach to education that introduces key concepts to students at a young age and covers these concepts repeatedly, with increasing degrees of complexity. This approach is also known as a "spaced" or "distributed" approach. It contrasts with "blocked" or "massed" curricula, which do not introduce difficult concepts until the student has reached a higher level of education. The spiral curriculum course structure requires a new way to teaching where lecturers need to be more well-versed in several disciplines and also work closely with other lecturers. This is important to ensure that topics to be learnt are sequenced in a progressive manner, so that modules within the same semester of study can mutually support one another, and modules at later semesters build on modules from earlier semesters.

Standard 10 of the CDIO Framework, "Enhancement of Faculty Teaching Competence" states the following:

"*A CDIO program provides support for faculty to improve their competence in integrated learning experiences (Standard 7), active and experiential learning (Standard 8), and assessing student learning (Standard 11). The nature and scope of faculty development practices will vary with programs and institutions. Examples of actions that enhance faculty competence include support for faculty participation in university and external faculty development programs, forums for sharing ideas and best practices, and emphasis in performance reviews and hiring on effective teaching methods.*"

This paper shows how workplace learning is used to provide continuing professional development to our

team of lecturers to better prepare them to tackle the challenges brought about by the implementation of the spiral curriculum.

What is Workplace Learning?

Lee, et al (2004) charged that there is no singular definition or one unified approach to what "workplace learning" is, what it should be, or who it is/should be for. Bratton, et al (2008) noted that the term workplace learning has become an established metaphor for capturing formal, non-formal, self-directed collective and even tacit informal learning activities. According to these authors, it is an interdisciplinary body of knowledge and theoretical inquiry that draws upon adult learning, management theory, industrial relations, sociological theory, etc. Two other commonly encountered words are: work-based learning, and work-integrated learning, which are sometimes used interchangeably with workplace learning. In Singapore's context, the Institute of Adult Learning makes the following distinctions between workplace learning and work-based learning (IAL, 2016):

- Work-based Learning – prepares students for employment. Examples include internship and trainee arrangements, often undertaken in conjunction with classroom learning.
- Workplace Learning – develops employees through doing the work. This development leverages on learning that happens naturally in the workplace.

Our use of workplace learning is consistent with the definition provided by IAL. The next section explains the importance of workplace learning for lecturer.

Why Workplace Learning for Lecturer?

Like many companies, academic institutions are increasing turning towards workplace learning as a way forward in continuing to hone the teaching competency of its lecturers.

The challenges faced by academics in upgrading their knowledge and skills are somewhat different from the corporate world. Lecturers often find it difficult to take time-off (say, 2 to 3 days) to attend training programs during office hours, most notably because of clashes with teaching schedule, and the challenges of arranging for make-up classes, that has to match availability of faculty, students and classroom. On the other hand, school vacation (which is fixed by the academic calendar) does not offer much respite for lecturers either, as many are making use the time to catch up with a plethora of administrative work, module review, or serving as liaison officers for students who are on mandatory internship during the vacation. Lecturers are also reluctant to make use of school vacation to attend training programs, understandably because they want to use this time for family vacation or other short excursions.

SP therefore turned to workplace learning as a way to provide continuing professional development for its lecturers. This practice varies from school to school and from diploma to diploma, depending on each school's organization and the diploma's course structure. The next section briefly explains the course structure for DCHE and the special challenges in teaching that it presented.

The DCHE Spiral Curriculum Course Structure

The DCHE Spiral Curriculum Course Structure for was introduced in Semester 1, Academic Year 2018/2019 in April 2018l, starting with Year 1 students. A simplified representation for Year 1 and Year 2 is shown in Figure 1. A key feature of the spiral curriculum is the use of "block teaching" and "cross-cutting" modules.

DCHE Course	Cross-Cutting Module	Core DCHE Module	Core DCHE Module	Core DCHE Module	Other Module (Note 1)
Year 2 Sem 2 (Stage 2B)	*POS2*	*DCHE 2B-1*	*DCHE 2B-2*	*DCHE 2B-3*	Others
Year 2 Sem 1 (Stage 2A)	*POS1*	*DCHE 2A-1*	*DCHE 2A-2*	*DCHE 2A-3*	Others
Year 1 Sem 2 (Stage 1B)	*LPS2*	*DCHE 1B-1*	*DCHE 1B-2*	*DCHE 1B-3*	Others
Year 1 Sem 1 (Stage 1A)	*LPS1*	*DCHE 1A-1*	*DCHE 1A-2*	*DCHE 1A-3*	Others
Note 1: These include modules offered and supported by other (non-DCHE) diploma / school, e.g. chemistry, mathematic, etc.					

Figure 1. DCHE Spiral Curriculum Course Structure

As can be seen in Figure 1, there are 4 "cross-cutting" modules, one for each semester, shown as *LPS1*, *LPS2*, *POS1* and *POS2*. A "cross-cutting" module, in the context of our spiral curriculum, is one *that* integrate topics covered in the other core modules and provide students with hands-on experience that require them to use knowledge gained from these core modules. The author is a member of the teaching team responsible for developing a new 45-hr "cross-cutting" module *Laboratory and Process Skills 2*, abbreviated as *LPS2* in Figure 1. The module is offered in Stage 1B (i.e. Year 1 Semester 1) and provides, in an integrative manner, the hands-on activities for topics covered in the 3 core modules (60-hour each) within the same semester, namely *Chemical Engineering Thermodynamics, Heat Transfer and Equipment*, and *Fluid Flow and Equipment*, shown as *DCHE 1B-1*, *DCHE 1B-2* and *DCHE 1B-3* as can be seen in Figure 1. These 3 modules are taught using the "block teaching" approach. Such coverage is consistent with the horizontal integration of CDIO Standard 3 Integrated Curriculum.

Figure 2 illustrate this for modules in Stage 1B (i.e. Year 1, Semester 2\). The "cross-cutting" *LPS2* module is taught over the full semester (15 weeks) whereas the 3 core modules, i.e. *DCHE 1B-1*, *DCHE 1B-2* and *DCHE 1B-3* are delivered in shorter duration. As such, "block teaching" means a more "compact" teaching format. This means that a 45- or 60-hour module now needs to be completed within lesser weeks instead of over a full semester (15-weeks) which is traditionally the case. This

necessarily means higher contact hours per week for the module. Other modules such as chemistry, mathematics, general education and stakeholder modules etc that are serviced by other schools are not integrated and are delivered in the usual manner over the entire semester.

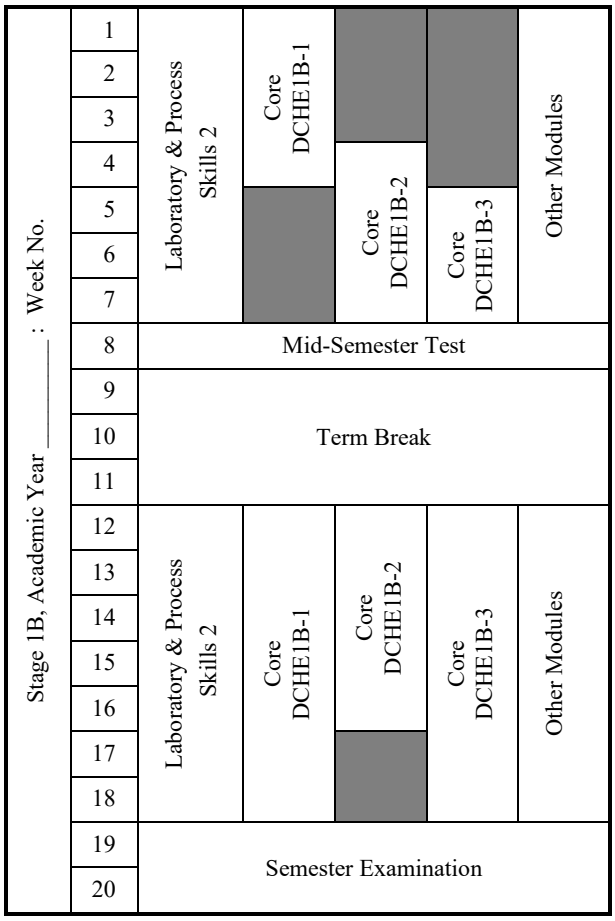


Figure 2. Revised Course Structure for Stage 1B Chemical Engineering Spiral Curriculum

The sequencing of core modules for "block teaching" allows for better alignment with the various hands-on learning tasks covered in *LPS2*. This is turn leads to more effective student engagement and learning of key concepts, and development of desired skills and attitudes (CDIO Standard 7 - Integrated Learning Experiences and CDIO Standard 8 Active Learning) and student learning (CDO Standard 11 Learning Assessment).

Similar implementation of such "cross-cutting" modules and "block teaching" in other stages of study also enables the vertical integration of the curriculum. Such a course structure allows better delivery of learning outcomes based on the CDIO Framework. Using *LPS2* as an example, in terms of a fully integrated curriculum (CDIO Standard 3), it can be seen that *LPS2* is fully back-integrated with *LPS1* in Stage 1A, and also forward-integrated with *POS1* in Stage 2A. An example would be the integration of self-directed learning (SDL) skills in DCHE, which started with enhancing students' growth mindset in *LPS1*, explicit teaching of SDL skills in *LPS2*, followed by applications in *POS1*, while at the same time students also master core skills in chemical processing technologies such as reading process flow diagram in *LPS1*, interpreting piping and instrumentation diagram and line-tracing in *LPS2*, and writing standard operating procedures for plant operation in *POS1*.

Challenges in "Block Teaching"

One of the main challenges in implementing the spiral curriculum is the way teaching of modules will be carried out. The combined impact of "block teaching" and "cross-cutting" modules is that more lecturers are now required to be well-versed in teaching more modules in a more intensive manner. For example, a lecturer who had been teaching *DCHE 1B-1* in the past must now be acquainted with the topics in *DCHE 1B-2* and *DCHE 1B-3* in order to be able to effectively facilitate student learnings in their learning tasks in *LPS2*; which contain elements of all 3 core modules. In addition, a lecturer must also be well-informed in how his/her module can leverage on student learning in earlier modules and also how his/her modules can support later modules.

This is in contrast with previous course structure whereby each lecturer tends to focus on teaching one or two modules only. These lecturers may only have academic knowledge about the topics they are now required to teach, acquired many years back during their university days. More importantly, many of our lecturers do not possess extensive working experience in chemical plant operations, and as such will have difficulty relating the topics in the spiral curriculum to real-world work situations. Such condition necessitates the training of lecturers in time for delivering the new spiral curriculum.

More importantly, due to the integrative nature of our integrated curriculum, it is highly unlikely that we can find an external training program that can meet the needs of our lecturers. Even if there is one such training, it is unlikely that the entire teaching team is able to attend such a training at the same time. The nature of training required is therefore best delivered in-house using own facilities in the laboratories. There is therefore a strong need to consider lecturers professional development via workplace learning, and the onus of delivering the required training thus fall on the shoulders of the module teaching team. This means we have to undertake

The 70:20:10 Model for Workplace Learning

Billet (2014) noted that over the past two decades, through interviews with workers from a range of occupations about how they learn through and for work, consistently they described it being premised upon: (i) engagement in work activities, (ii) observing and listening and (iii) "just being in the workplace". Working is therefore highly intertwined with learning and consequently as in the words of Michael Fullan: "Learning is the Work" (Fullan, 2011). Learning at the workplace therefore mostly occurred through work-related interactions, where skills were upgraded, and knowledge is acquired and is generally described as contributing to the learning of both the individual

employee and the organization as a whole (Cacciattolo, 2015).

The 70:20:10 Model is a learning and development model that arisen from the above observations. It stated that 70 percent of learning happens in the workplace through practice and on-the-job experiences; 20 percent comes through other people via coaching, feedback, and networking; and 10 percent is delivered through formal learning interventions. It is a model that is easy to understand but equally easy to misunderstand. The 70:20:10 concept makes intuitive sense, as most of what employees learn, they learn on-the-job during the course of doing their work - that is where they spend most of their time. Practical examples of 70:20:10 are shown in Table 1.

Table 1. Practical Examples of 70:20:10

70 – Learn & Develop Through Experience
• Apply new learning in real situations • Use feedback to try a new approach to an old problem • New work and solving problems within role • Increased span of control • Increased decision making • Champion and/or manage changes • Cover for others on leave • Exposure to other departments/roles • Take part in project or working group • Coordinated role swaps or secondments • Stretch assignments • Interaction with senior management, e.g. meetings, presentations • Day-to-day research, web browsing • Leadership activities, e.g. lead a team, committee membership, executive directorships • Cross-functional introductions, site/customer visits • Research and apply best practice • Apply standards and processes, e.g. Six Sigma • Work with consultants or internal experts • Internal/external speaking engagements • Budgeting • Interviewing • Project reviews • Community activities and volunteering
20 – Learn & Develop Through Others
• Informal feedback and work debriefs • Seeking advice, asking opinions, sounding out ideas • Coaching from manager/others • 360 feedback • Assessments with feedback • Structured mentoring and coaching • Learning through teams/networks • External networks/contacts • Professional/Industry association involvement or active membership • Facilitated group discussion, e.g. Action Learning
10 – Learn & Develop Through Structured Courses
• Courses, workshops, seminars • eLearning • Professional qualifications/accreditation • Certification • Formal education, e.g. University, Business School

It is important to note that the numbers 70:20:10 merely served as a useful reminder that most learning occurs in the context of the workplace rather than in formal learning situations and that learning is highly context dependent. Despite the lack of empirical data supporting the 70:20:10 distribution, it nonetheless remains the most popular percentages widely quoted and used by many organizations. As noted by Arets, et al (2016), it is not about the fixed ratio, but rather it is all about the mix in learning approaches that can be designed to bring about change. Blackman et al (2016) who studied the model for its effectiveness as a model for middle management capability development in the Australian public sector, cautioned that it is important the elements in the 70:20:10 model should not be perceived to be implemented in isolation. Rather, an integrated and complementary approach must be adopted. In practice, the 70:20:10 model is often implemented using the Adding, Embedding, Extracting Model (AEEM) as will be explained next.

AEEM for Workplace Learning

The AEEM (Adding, Embedding, Extracting Model) for workplace learning (Figure 3) is a useful model that can be used for exploiting development opportunities in the workplace and making informal learning more effective (Jennings, 2014).

Implementation of workplace learning can be enhanced with the use of proper performance support (Arets, et al, 2016). Rossett & Schafer (2006) define performance support as “a helper in life and work” that provides “a repository for information, processes, and perspectives that inform and guide planning and action”. Performance support comes in many forms whether it is getting guidance via a checklist, common time slot for meetings, help desk, access to experts, etc.

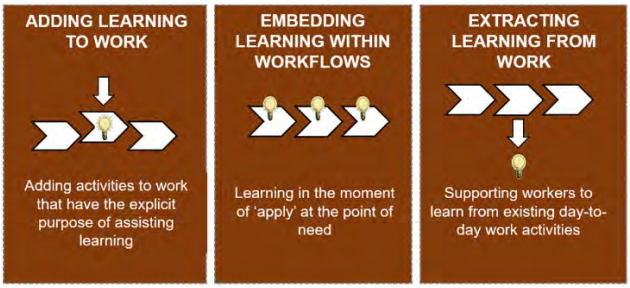


Figure 3. The Adding, Embedding, Extracting Model (AEEM) for workplace learning

Workplace Learning in DCHE using 70:20:10 Model

The 70:20:10 Model had been introduced by the SP Management recently to build up staff capability using an Individual Development Plan (IDP) where each lecturer plans for his/her personal and professional development. Consistent with the institution-wide initiative, the DCHE Course Management Team (CMT) henceforth adopted

the 70:20:10 Model to introduce workplace learning to build up staff capability in delivering the spiral curriculum, in particular in the area of chemical process plant operation, brought about by the use of "cross-cutting modules" and "block teaching". The DCHE Course Chair formed three curriculum development teams, one for each year of study led by one CMT member.

Learning is built into the curriculum development work using AEEM. Table 2 shows the work done in the three stages of the AEEM, using the "cross-cutting" module *LPS2* as an example.

Table 2. AEEM Examples of Work Done in *LPS2*

Adding learning to work	As members of the Year-1 Curriculum Development Team to rationalize, streamline, and sequence the content for "block teaching" in consultation with Senior Academic Mentor Time is set aside (Wednesday, 1 – 5 pm) during the developmental phase so that all involved do not have teaching duties during this period, hence can meet up for discussions
Embedding learning within workflows	Lecturer in charge of developing an activity prepare suggested lesson plan for the activity, model answers and sample calculations, along with brief guidance notes Lecturer in charge of developing an activity conduct a boot camp for the rest of the teaching team, at least 2 weeks before start of semester On-going consultation with lecturer developing content: Just-in-time clarification (e.g. calculations or result analysis), updates on errors previously not spotted
Extracting learning from work	Carry out regular updates among teaching team members via email, after every activity, on new learning if any, or insights Conduct After Action Review of entire module at the end of the semester, identify areas of improvement, prepare new performance support resources, if any Prepare facilitation notes based on teaching experience during the entire duration of pilot launch, to assist in the next run of the module

The entire teaching team for *LPS2* consists of 8 lecturers, whereby 5 lecturers (including the author) are full-time staff and 3 are adjunct lecturers. The author and two lecturers (one from the teaching team and also a CMT member) and another lecturer not from the teaching team took the lead for the development work for *LPS2*. The development of learning tasks was divided among these 3 team members based on each member's domain knowledge. The rest of the full-time teaching members are themselves leading the changes in other modules for example *DCHE 1B-1* and *DCHE 1B-3*.

Altogether these 3 team members designed a total of 11 learning activities (using the CDIO Framework) for *LPS2*. Workplace learning takes the form of cross-training among the lecturers. The lecturer who developed an activity took the lead to provide proper performance support for the rest of the teaching team. The first author for example, conducted a 3-hour boot camp for the three activities that he designed. To help the teaching team, he also drafted some brief guidance notes and prepared model answers for each activity. Similar performance support was provided for the remaining eight activities. On-going discussion was carried among team members even after the *LPS2* module was rolled out, where the learning activities were finetuned.

At the conclusion of the semester, an After-Action Review (AAR) of the module was carried out as part of the module review process. Items that worked and not worked were discussed; and areas of improvement identified. Finetuning of support measures were noted based on feedback from team members, and survey of students on their learning experience in the module.

Lastly, it is worth noting that student feedback indicated that students found the approach useful in helping them learn better, although some initial adjustments were needed in keeping up with the more intense contact (Yang, Cheah & Phua, 2021).

Reflections: Challenges and Learning Points

One of the key challenges in the development of the module is that of coordination. During the earlier phase of module development, numerous discussions were carried out to scope and sequence the activities. This was done in parallel with the planning of how the "block teaching" for the 3 core modules is to be done. The development team also had on-going discussions with other colleagues who had the relevant industry/academic experience for each of the activity being developed; and worked closely with module development teams for the 3 core modules in the same semester as well as module development teams for core modules in the past and subsequent semesters to ensure industry relevance, proper integration and the right level of progression. Scheduling these meetings become more challenging when the semester got going.

Another challenge is to keep all team members updated and abreast of the latest version of each activity. This is because not all development work were completed before the start of a semester. The 11 activities in *LPS2* were conducted once per week over a period of 13 weeks within a 15-week semester – one week is taken up for mid-semester test (MST) during which no classes are conducted, and one week for make-up class in the event of a public holiday (Figure 2). The module is delivered to 7 classes each week. Despite the best of intentions, and having cross-checked the design of each activity, not all mistakes were picked up before the start of the semester. As it turned out, several minor mistakes were discovered during the delivery of the module.

The teaching team may not have been fully prepared to deliver each activity exactly as intended. Simply put, the lecturer who designed an activity best knows exactly how it is to be delivered. However, he/she may not be able to share every single aspect or insight required for exact delivery during the boot camps. Indeed, some insights only came to us later, at the time of our own

delivery of the very activity itself. Due to timetabling constraints, the authors' own class is scheduled in the middle of the week. Hence, it is not always possible to share these insights in time with other teaching team members whose classes preceded our own.

Furthermore, to conduct numerous boot camps for a large teaching team presents its own challenges due to availability of all members, in particular adjunct lecturers. Lecturers who are full-time staff also had other work commitments. As a result, all boot camps had to be conducted twice, with the hope that all members can be briefed on what to do for each activity. Even then, several one-to-one sessions still had to be arranged for individuals who were unable to attend both sessions. There was also an instance where an adjunct lecturer pulled out at the last minute due to other commitments. All these translated to more time and effort, to ensure all members were sufficiently prepared to facilitate the learning process effectively.

Seen holistically, the most important benefit would be the professional development of the entire teaching team within office hours without incurring additional training cost. The cross-training benefits everyone, working collaboratively and growing professionally. Colleagues who had the relevant industry experience and/or technical know-how were able to develop as mentors, and to help ensure knowledge transfer to younger colleagues. The teaching team also learnt to step out of one's comfort zone and take on teaching of new module, of which some content could only be learnt "just-in-time" before they had to teach students. The other benefit gained was the enhanced understanding of the entire course structure and contents of all related modules in the preceding semester, current semester and subsequent semesters, which is helpful taking on the teaching of other modules.

Overall, team members expressed satisfaction with the on-the-job workplace learning that was put in place. The mutually supporting nature of our implementation of 70:20:10 model for workplace learning meant that every lecturer had a role to play in training fellow colleagues and in return be trained. Lecturers teaching some of the technical topics for the first time, in particular, reported the usefulness of the boot camp. Everyone also contributed positively to ways to improve the module in the future.

Conclusion

This paper presented an approach used to implement workplace learning for lecturers teaching the Diploma in Chemical Engineering based on the 70:20:10 Model. While many of activities described in this paper are not new, what is new here is the way professional development for lecturers can take place, at least for the team. The development work achieved via workplace learning through development of the new module and preparing colleagues for module delivery, we clearly see the benefit of shifting from formal training that takes place away from work to informal learning as part of work. The ultimate goal would be to use workplace learning and development to promote of a culture of sharing among the lecturers, so as to further improve the teaching of chemical engineering using the spiral curriculum course structure.

References

Arets, J., Jennings, C. & Heijnen, V. (2016). *70:20:10 into Action*, 702010 Institute

Billet, S. (2014). Mimesis: Learning Through Everyday Activities and Interactions at Work, *Human Resource Development Review,* No.13, pp.462-82

Blackman, D.A., Johnson, S.J., Buick, F., Faifua, D.E., O'Donnell, M. and Forsythe, M. (2016). The 70:20:10 Model for Learning and Development: An Effective Model for Capability Development? Academy of Management Annual Meeting, Aug 5-9; Anaheim, CA

Bratton, J., Mills, J.H., Pyrch, T. & Sawchuk, P. (2008). *Workplace Learning – A Critical Introduction*, Higher Education University of Toronto Press

Bruner, J.S. (1960). *The Process of Education*, Cambridge MA, Harvard University Press

Cacciattolo, K. (2015). Defining Workplace Learning, *European Scientific Journal*, Vol.1, pp.243-250

Cheah, S.M. & Yang, K. (2018). CDIO Framework and SkillsFuture: Redesign of Chemical Engineering Curriculum after 10 Years of Implementing CDIO, *Proceedings of the 14th International CDIO Conference*, Jun 28 – Jul 2; Kanazawa Institute of Technology, Kanazawa, Japan

Fullan, M. (2011). Learning is the Work, Unpublished Paper, from https://michaelfullan.ca/ (assessed Oct 11, 2018)

IAL (2016). *Blending Classroom with Work and Technology*, Institute of Adult Learning Singapore

Jennings, C. (2014). Implementing 70:20:10, *Inside Learning Technologies & Skills*, January Issue, pp.55-59

Lee, T., Fuller, A., Ashton, D., Butler, P., Felstead, A., Unwin, L. and Walters, S. (2004). Workplace Learning: Main Themes and Perspectives, in *Learning as work research: Paper No. 2*, Centre for Labour Market Studies, University of Leicester

Rossett, A. & Schafer, L. (2006). *Job Aids and Performance Support: Moving Knowledge in the Classroom to Knowledge Everywhere*, 2nd Ed., San Francisco: Pfeiffer.

Yang, K., Cheah, S.M. & Phua, S.T. (2021). Evaluation of Spiral Curriculum for Chemical Engineering using CDIO Framework, *Proceedings of the 17th International*

CDIO Conference, Jun 21-23; hosted online by Chulalongkorn University, Bangkok, Thailand

REPORT OF THE 2ND INTERNATIONAL HACKATHON

N. Shirahama[*,a] and T. Fukuda[a]

[a] National Institute of Technology (KOSEN), Kitakyushu College, Department of Creative Engineering, Kitakyushu, Fukuoka, Japan

*E-Mail naruki@kct.ac.jp

Abstract

We report on international hackathons conducted at Kyushu Okinawa District College of Technology and overseas partner schools. We mainly focus on STEM education, producing many internationally competitive human resources adapted to IT and global societies. We have hosted international ideathons and hackathons so far. The ITS Ideathon was held in May 2018, and the disaster prevention hackathon in November 2018. This paper describes the mobility hackathon's detail in August 2019 and its educational effects based on the background so far. First, we introduce the management organization, ProPolys (Progress Polytechnic Resources Growth Consortium), as an industry-academia collaborative organization to develop next-generation educational engineering human resources.

Students from 8 KOSEN in Kyushu and five overseas educational institutions participated in this hackathon. We created 11 mixed teams of students from various backgrounds for interaction. The theme of this hackathon was mobility. Participating students were required to solve problems and propose new values related to "mobility" with prototypes. Students were able to freely use the Arduino-based robot kit "mBot" and various sensors. Various prototypes have been proposed.

Finally, we refer to the educational effects of the hackathon. To measure the effectiveness of education, we made rubrics for the six skills of teamwork, leadership, problem-solving, communication, technology, and social contribution. Four levels were set for these six skills for the participating students, and they were asked to answer the level corresponding to them. A, B, C, and D were given scores of 4, 3, 2, and 1, respectively, the top three scores for each item would be "Teamwork" (3.17), "Social contribution" (3.08), and "Technology" (3.06). KOSEN students tended to score better than the previous hackathon. We can also confirm the tendency of Japanese students not to become leaders.

This international hackathon and its evaluation method can be said as an example of advanced engineer educational practices.

Keywords: *Hackathon, Robot, IoT, Mobility, Independent and collaborative learning, Competency evaluation*

Introduction

In recent years, there has been a growing recognition of the importance of fostering human resources in technology through industry-government-academia collaboration. However, in general, cooperation between industry, government, and academia is still insufficient, and higher education institutions cannot always meet the industry's expectations. In particular, there are still various issues regarding the supply of technical personnel to local industries. There is a severe shortage of engineering talent in recent years, and there is a strong tendency for engineering talent who have studied at technical colleges/universities to leave for the center. It is essential to form a new community of higher education institutions and local companies with various ideas and create value through cooperative research and joint technology development to foster the next generation of engineers and promote their employment in local companies. We are working to build a network of higher education institutions, human resources, and local companies and create opportunities for human resource development and hands-on learning through industry-government-academia collaboration.

We are engaged in educational activities at KOSEN (National Institute of Technology) in Kyushu (one of the four main islands in the southwest of Japan), and we share these problems. The percentage of graduates who find jobs in their hometowns is low, and most of them find jobs in metropolitan areas such as Tokyo, Osaka, and Nagoya. Of course, it is not a bad thing for talented people to be active in large companies. However, there are also cases where people find jobs in major enterprises and have a better life. What is essential is more appropriate matching, and in order to halt the decline of rural areas, we need a mechanism for engineers to settle in rural areas through industry-government-academia collaboration. In response to this situation, we have established a general incorporated association, "ProPolys," (Progress Polytechnic Resources Growth

Consortium), to build a network between technical colleges and local companies, fostering human resources and creating opportunities for hands-on learning. We are working on the project to bridge human resources and spread awareness of manufacturing through industry-government-academia collaboration.

ProPolys aims to contribute to creating "Serendipity" through the practice of "Planned Happenstance Theory." The following is a list of specific goals.

- Establishing a network between engineering personnel such as technical college students and local companies to foster excellent engineers and secure human resources for local companies.
- Realization of international exchange and internship acceptance in cooperation with overseas educational institutions similar to technical colleges.
- Supporting the development of internationally competitive engineers based on STEM education
- Realization of new insights through experiences and encounters, and creation of opportunities for purposeful learning and encounters with companies that match our objectives

We focus on STEM education to produce more globally competitive human resources that adapt to IT and global society. In other words, it is about enhancing various abilities such as initiative, creativity, judgment, and problem-solving skills. IT, computers, and technology make this possible, and we will continue to promote a 21st-century educational system.

Materials, Methods, and Pedagogy

This section will outline the reasons for adopting hackathons for global engineering education and the materials used in the hackathons.

Global Engineer Education and Hackathon

A shrinking population due to a declining birthrate means a shrinking domestic market and a shrinking workforce, including engineers, which will lead to changes in the social structure. As the domestic market shrinks, it will be essential to provide products and services accepted in overseas markets. In order to compensate for the decrease in the working population, we will inevitably have to accept labor from overseas. Therefore, it means more opportunities to work overseas and with overseas engineers even when working in Japan. Inevitably, engineers of the future will be required to have global communication skills. We hope that by providing as many students as possible with the opportunity to work on a single task in collaboration with students from overseas, they will acquire global communication skills. To achieve this goal, we adopted the Ideathon / Hackathon method that we use. We created a mixed team of overseas and Japanese students and asked them to work on a task in a short period. Instead of competing by country or institution, have students from different countries and different schools form teams. In the future, they will be working with a variety of people from different nationalities and backgrounds. The most practical education for global engineers is collaborating with students from other countries on various issues while still young. For example, consider problem-solving for the SDGs. The ideas that the students come up with tend to be derived from their own lives and experiences. Their ideas and thinking are highly dependent on the country's social, historical, and cultural characteristics. Team discussions can be a good opportunity for participants to understand that cross-cultural understanding is also essential for engineers.

STEM Education Materials

We adopted mBot as a prototype production material for this hackathon. Hackathons require not only an idea for a solution but also a prototype and a demonstration. The students participating in this project have various backgrounds, and it is desirable to avoid technical tasks that require a high level of expertise and skills. Therefore we decided to use Makeblock's mBot robot kit as it is easy to realize ideas and has high scalability to present various application possibilities. This robot kit can be easily assembled with a single screwdriver, and its functions can be expanded by attaching various sensors. In addition, the robot can be controlled using a visual programming language based on Scratch, making it easy to realize the idea.

International Hackathon 2019

This section describes the outline of the hackathon that we conducted. The duration of the event is seven days and six nights from August 18 to 24, 2019. The participants will stay at the JICA (Japan International Cooperation Agency) Kyushu Center venue to address the challenges. The technical theme is "Robot x IoT x Mobility." In addition to the mBot and various sensors provided by us, there were no particular restrictions on what could be used, such as participants' smartphones and servers that could be used openly. MOBILITY" here means "fluidity" and "movability." The teams will compete to see what they can propose using "robot" and "IoT" to create a prosperous society. The teams will be asked to think about why MOBILITY is necessary according to the following flow.

1. Have a goal I want to achieve.
2. Need to move to achieve the goal
3. The destination is determined by the will
4. Choose the best means of transportation
5. Arrive at destination and achieve the goal

Participating students were invited from Kyushu-Okinawa area KOSEN and overseas partner schools. Figure 1 shows the number of participants by country. Since it was held in Japan, many Japanese students

participated. Many students from Hong Kong also participated. The ratio of participants between Japanese and international students was 1:1.38, with more overseas students, which was a very favorable situation as even students who were hesitant to speak English were forced to speak in English. Figure 2 shows the number of participants by the educational institution. The number of participants from Hong Kong is higher because it was counted as one campus. The participation of more than 12 campuses in 6 countries far exceeded our initial expectations.

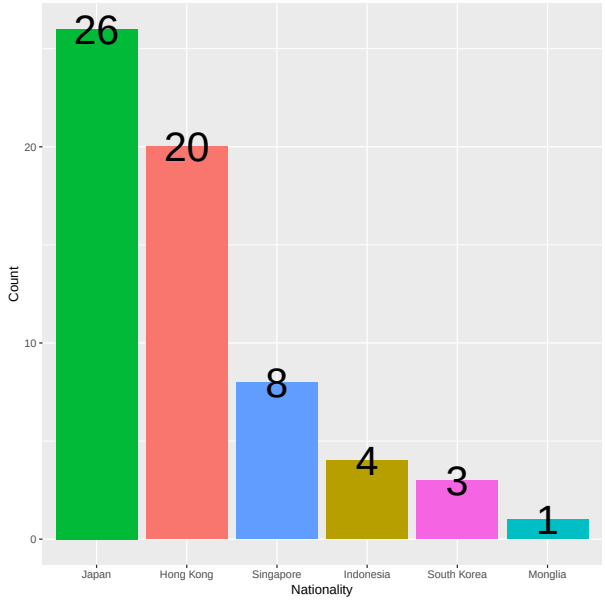


Figure 1. Number of participants per country

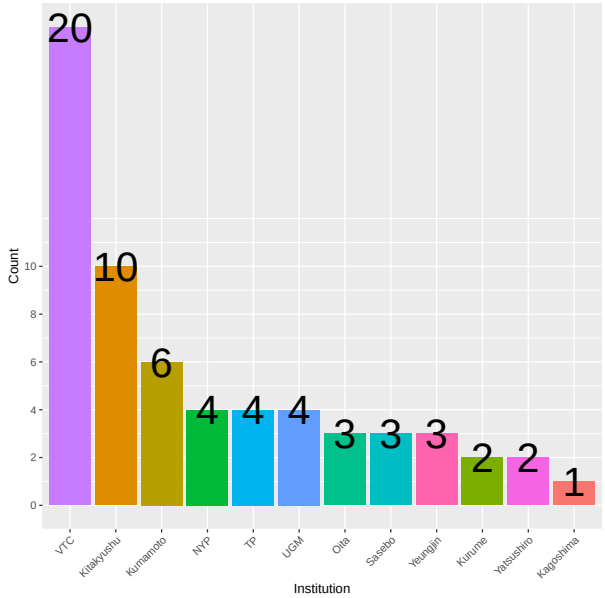


Figure 2 Number of participants per educational institution

The larger the number of participating countries and institutions, the more difficult it will be to manage, but the more affluent the diversity of student learning will be.

The flow of the hackathon

The progress of this hackathon can be divided into four major sections. These are 1. factory tour, 2. idea generation, 3. prototyping, and 4. presentation. A brief overview of these sections is given below.

1. Factory Tour

Before and after the event, we visited companies and factories related to the technical theme of the assignment. The purpose of these tours was to give the participating students a first-hand experience of what technologies and products are needed in society by visiting robots developed by companies and highly automated automobile production sites. Figure 3 shows a tour of the Yaskawa Innovation Center of Yaskawa Electric Corporation, one of the world's leading manufacturers of industrial robots. Figure 4 shows a tour of the Toyota Motor Kyushu Miyata Factory. The students learned about producing vehicle body colors and other parts to order and quality control efforts. Also, we experienced maintenance using VR at TOYOTA Production Engineering (TPEC). All of these companies are in line with the theme of "Mobility" and were selected for the tour to inspire the participants.

Figure 3 Visit to the Yaskawa Innovation Center

Figure 4 Toyota Motor Kyushu Miyata Factory

2. Outline ideas clearly

We did team building and idea generation at the same time. Students' young sensibilities are full of potential to generate new ideas, but they do not know how to generate ideas efficiently. The first thing we did was to give each student a practical exercise called "idea sketch. The idea sketch is a process of expressing one's idea in a headline, describing the details and supplementary explanations underneath, and summarizing it as an article on a sheet of A4 paper. Consideration is given to ensure that each team comprises students from as many different countries and educational institutions as possible. Next, each team worked on a "business design chart" to refine the details of their idea. This chart summarized the five aspects of the idea: target, the value provided, benefits, the scope of activities, and success requirements. The work was done in parallel with the creation of a honeycomb map to expand the ideas freely. Honeycomb map is a variant of the Mind map. Figure 5 shows a scene of the exercise using the Business Design Chart and the honeycomb map. Finally, each team gave a presentation. The scene is shown in Figure 6. After completing the work described above, all 11 teams had their ideas and were ready for prototyping the next day. Ideas such as "a guide robot that can take the place of a guide dog," "a vehicle that can be driven and controlled by voice even by people with disabilities," and "all-weather bicycles and motorcycles" were highly evaluated.

Figure 5 Generating ideas using honeycomb maps and sticky notes.

Figure 6 Presentation of ideas

3. Prototyping

Once the ideas were firmed up, the teams worked all day on prototyping. Once the ideas were firmed up, each team spent the whole day prototyping. The materials given to each team were a mBot robot kit and various sensors that could be attached. The robot can be controlled by Makeblock, a visual block language like Scratch, or programmed in C. Figure 7 and 8 show the robot fabrication and programming and parameter adjustment. We also assigned supporters familiar with robotics to help them realize their ideas and solve any problems in the fabrication process. Thanks to the supporters, all the teams were able to complete their robots without any significant problems.

Figure 7 Assembling the mBot, a robot kit.

Figure 8 Robot operation check and parameter adjustment by programming

Figure 9 Final results presentation

4. Presentation

The presentation contest was held at the Kitakyushu International Conference Center on the last day. The judges of this contest were selected from among the sponsors and experts in the field. The presentation included a video demonstration. Figure 9 shows the presentation.

Results and Discussion

We conducted a self-assessment questionnaire to analyze the educational effects of the hackathon. The format is a rubric with four levels (A-D) of achievement for the six educational effects (Teamwork, Leadership, Problem-Solving, Communication, Social Contributions, and Technology) that students are expected to obtain (Figure 10).

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.

Problem-Solving
A. I can understand several solutions and can narrow them 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 descriptions and figure correctly.
D. I could not do anything.

Social contributions
A. I can explain the possibility that our ideas can solve world problems.
B. I can explain the possibility that our ideas can solve regional problems.
C. I understand that our ideas do not contradict laws and morals.
D. I could not understand anything.

Technology
A. I can propose an excellent prototype by combining multiple functions.
B. I can create a prototype according to the technical theme.
C. I can explain the function of parts.
D. I could not understand anything.

Figure 10 Four achievement levels of skill Rubric

This self-evaluation rubric is identical to the one used in the previous international hackathon.

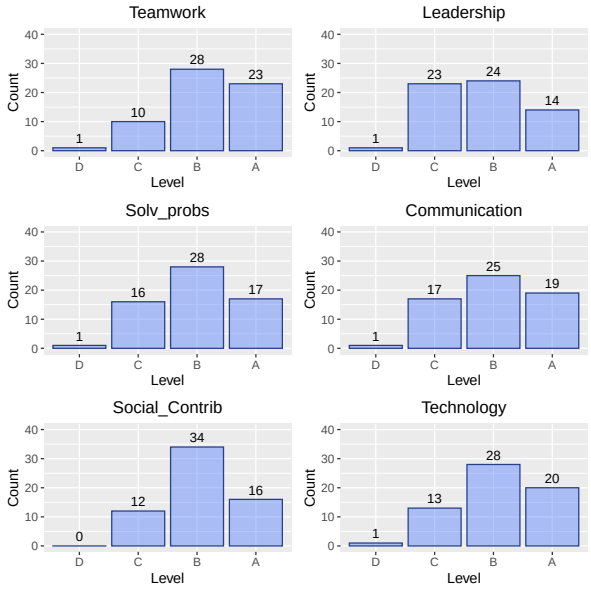


Figure 11 The histogram of self-assessment by six competencies

Figure 12 The six self-assessed rates (compared to Japan)

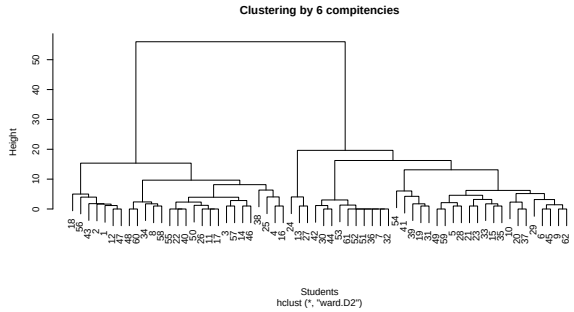


Figure 13 Hierarchical clustering based on six competencies

For more information, please refer to the paper reported at ISATE 2019. Figure 11 shows the results of the responses to the self-assessment rubric in histogram format. In the skill levels of A, B, C, and D, A is the highest, and D is the lowest. Therefore, it can be seen that "Teamwork" was the item that was rated the highest. If A, B, C, and D were given scores of 4, 3, 2, and 1, respectively, the top three scores for each item would be "Teamwork" (3.17), "Social contribution" (3.08), and "Technology" (3.06). This histogram shows that most participants answered "B," the second-highest skill level, for all items. Therefore, it was confirmed that the participating students had learned a lot from this hackathon. The item with the lowest number of responses, "A," is "Leadership." Since the number of leaders is proportional to the number of teams, the small number of responses is unavoidable.

The next step is to analyze whether there is any difference in self-evaluation between Japanese and overseas students. The results were tabulated for Japanese students and overseas students, respectively. However, since the number of participants differed, the percentage was determined. The results are shown in Figure 12. There is no significant difference in the distribution trend of skill levels A-D. However, more overseas students are in Skill Level A and more Japanese students in Skill Level B. Japanese students also gave high marks, but the self-assessment of overseas students was even higher. The fact that Japanese students are not willing to become leaders is consistent with our impression.

Finally, cluster analysis was conducted as an applied analysis. In this case, we used hierarchical clustering by Ward's method to conduct the analysis. The tree diagram of the clustering is shown in Figure 13. The hierarchical clustering diagram shows that there were no clusters of Japanese students of a specific size. We could not identify any clusters with a high concentration of Japanese students.

Conclusions

We conducted the second international hackathon with 62 participating students from 6 countries and 12 educational institutions. The technical challenges were IoT and Mobility, and 11 mixed teams created prototypes and proposed concepts in presentations using mBot, a STEM teaching tool. A self-evaluation questionnaire was conducted with four levels of six skills required for the next generation of engineers to analyze whether they learned proactively from this educational event. The results of the analysis confirm that they have learned a lot. These are consistent with their free-text impressions. We also received high praise from the participating faculty members of overseas educational periods. Therefore, it can be said that our main goal of providing opportunities for future technical college students to be active on the global stage has been largely achieved. We will continue this effort in the future.

Acknowledgments

We would like to be deeply grateful to the Japan International Cooperation Agency Kyushu for providing the venue and many valuable suggestions. We would also like to express our sincere gratitude to many companies, including TPEC, effect, LAC, Ruby Development, YASKAWA Electric Corporation, QTnet, ASKA Corporation, YOU System, SEIKO Electric, Vintage, DAICHI Koutsu Sangyo, Software Ryutsu Center, and NEC solution innovator and Toyota Production Engineering corporation for supporting this hackathon as a sponsor. This work is partially supported by JST Sakura Science Plan for the exchange program and Kitakyushu Convention & Visitors Association. We would also like to express our gratitude to the National Institute of Technology, Kitakyushu Foundation for the Advancement of Industry, Science and Technology, Kitakyushu city, Kyushu Bureau of Economy, Trade and Industry Fukuoka prefecture, Fukuoka Prefecture Robotics & Advanced System Industry Development Council for their support.

Finally, we would like to express our sincere appreciation to ProPolys, the organizer of this hackathon.

References (Media)

[1] NIKKAN KOGYO SHIMBUN (日刊工業新聞) (in Japanese) https://www.nikkan.co.jp/articles/view/00529241

[2] Report, FUKUKEI (福岡経済) October issue, 2019 (in Japanese)

References

N. Shirahama and T. Fukuda (2019). An International Hackathon with the Theme of Disaster Prevention Collaborating with Industry. *Transactions of ISATE 2019, The 13th International Symposium on Advances in Technology Education*.

N. Shirahama (2018). An International Ideathon with the theme of ITS collaborating with industry. *Transactions of ISATE 2018, The 12th International Symposium on Advances in Technology Education*.

N. Shirahama (2017). An Approach to Introduction and Improvements of Ideathon in ICT Education. *Transactions of ISATE 2017, The 11th International Symposium on Advances in Technology Education*, pp.291-296.

N. Shirahama (2016). The practice of Active Learning by Role-play of Start-up Companies. *Transactions of ISATE 2016, The 10th International Symposium on Advances in Technology Education*, pp.275-280.

ATC21S (2017). Assessment & Teaching of 21st Century Skills. *http://www.atc21s.org/*

Collaboration of Educational Institutions and Industry in Kita-Kinki Region

Yasuo Utsumi[*,a], Takuya Ueno[b], Kazuya Tamada[c], Yoshinori Kato[c],
Masanori Takahashi[d] and Kozo Toshihiro[e]

[a] National Institute of Technology, Maizuru College/President, Maizuru, Japan
[b] National Institute of Technology, Maizuru College/Department of Civil Engineering and Architecture, Research Associate, Maizuru, Japan
[c] National Institute of Technology, Maizuru College /Department of Civil Engineering and Architecture, Professor, Maizuru, Japan
[d] PMI Japan Chapter/Adviser, Tokyo, Japan
[e] Green Consulting Services/Delegate, Tokyo, Japan

* y.utsumi@maizuru-ct.ac.jp

Abstract

The decline of Japan's population and the birth rate have been making the society of aged people, and the government is working on regional revitalization. The population is decreasing in the Kita-Kinki region as well, and 5 cities and 2 towns in Kita Kinki (Maizuru City, Ayabe City, Fukuchiyama City, Miyazu City, Kyotango City, Ine Town and Yosano Town) have been responding individually or in collaboration. The following are considered necessary to become a sustainable region for the future. 1) Build the system that can solve various problems in the region by themselves. 2) Increasing the income of the people living in the region by promoting local industry. Toward regional revitalization, domestic cases in Miyagi prefecture for the recovery from East-Japan great earthquake and overseas cases in Spain based on the project of EU Horizon 2020 are introduced. According to the successful activities, the way of thinking of regional promotion is analysed in terms of confronting problems, regional potential, and the collaboration of stakeholders. The structure of four layers and how to weave the story to settle the problem are indicated. Concerning to increasing the income in the region, the current situation of Kita-Kinki region is analysed from the viewpoint of regional economic flow analysis, that is, the value of produce and sales, the distribution amount, and the expended amount. Active companies clarified by the influence coefficient and sensitivity coefficient may be exploited to activate the region. As an example, the implementation activities of the water level monitoring system in collaboration with Maizuru city, KDDI, Omron and Maizuru College is described. It is to prevent the disaster from the flood by small size of rivers not always well covered by the government. To make the above activities sustainable, the startup methodologies related to SDGs are introduced. It consists of nine steps in series, the problem finding, description of the whole problem and solution, the description of the relation between settlement and SDGs, targeting, raising the achievement, setting the value and KPI of the beneficiary, the construction the project activities, ESG investment, and the completion and the report.

Keywords: *aging society, region, economic analysis, water level monitoring, SDGs, Startup*

Introduction

Currently, the population of Japan is declining where the birth rate is decreasing and the population is aging, and the government is working on regional revitalization. The North Kinki region is in the same situation and has many small settlements in the mountainous and coastal regions. Self-help, mutual assistance and public assistance are provided to ensure convenience in social life such as securing transportation.

The 5 cities and 2 towns of North Kinki (Maizuru City, Ayabe City, Fukuchiyama City, Miyazu City, Kyotango City, Ine Town and Yosano Town) are also responding individually or in collaboration. These local bodies aim to be sustainable in common, considering; 1) to construct mechanism to solve the problems by themselves, and 2)to increase the income of the people by the promotion of the regional industry.

The Concept of Regional Development

Experience of Regional Development in Japan: Reconstructing activities after the Great East Japan Earthquake in Higashi-matsushima City in Miyagi prefecture are introduced. After losing infrastructure, industry and a large number of residents due to the earthquake, many coastal areas on the Pacific side had

faced problems such as population decline and industrial decline that should come 20 to 30 years later.

Local industry, academia including the author, government, and private organizations responded to national and local government policies and measures. JASFA (2021) was established as an industry-academia organization mainly by local companies. Taking advantage of the community-based platform consisting of small and medium-sized enterprises, many projects are taken interacting and cooperating with many habitants.

A hybrid pole with a self-sustaining power source from renewable energy was installed as night lighting in the Hibiki Industrial Park where temporary houses were installed (Figure 1). JASFA provided support for the establishment of the Miyato area reconstruction and regeneration multipurpose facility "Aomina" (Figure 2) conducted by local companies. "Smart disaster prevention eco-town" (Figure 3) is an example of achieving sustainable living and energy supply. It supplies housing and power from renewable energy utilizing FIT, Feed-In Tariff.

Higashi Matsushima City was selected by the government as an environmental future city in 2012 and as an SDGs future city in 2018.

Visit Survey in Spain: With the support of the Government of Japan and EU (JEUPISTE), the investigation was carried out to clarify the mechanism of industrial promotion in local cities in Spain and the method of building smart communities during 2013 and 2015. The cities visited are Barcelona, San Sebastian, Bilbao, St. Cugat, etc., and we interviewed stakeholders such as industry, academia, government and the private sector involved in the promotion of local industry.

Characteristics of activities in Higashi Matsushima and Spanish cities: In Higashimatsushima City, the standpoint of residents is considered, and the needs are matched with the seeds of the voluntary participants. After grasping the resources necessary for the reconstruction project, individual projects were executed. The unity of stakeholders and the participation of residents were effective.

Common things with all cities is that they were inconspicuous and slowly declining areas and that there were people aware of the serious situation. They carried out planning and implementation by roughly following the steps below.

1) Sub-leaders among stakeholders and members in a secretary position gather with 10 or less people. They clarify and share issues that were not manifested before, but were implicitly known and worried.

2) They discuss the future for 3 to 5 years and make a plan. The overall direction and roles of each stakeholder are shared.

3) In the plan, the division of responsibilities for each work content, cost in execution, and who takes the risk are clearly described.

4) Even if things are not going well, they were determined to continue working for about 5 to 10 years with patience.

The problems and the Potential in the Region: Figure 4 shows the structure of regional potentials and issues considered from the surveys. The local climate, culture, infrastructure, public services, etc. are the first issues and change slowly on a yearly basis. For example, the limit of renewable energy use can be estimated in advance depending on the climate.

Problems common to developed countries such as safety/security, declining birthrate and aging population, environment/energy, etc. will become apparent as unique

Figure 1 Self-sustaining lighting system in the area of temporary houses

Figure 2 The regeneration multipurpose facility "Aomina"

Figure 3 Smart disaster prevention eco-town

issues related to each area situation, e.g. a landslide in the mountains and a tsunami in the sea concerning to the disaster. Organizations as stakeholders have individual purposes and are influenced by economic trends. Residents live as members of the organization.

The problems that can be solved are largely determined by the combination of the region, the capabilities of people and organizations. If solar power is to be generated in the coastal areas of the Sea of Japan where sunlight is difficult to obtain, it is necessary to consider applications that require a small amount of power generation in advance. If you try to solve a problem using IT in an area where there is no IT industry, the people concerned will come from outside the area and use the local funds and resources, so the local resources will flow out.

The ability of the entire region to solve problems while supporting future life is considered to be the potential of the region. If we can grasp this, we should be able to predict whether or not the problem can be solved and to figure out the concrete method to some extent, and at least can avoid fatal failures.

By describing the population, main industries, etc. for each issue in Figure 4, the current state of resources, energy, regional projects, etc. can be grasped, and the potential of the region can be foreseen.

As a general procedure for solving regional issues, according to the survey so far, the following procedure can be considered.

1) Understand the needs and issues of the region.
2) Think of the region as a solution platform.
3) Plan a project based on the potential of the region.
4) Plan to procure the necessary resources.

Regional characteristics and strengths can be considered as seeds, and issues and weaknesses can be considered as needs. In order to realize the future image that the residents envision, the facing issues are listed and priorities are decided, but it is important to judge whether or not the solution is possible according to the potential.

After deciding the problems that can be solved, it is necessary to match the seeds to the needs and to connect them with a story are necessary.

The status of Kita (Northern)-Kinki region

The survey by Northern Kinki Regional Cooperation Conference: "Kita-re" (2021) is a platform operated by University of Fukuchiyama, acting as "a base of wisdom and solidarity" between local communities and universities.

The theme "Proposals for building a compact city based on SDGs in the Kita Kinki region" by Maizuru College was adopted by Kita-re and the study was held in FY2019. The purpose is to make concrete recommendations to ensure the sustainability of the community in the future.

Regional issues: The raised regional issues are;

1) The biggest issue is that the population decline in the Northern Kinki region will not stop. Between 2010 and 2015, the number of people decreased by 15,000, which

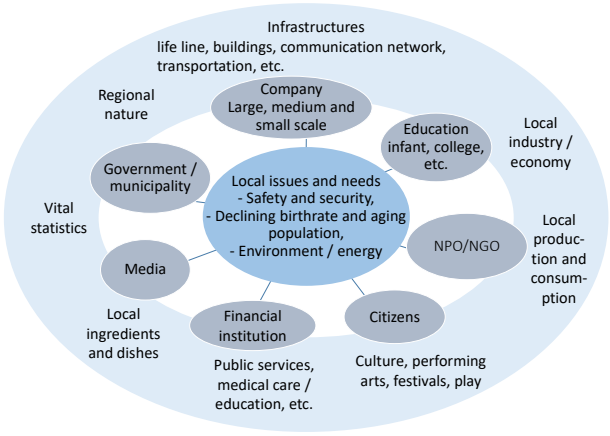


Figure 4 Relation between regional potentials, stakeholders and the problems

is decreasing faster than expected. Related concerns are;

(1) The business of the company cannot be inherited.

(2) It is not possible to secure on-site human resources in the area.

(3) There are few intermediate layers between management and the field.

(4) Within 20 years, there is no place to work and few people returning to their hometown to get a job.

(5) The age structure in the area and housing complex should be considered.

(6) The population of depopulated areas is declining due to the death of the elderly.

(7) There may be a problem with the structure of the Japanese social system, e.g. a flow of people from rural areas to cities.

2) We need players who think positively about the future.

3) We should consider future activities that take advantage of the characteristics of the Northern Kinki region.

4) There is a hidden waiting child for childcare.

Response to solve problems: The proposed efforts to be taken by the participating members are;

1) Hiring and finding employment in the region.

(1) It is necessary to consider and explain the difference between rural areas and cities, in terms of the salary, living expenses, the housing and the charms.

(2) When employment, the school side considers the difference in dealing with large companies / SMEs and parents / junior high school students.

(3) There are few opportunities for human resources in development and research to play an active role in regional companies.

(4) An internship for social experience and solving problems at the company is effective.

(5) As a corporate issue, it is necessary to invest in corporate public relations and human resource acquisition.

(6) There is a wage gap between major companies and local companies.

(7) How about trying to hire a business that solves local issues?

2) Although there are subsidies from the Cabinet Office and each ministry and agency, know-how is required for

application.
3) A list of efforts for regional infrastructure and regional revitalization would be useful for information sharing.
4) I order to get a new way of thinking, a place to share the contents discussed here is needed, e.g. business structure, way of life in 100 years of life, collaboration of local stakeholders on each issue.

Regional Economic Cycle Analysis of North Kinki

Region Regional Economic Cycle Analysis: It is a complex analysis centered on the inter-industry relations table and the regional economy accounts for each local bodies. Figure 5 shows the concept and an example of North Kinki region based on the three aspects of production, distribution and expenditure. It is positioned as an "analytical method" that gives a overview of the flow of the industry and visualizes the actual state of the industry (main industry / production spreading effect) and the relationship with outside the region (import / export) (Development Bank of Japan, 2019).

The Ministry of the Environment has published a regional economic cycle analysis tool (2015). From the perspective of how to improve the income of residents based on the local industrial and economic conditions, it is possible to aggregate multiple local governments together. The following uses the latest 2015 version.

The Analysis in North Kinki: Given that there are many other differences in production, distribution and spending, and it is necessary to reduce imports into the region and increase transactions within the region, so that the all local bodies should work together. "Kyoto Prefecture Northern Region Regional Cooperation Metropolitan Area Vision" (2017) is appropriate for grasping the current situation.

Specifically, regarding production, the industry that gives the most added value by industry is public affairs. In the manufacturing industry, ceramics and earth and stone products are followed by construction and chemistry. In the tertiary industry, next to public affairs, there are housing leasing business, health and hygiene / social business.

Regarding distribution, the employer income of the tertiary industry is the largest. The income per capita at night is 4.26 million yen / person, which is higher than the national average.

Regarding spending, ceramics / earth and stone products, public affairs, and electricity are earning income from outside the region. Consumption is flowing into the region about 10% of the consumption of local residents. The investment has flowed out of the region about 30% of the investment amount of local residents and business establishments.

The core industries in the region are pulp / paper / paper processed products, chemicals, steel, non-ferrous metals, electronic parts / devices, other manufacturing industries, construction industries, Information and communication industry, etc. If resources are invested in

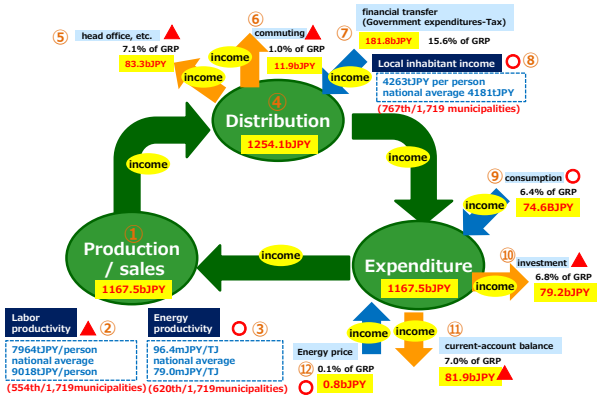


Figure 5 The concept and a regional economic cycle analysis and an example of North Kinki area

these competitive industries, the possibility of solving issues will be greater than in other industries.

Steps to promotion: Development Bank of Japan (2020) proposes possible steps as follows.
1) Activation of interregional trade: Labor productivity can be expected to improve by shortening the time required to transfer goods in the neighborhood.
2) Activation of local procurement (clustering): Strengthen the ties between sales and procurement sources, resulting in improved labor productivity.
3) Fostering and strengthening industries that are the core of regional transactions: It is expected that the productivity of all industries in the region with which we have transactions will improve.
4) Inflow of capital investment: If industrial activities in the region become active, capital investment will occur in the region, and labor productivity can be expected to improve.

Examples of Activities of Maizuru College in Maizuru City

Water level monitoring system for small rivers: Maizuru City has been aggregated needs in society and responding to them. Maizuru College collaborates in terms of research / technology and developing a disaster prevention system by receiving feedback.

The contents of Maizuru College are analysis of the outflow of the Shiraku River that flows directly into Maizuru Bay and evaluation of the impact of tide level fluctuations. If the river water level could be estimated in a few hours beforehand, residents could move to the evacuation center safely. Figure 6 shows the situation in the eastern district of Maizuru City.

The Shiraku River has been flooded several times in the past and is a second-class river with a length of 6.352 km, a basin area of 15.3 km². The analysis is performed in the middle basin. This is because there is past measurement data and it is not affected by the tide level.

By using the amount of precipitation from the rain cloud forecast of the weather forecast, a prediction of the water level in a few hours is tried. Figure 7 shows an example of the results of predicting the water level 1 hour

and 3 hours after the distribution of rain clouds at the peak of typhoon No. 21 in 2017. Both results have an absolute error of 0.79% or less and a relative error of 0.87% or less, therefore it can be used for prediction.

The developed system can be applied to another area that has same inundation problem and also can be implemented as an edge computing system with accumulated data and expertise. North Kyoto PMS (Product Manufacturing Service) is being aligned to produce such a system with a high performance PC called AMATERAS (2020).

Cabinet Office Public-Private Partnership SDGs Platform: The Cabinet Office started the public-private partnership SDGs platform in 2019. The startup research subcommittee, whose secretariat is the PMI Japan chapter, is researching the method to economically launch and sustain SDGs. Business startup are needed not only to solve problems using existing resources, but also to make the activities sustainable.

Maizuru College is exchanging opinions by reporting the above-mentioned water level monitoring system project as an example in the advanced course. It is carried out as the theme of graduation research, and it is desirable that the next generation of young people be involved under the situation of the declining birthrate and aging population.

The scope of SDGs is broad, therefore it is useful for organizing regional issues. Problem-solving projects require the cooperation of local stakeholders and have great significance to establish a methodology for starting up in cooperation.

Startup method associated with SDGs: From 2020, a basic course and an advanced course have been provided. The former deals with the connection between the basic matters of project management and the way of thinking of SDGs. The latter is studying startup methodologies based on actual examples. The steps to be taken can be described as below.

1) Discovery of regional issues through interviews, etc.: Interviews and / or questionnaire surveys with local residents are conducted. It is possible to get information about the potential of the region and stakeholders, as well as the background and past attempts that residents would not know unless they lived for many years.

2) Draw an overall picture of issues and solutions: Create a lean canvas (2013) to realize a startup while solving problems. Figure 8 shows an example of creating a water level monitoring system for small rivers. First, write down (1) customer segment, (2) issues, (3) unique value proposition, (4) solution and so on. Exploring the possibilities of a startup, all items are not to be written from the beginning. For example, (6) revenue flow and (7) cost structure require a survey of the regional economic cycle, which can be postponed. If you can't write convincing content in (1) to (4), there may be no regional potential, and (9) there is no overwhelming advantage, the possibility of startup may be low.

3) Connecting problem solving and SDGs: The mapping of 17 SDGs goals, preferably the correspondence with

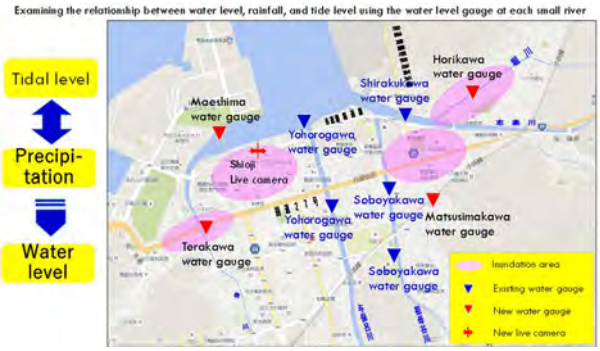


Figure 6 Activities regarding inundation in the eastern area of Maizuru City

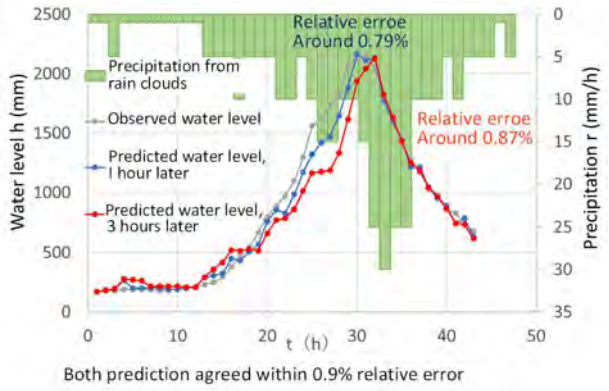


Figure 7 Later Water level prediction 1 hour and 3 hours in advance of Typhoon No. 21 in 2009

169 targets, according to the solution project, enables to classify and organize the various issues and activities obtained.

4) Set a solution goal: The list of the task and person in charge allows to foresee the specific goals, necessary resources and activity contents, activity period, etc. The requirements as a project can be almost satisfied. Figure 9 shows a part of the target list examined.

5) List the results of activities: Organizing the results obtained as a result of the activity and creating a logic model make specific description of the relationships between members involved in problem solving and what to achieve.

6) Determine the value and evaluation index for beneficiaries: After writing down short-term, medium-term, and long-term outcomes for each target, a list of the beneficiaries and benefits of the value can be obtained.

7) Assemble the activities to be performed: Each series of items will be reviewed and revised from time to time, but a WBS (Work Breakdown Structure) will be created for implementation and then the structure of the entire activity can be seen.

8) ESG (Environment Social Governance) investment: Develop analysis and methods to fund project execution and start-up. For example, consider the feasibility of corporate version hometown tax payment and crowdfunding.

9) Implementation and reporting: Maizuru City is proceeding with some of the ongoing measures. Maizuru

College continues the above-mentioned activities as a graduation research.

Firstly, it is important to carry out as much as possible with self-dominant resources, and to provide information through public relations, activities and open lectures. Information would be shared with residents and stakeholders, and efforts will be made to acquire various subsidies and resources.

Conclusions

Expected spillover effect: While there are many good examples of solving regional issues at present, but it seems that there is no established methodology that can be applied to new issues.

The proposed method of organizing regional issues from the perspective of SDGs and implementing the project after grasping the regional potential and regional economic cycle may analyse the success factors of individual cases and can be widely applied to regional issues.

The next deployment: Continuing the current project, the industry in Kyoto prefecture (Industry Association of Kyoto, Creation Forest, etc.), the local bodies (5 cities, 2 towns, etc.), the academy (University of Fukuchiyama, Kyoto Institute of Technology, etc.) are being involved.

More specifically, with the support of the Chutan Regional Promotion Bureau of Kyoto Prefecture, the establishment of PMS (Product Manufacturing Service) is proceeded as a corporate alliance and the development of necessary devices and systems.

As the population continues to decline, we will aim for sustainable Northern Kinki through the realization of SDGs.

Acknowledgements

For activities in Higashimatsushima City and Miyagi Prefecture, the authors appreciate Higashimatsushima City (Mayor Hideho Abe, then), HOPE (Higashi-matsushima Organization for Progress and Economy, Education, Energy) (Chairperson: Yasutaka Iguchi, then), JASFA (Japan Sustainable Free Powered Energy System Exploit & Promotion Association) (Chairpersonn: Yasutaka Iguchi, then), JEUPISTE (Japan-EU Partnership in Innovation, Science and Technology, EU-Japan Center for Industrial Cooperation), Ambassador of Spain. Also the authors received the support and opinions of Hasekura 2.0 project (Chairpreson: Renata Piazza) and other related parties. The development of the "water level monitoring system for small rivers" is based on an agreement between Maizuru City, KDDI and Maizuru College, and we received various advice and support from Omron and others. Regarding the promotion of the Kita Kinki region, we exchanged opinions with University of Fukuchiyama, “Kita-re”, “Regional Techno Academia” of Maizuru college, and local government officials in Kita Kinki region. We would like to express our deep gratitude to everyone for their kind collaboration.

【A. lean canvus】 Proof of Concept (PoC) of the construction of SDGs model project based on basic concept

②Problem	④Solution	③Unique Value Proposition	⑨Unfair Advantage	①Customer Segment
· It is necessary to predict floods in small rivers. · It is necessary to disseminate predicted river information. · Citizens need to handle disaster prevention information appropriately. · It is necessary to continuously collaborate and share information between the research institute (Maizuru College) and Maizuru City Hall.	A. Construction and operation of flood forecasting system (hardware) B. Dissemination of disaster prevention information and maintenance of system (organization / system) (software side) C. Development of disaster prevention human resources	(Company) Communications-related companies, Local company (school) Elementary and junior high schools in Maizuru City, Maizuru College (Municipality) Maizuru City, Kyoto Prefecture (Citizen) Maizuru and other area citizens	· Communication and relationships of trust between researchers, practitioners, and the community exists. · The track record of collaboration and earned trust of stakeholders of Maizuru College has an overwhelming advantage. · This project can be implemented under the existing system from the contract research.	(Company) Communications-related companies, Local company (school) Elementary and junior high schools in Maizuru City, Maizuru College (Municipality) Maizuru City, Kyoto Prefecture (Citizen) Maizuru and other area citizens
Existence Alternatives	⑧Key Metrix		⑤Channel	Early Adopters
· Flood prediction based on rain gauge and water level gauge information near rivers and past experience · Water level measurement method without communication function (visual and wireless communication) · Hazard map	· Obtain information such as water level and rainfall every few minutes for 24 hours and visualize it to concerned municipals. · Always inform the residents of dangerous / warning water level information when it rains. · Improvement of citizens' understanding of disaster prevention		Self-help, mutual help + public help · Disaster prevention officer of the local government · Disaster prevention personnel in national administration ·Workshop ·Open lecture	· Local governments in areas where disasters occur frequently · Participants of the extension course · Elementary and junior high school
⑦ Cost Structure			⑥Revenue Stream	
under discussion			under discussion	

Figure 8 Example of creating a lean canvas

【C2.Target setting】 Extract keywords from SDGs business solutions and set target candidates by short, medium and long term

Solution	measures / goal	Keyword extraction	Keyword expansion (target candidate)		
			short	midium	long
A. Construction and operation of flood forecasting system (hardware)	(A. from Lean Canvas) A flood prediction system (Technology Seeds) will be constructed to clarify the prediction accuracy.	· Maizuru City, disaster prevention, small rivers, safe living · Flood prediction, accuracy, rainfall gauge, water level gauge, communication system, data storage, big data, analysis, operation · Stakeholder interest, community / local government / company / school collaboration, sustainable partnership · Systems and methods for launching new businesses	· Maizuru City, disaster prevention, small rivers · Flood forecasting, water level gauge, communication system, data storage system · Stakeholder interest	· Big data, analysis, prediction model, prediction accuracy · Collaboration, development and operation of residents / local governments / companies / schools	· Safe living · Sustainable partnership · Systems and methods for launching new businesses
	(From C1.ESG analysis) C6. Both job satisfaction and economic growth ○ 11. Town development that allows you to continue living △ 13. Take concrete measures against climate change ○ 17. Achieve your goals in partnership ✕ 14. Let's protect the richness of the sea ✕ 15. Let's protect the richness of the land				

Figure 9 Example of target setting (part)

References

Study Tech (2013). *What is lean canvas*, Retrieved from https://www.slideshare.net/studytech/ss-23454300 in Japanese

Ministry of the Environment, (2015), *Regional economic cycle analysis,* Retrieved from http://www.env.go.jp/ policy/circulation/index.html in Japanese

Maizuru city, (2017). *Kyoto Prefecture Northern Region Regional Cooperation Metropolitan Area Vision,* Retrieved from https://www.city.maizuru.kyoto.jp/ shisei/msfiles/contents/0000003/3312/renkeibizyon.pdf in Japanese

Development Bank of Japan, Value Management Institute, Inc. (2019). *Methods and practices of regional economic cycle analysis,* Diamond Inc. in Japanese

Non-Profitable Organization AMATERAS (2020), *AMATERAS, Advanced Massive Architecture of Technology, Education and Research Accelerating System*, Retrieved from http://amateras.tech/wpa/wp-content/uploads/2021/ 01/20201211- AMATERASv28. pdf in Japanese

JASFA, (2021). *JASFA, Japan Sustainable Free Powered Energy System Exploit & Promotion Association.* Retrieved from http://jasfa.info/ in Japanese

University of Fukuchiyama, Kita-re, (2021). *KITAKINKI Regional Revitalization Collaborative*. Retrieved from https://www. fukuchiyama.ac.jp/kitare/ in Japanese

Effectiveness and Improvement of Home Based learning: What matters to my students?

Lim Choo Heang (Author)

Singapore Maritime Academy
Singapore Polytechnic, Singapore.

LIM_Choo_Heang@sp.edu.sg

Abstract

Year 2020 was a pandemic year. Home based learning (HBL) was an inevitable mode of learning due to the social distancing measures put in place. For educators who have conducted HBL for a full semester, many wonder about students' learning experience and the effectiveness of their online teaching; whether the students were learning more or less the same ways as the physical in-class experience, and if there were more effective means of making the learning experience better for the students.

This paper shares the HBL experience of both the student and educator groups, through surveying when both the groups have completed a full semester of HBL in a diploma course within an institute of higher learning (IHL). The survey data collected on their HBL satisfaction level, challenges faced and feedback on areas for improvement were analysed for the teaching team.

Analysis and comparisons between the perspectives of the students and educators to be shared. Suggestions for enhancing educators' preparation, competency, software and hardware requirements for future HBL experience to be included as well.

Survey Method

1. **Identified a group of students who had completed a full semester of HBL to participate in a survey. The survey to include questions on students satisfaction level about HBL, the problems they are facing during HBL and opinions on how to improve HBL?**
2. **Identified a group of educators who had completed a full semester of HBL to participate in a survey, to look for their opinion on lecturing through HBL platform.**

Analysis

1. **Based on the student survey results, quantified the student satisfactory level, then analyst the frequent problems faced by students, then suggest improvement for HBL.**
2. **Based on the lecturer survey results, quantified the lecturer opinions on HBL and their suggestion on HBL improvement.**

The paper shares student's and educator's experiences on:

- **The positive or negative contributions of HBL toward learning journey.**
- **The common problems faced by students during HBL.**
- **The general expectation of students toward HBL.**

The paper also provide suggestions on:

- **Educator preparation for HBL.**
- **The skills or competency requirements for educators to prepare HBL.**
- **The software and hardware requirements to improve HBL.**

Keywords: *Home-based learning, HBL, classroom, virtual classroom, inevitable, student expectation, competency, software and hardware.*

Introduction

Year 2020 was the implementation of full HBL within IHL due to pandemic. In order for the IHL to better understand the effectiveness of HBL on student perspective, students survey has been initiated within Singapore Polytechnic. I have a pleasure to review the survey result of a course and concluded my findings in this paper.

Students Survey and Results

There are 5 questions within the students survey. The survey questions and data gathered are listed as follows:

Question 1*(Multiple-choice)* - The e-learning / lecture materials in this module had been effective for my learning?

Data gathered as follows:

Choices	Percentage
Completely agreed	17%
Mostly agreed	36%
Somewhat agreed	35%

Somewhat disagreed	7%
Mostly disagreed	3%
Completely disagreed	2%

The result shown that majority or 88% of the students are agreeing about the effectiveness of HBL.

Question 2*(Multiple-choice)* - The synchronous "live" sessions in this module had been effective for my learning?

Data gathered as follows:

Choices	Percentage
Completely agreed	15%
Mostly agreed	33%
Somewhat agreed	38%
Somewhat disagreed	8%
Mostly disagreed	4%
Completely disagreed	2%

The results shown that majority or 86% of the students are agreeing with synchronous class are effective in their learning journey.

Question 3*(Open-end)* - Highlight the most important areas of improvement for the e-learning / lecture materials in this module.

Top 5 reappearing words gathered using word-cloud software (aka. tag cloud or wordle) are Lecture, Learning, E-materials, Clarity and Assignments.

Based on the top 5 words gathered, further review were done on the feedback. It was found that the improvement needed on e-learning as suggested by students are:

- Lecture – accessing and navigating the lecture notes online.
- Learning – Opportunity to consult with lecturer to further clarify the lesson and assignments questionnaires.
- E-material – Time taken to complete the complex e-material.
- Clarity – Audio and visual clarity during lecturing to be improved.
- Assignments – Assignments to help the students on examination preparation.

Question 4*(Open-end)* - Highlight the important areas of improvement for the synchronous "live" sessions in this module.

Top 5 reappearing words gathered using word-cloud are Live, Classmates, Lecturer, Interaction and Contents.

Based on the top 5 words above, further review were done on student's feedback. It was found that the improvement needed on HBL are:

- Live - Clarity, duration & pace of the "live" session.
- Classmates - Collaboration with classmates during class are missing.
- Lecturer – lecturer to pace his online lesson based on student's behaviour and mode.
- Interaction – the interaction between lecturer and student are in-sufficient.
- Contents – clarity and ease of using the on-line platform for contents searching to be further improved.

Question 5 (Open-end) - Please share your good experiences about HBL in this module and tell us why?

Top 5 reappearing words gathered using word-cloud are Good, Time, Experience, Lecture and Learning

Based on the top 5 words above, further reviews were done on student's feedback. It was found that the improvement needed on e-learning as suggested by students are:

- Good – The good parts of HBL are flexible timing and learning under the comfortable environment at home. HBL is a very good interface period, for student to adapt the changes from secondary school to polytechnic.
- Time - HBL required a lot of self-disciplines to keep up with the HBL time-table.
- Learning – Book store and library are closed during circuit breaker, and student unable to get the necessary learning materials and stationary for their lessons.
- Lecture – The lecture classes are recorded and ability to replay for easier revision.
- Experience – Students are heavily depending on e-social platforms (WhatsApp, Emails, Telegram, FaceTime) for any discussion with classmates and lecturers. It is a new experience for students.

Educators Survey and Results

A survey question is done on educators about their general feedback & option about HBL. The data is analysed using word-cloud, and the top 5 words gathered are Students, Learning, Effective, Majority and Assignments.

Further reviews were done on lecturer's feedback based on the top 5 words above, and it was found as follows:

- Students – Lecturers are facing difficulties in communicating and motivating the students during HBL.
- Learning – HBL is done by simulating the lesson plan as it is physical in-class.
- Effective – HBL is effective on theoretical modules. However, modules involve workshop practices, laboratory experiments and engineering drawings, the effectiveness is limited due to students unable to perform the task physically and lecturer unable to gauge the student skills on site.

- Majority - Lecturer found that majority of the students are actively engaged during online lesson and HBL is generally effective during lecture.
- Assignments - Lecturers gauge the student's learning progress via assignments/assessment received.

Suggestions of Improvement

Upon analysing the collected feedbacks, it is concluded that the students are agreeing with HBL, however following issues to be further improved:

- Clarity of contents
- Pace of teaching
- Collaboration with peers
- Opportinity for Q&A sessions with lecturer
- Ease of using the e-platform for accessing module contents.
- Equipment supports (internet bandwidth, computer, stationary, reference materials)
- Self-discipline (motivation to attend class)

While, the educators did agree that:

- HBL is effective for lecture class, however the the effectiveness of tutorial and workshop based classes are limited.
- On educator perpective, the current HBL practices are evolution of physical classroom; only minority of educators carried out major revamp to their teaching methods and lesson plan for HBL specified.
- HBL reduced educator interaction with students.
- Abilities for educator to observe the students performance via facial expression or body language is limited during HBL.

Based on the conclusions above, educator are suggested to further improve their HBL quality on:

- Lesson Preparation.
- Improving HBL skill.
- Software & Hardware requirements.

Lesson Preparation

PowerPoint slides are typically presented with bullet points form during physical classroom teaching. The pace of teaching physical class is specifically adjusted base on observing the attending student's facial expression and body language. At the same time, students pay attention during physical class by observing the body languages of lecturer, the slides displayed and the writing on whiteboard.

During HBL, the interaction between lecturer and students on facial expression, body language and white board writing or sketching are limited, and caused the teaching and learning pace to be out of sync between both end. In additional, audio quality during HBL may be poorer due to resources limitation on hardware. In this case, the overall HBL experience is not as good as physical class.

It is suggested that the lesson preparation for HBL to be specifically planned as follows:

- The slides for each lesson to be graphic based, and keep the explanation in words as extra handout for student as reading material after class. Graphical based slides is better in drawing student's attention during class. Then, the written notes may be distributed to students for further reference after class.
- Teacher to plan and utilise the breakout-room function in the e-platform, so that the students may experience better interaction with each other during HBL.
- The teacher to uppgrade their audio system (microphone) to reason quality, so that the voice clarity is improved for better understanding by student during HBL.
- The teacher to upgrade their webcam to better quality which is capable of 1080P and 60fps, so that the student may see the educator's facial expression, for better sychronising between teacher and student dring class.
- During HBL class, the lecturer to dress in standard office wear, so that the educator appear professional before the student.
- It is essential for the lecturer to appear in "dedicated-room" for HBL. The room may be a corner of bedroom or living room, with plain or decorated backdrop, as the view from the student's screen is never a complete room but a portion of space. This is to create an conducive classroom ambient before the screen.
- During the class, lecturer to avoid all the unwanted background noise that may affect HBL. Noise like door bell, bird chirping, laundry noise and background conversation to be avoided as much as possible.

Improving HBL Skill Competency

In order to improve the HBL lesson skill, the lecturer to carry out the following:

1. Professional look – educator to put up a proper office wear and tidy look during HBL, as if they are teaching in campus.
2. Familiar with the function of social platform (Zoom, MS Team, or Google Classroom) that is used for HBL class.
3. Test the audio and video equipment before class, to avoid embarrassment.
4. Check the room ambient is suitably silent for good audio recording. At the same time, use ear phone for receiving voice feedback from student, during class.
5. Teacher also needs to master the skill on microphone handling, so that enhance voice quality during HBL.

6. Educator to consider the lighting effect on video capturing. Rule of thumb, the light source should be facing the educator not behind the educator.
7. A suitable backdrop at educator preference. Else, a plain wall may serve the purpose as well. When DSLR camera is used for video capturing, the educator may consider using the correct len for bokeh effect at his background.
8. Check correct presentation slide is shared before class.
9. Educator to strengthen their skill in photos or video editing for best presentation effect in PowerPoint slides.
10. Teacher needs to enhance their skill in PowerPoint slides creation and utilise the animation functions in the software for best presentation effect.
11. During HBL, it is best to present the slides as much as possible in graphical forms. The student is looking only at the screen during HBL. When slides are only words, the student may lost focus quickly. When the slides has lots of graphical images (sketches, photos, animation), then the slides may gain more attention from students. When the graphical slide is coupled with clear audio narrative from educator, the overall HBL experience shall vastly improve.
12. The teacher need to master the operating skill of writing or sketching in e-tablet, for enhancing lesson quality when mathemtical or chemistry formulas and/or any engineering sketches to be demonstrated during class.

Whether the educator to stand or sit during HBL class, it is up to individual preference. Some of the educators may find that stand up lecturing is more effective.

HBL class is similar to a movie. Nobody like to watch a movie with poor audio, visual and story line. It is essential for educator to treat their HBL lesson as a live streaming session to live movie. Attractive presentation is essential for student to buy the product.
HBL is a three dimension (3D) presentation. First two dimensions are the screen, and the last dimension is the voice. All three dimension to work in harmony and quality, then the effectiveness of knowledge transfer may be enhanced.

Software & Hardware requirements

Software requirements are

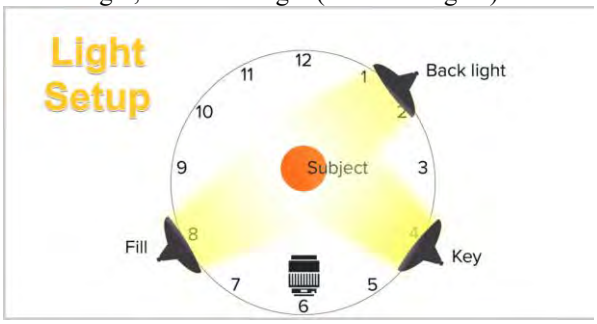
- latest Microsoft PowerPoint,
- Google searching engine for sources of photos, short videos, and refence materials.
- MS Team, Zoom or Google Classroom for best e-classroom experience and
- E-platform with ability for breakout-room.

Hardware are essetially required for improving HBL. The hardwares include:

- a computer,
- good quality USB microphone. Microphone suggested like Blue Yeti USB Microphone, Audio Technica AT2020 USB, Rode NT-USB, or Shure MV5.
- webcam to capture high quality 1080p and 60fps image. Webcam suggested like Logitech StreamCam or Logitech Brio.
- Suitable backdrop. Backdrop may be just a piece of plain colour muslin cloth, plain or pattern paper backdrop, or decorative wall.
- writing tablet (such as Wacom, Huion) for live demonstrating mathemmical or chemical formulas and any graphical sketching.

When the budget is permitted, the educator may further improve their HBL hardware as follows:

- Teaching studio. Ideally a sound treated dedicated studio is best in performing high quality audio during HBL lesson.
- A good quality condenser microphone when a dedicated studio is available, else a good quality dynamic microphone like Shure SM7B with mic activator.
- A good quality sound mixer and interface to adjust the gain, treble and bass of the educator's voice for best audio effect. Suggested sound mixer cum interface like Creative Sound Blaster K3+, Yamaha MG10XU or Behringer XENYX Q802USB.
- DSLR camera with interface to computer for high quality image capturing. When DSLR camera is used, the educator may replace the standard lens with large aperture type (below f2.0) to create the bokeh (out-of-focus) background effect. Camera suggested like Sony A5100 or Canon EOS.
- Camera required a lot more light than human eye for good quality image. The light needs to come from the correct angle, to make the educator look natural before the screen. The most common setup for lights is called three-point lighting. It consists of a key light, a fill light, and a backlight (aka. “hairlight”).



Assuming the educator (subject) is at the center of a clock, with the camera is located at six.

- The key light is located approximately at 4. It should be the brightest of the three and provides the bulk of light to your subject.
- The fill light is approximately at 8, and eliminates shadows caused by the key light. The fill light should be about half the intensity of the key light so that it eliminates shadows, but doesn't produce a flat-looking shot due to the fill and key lights are matching too closely with each other.
- The backlight located somewhere between one and two, separates the subject from the background. The light creates depth and prevents a flat-looking shot. The backlight can be hard light (no diffusion), as it won't create shadows visible to the camera on the subject's face.

Above shown the effect of lights on image's quality.

Conclusion

HBL lesson is an evolution of physical in-class teaching due to advancement of IT technology, then it became the main trend during pandemic period.
Based on the preference of current young generation, educator needs to master the live streaming skill at professional level, so that their HBL lessons become more attractive to improve the student's learning experience.

References:

For URLs:

- https://www.youtube.com/watch?v=x2AlLG1iBBE (Online teaching)
- https://www.youtube.com/watch?v=Iwpi1Lm6dFo&t=318s (Slides design)
- https://www.youtube.com/watch?v=BKOx4hZKmOs (Which Mic?)
- https://www.youtube.com/watch?v=4uHk4KU1dZs (Webcam / DSLR)
- https://www.youtube.com/watch?v=jiUpK0dhWTE (Video Lighting)
- https://www.youtube.com/watch?v=4RCXfCvh54I (Home Studio set up)
- https://www.techsmith.com/blog/get-perfect-lighting-video/

Effectiveness of Bite-Size Assessments on Students' Performance

Cheng Sheau Chin[*,a] and Shella Tong[b]

[a] Nanyang Polytechnic/School of Engineering, Smart Connected Solutions Centre, Singapore
[b] Nanyang Polytechnic/ School of Engineering, Robotics & Automation Centre, Singapore

*cheng_sheau_chin@nyp.edu.sg

Abstract

Teaching and learning comprise three crucial components – curricular learning outcomes, pedagogy, and assessment. Assessments play a vital role in fostering effective learning and provide judgements of students' work. This paper presents the effectiveness of bite-size assessment on students' performance for Engineering Mathematics offered by the School of Engineering at Nanyang Polytechnic. It also highlights the guiding principles behind effective bite-size assessment practices and gives insight into how bite-size assessments affect the learning outcome.

In the bite-size assessments approach, evaluation of learner's progress is through continual assessments of relatively small learning units. The methodology involves breaking a typical content-heavy assessment such as year-end examination into bite-size pieces of work, such as class assignments, homework, quizzes, and topical tests. Traditional assessment approach such as tests and examinations at the end of the semester tends to direct students' attention to grades and marks.

The bite-size assessments approach integrates assessments into the lesson plan. Lessons are planned in the sequence of "learn-assessment-feedback" cycles. A typical 2 hours lesson is re-organised into a short lecture followed by related class activities such as assignments and quizzes. Once the students have completed the tasks, the teacher will go through the answers and wrap-up. Students will ask questions for clarification on any concepts that are unclear and the teacher will highlight common misconceptions that the students have. The bite-size assessments approach emphasises engaging and facilitating students in their learning and helps the students to achieve the learning outcomes and attain better performance.

Adaptation of ICT tools in assessment can facilitate data capturing and analysis quickly so that the teachers can render timely intervention to close the gaps. The use of game-based learning platforms such as Kahoot and Mentimeter makes assessments fun and engaging.

The study compares the outcome of bite-size assessments against the traditional approach (closed-book, pen, and paper mid-term test and end-of-semester examination). The study results showed statistically significant improvements in the assessed learning outcomes and students' performance for the bite-size approach over the traditional high cognitive load assessment approach. The failure rate decreased from 7.9% to 3.6% and 30.8% to 12.5% for two student cohorts from 2 diplomas involved in the study. The number of students who scored grade B and above increased by 6.8% and 12.5%, respectively.

The survey also reflects positive results on students' learning experience. The findings suggest that bite-size assessments enhance the learners' retention of knowledge and enable learners to monitor and regulate their learning. Students build a habit of regular revision to become self-directed learners who are responsible for their learning progress.

From the teacher's perspective, bite-size assessments provide useful feedback for intervention to improve and facilitate the students' learning experience. Learners receive timely and constructive feedback. This helps them to firm up ambiguous concepts and build their confidence. The learners are motivated to keep going on their learning journey.

The study shows that the bite-size assessments approach receives positive feedback from both the learners and the teachers. This strategy could be used by other modules and give insight to practitioners to transform their assessment method into bite-size which is more learner-friendly.

Keywords: *bite-size assessments, topical, feedback, performance, learning outcome, learning experience*

Introduction

Teaching and learning comprise three crucial components – curricular learning outcomes, pedagogy, and assessment. Assessments play a vital role in fostering effective learning and provide judgements of students' work. Most students tend to associate assessments with

stress and anxiety. For decades, formal assessments such as tests and examinations are popular tools to determine students' mastery of a subject and serve as learners' achievement indicators.

Traditionally, students learning was assessed through high-stakes assessments such as mid-term and final semester examinations. The bite-size assessment approach aims to reduce heavily weighted testing to foster deeper and more engaged learning. The tables below show the assessment components for Engineering Mathematics before and after the implementation of bite-size assessments.

Table 1 Traditional Assessment Plan for Engineering Mathematics

Assessment Component	Week	Weightage (%)
Mid-Term Test	8	20
Final Examination	19/20	50
Assignment	16	30

Table 2 Bite-Size Assessment Plan for Engineering Mathematics

Assessment Component	Week Due	Weightage (%)
Assignment 1 & 2	3	10
Topical Test 1.1-1.3	5	17.5
Assignment 3 & 4	7	10
Topical Test 1.4-1.6	8	17.5
Topical Test 2.1-2.2	13	17.5
Assignment 5 & 6	16	10
Topical Test 3.1-3.3	17	17.5

Many students struggle to learn more complex concepts in Engineering Mathematics when their basic concepts are still unclear. The problems compounded conceptually and emotionally as complex questions are impossible to solve without a good grasp of the basic concepts.

Shavelson (2006) suggested that assessments are tools to provide active feedback loops that assist learning. His conception is that assessments can be integral rather than an add-on to teaching and learning. When the content is heavy and the pace of learning is fast, learners may not have enough time to engage in the deeper processes of organizing their thoughts. Cognitive Load Theory suggests that our working memory is subject to certain types of load and overloading working memory impedes learning. From a cognitive load perspective, the bite-size approach will help to better manage working memory than the traditional content-heavy approach (Clark et al. 2005). Wyer et al. (2004) suggested that it is possible to allow learners to digest intellectually one chunk of it, in tandem with topical assessments to provide feedback about the students' learning, make decision to improve learning, before moving on to the next. He presented in his research that when clinical learners are offered mini-lessons assisted by clinical problem-solving, they can achieve the best learning outcomes. His finding highlights the better learning experiences and more effective and successful scenarios by having focused "easily digestible bites" assignments related to each mini-lecture.

Methods and Pedagogy

We experimented with the bite-size assessment approach with a second-year Engineering Mathematics module, "Differential Equations & Series", which is a core module that has a relatively high failure rate of about 10%.

Participants

The study on the effectiveness of bite-size assessments was conducted on two student cohorts from two diplomas: Diploma in Electronic Systems (DES) and Diploma in Electronics, Computer & Communications Engineering (DECC). A total of 92 candidates participated in the study.

The intervention was made over 15 instructional weeks. Pre-intervention data was based on 104 candidates from the previous semester using their final score. 8 students who failed and repeated the module took part in both the pre-intervention (traditional assessments) and post-intervention (bite-size assessments) observation and performance checklist.

Method

In the traditional assessment approach, the syllabus is delivered through a 2-hour lecture and 2-hour tutorial weekly. The first term spans over eight weeks and wrap-up with a mid-term test (closed-book, pen-and-paper). The lessons resume after a mid-term break and continue in the same manner for the remaining of the weeks. The module is concluded with a final examination. Students are given a week of study leave to prepare for the final examination. On average, the failure rate of this module is around 10%.

Figure 1 Traditional Assessment Approach

The intervention was made over 15 instructional weeks in the subsequent semester using a bite-size assessment approach (see Figure 2). Lessons are planned in the sequence of "learn-assessment-feedback" cycles.

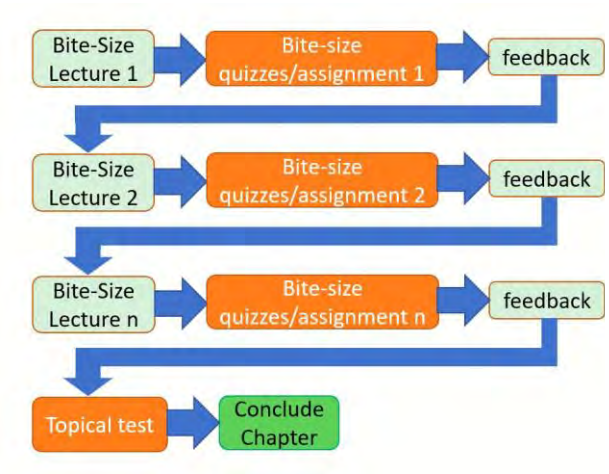


Figure 2 Bite-Size Assessment Approach

Assessments are integrated into the lesson plan. A typical two-hour lesson is re-designed with a shorter lecture, followed by a related tutorial and assignment or quizzes. After each assignment, the teacher will go through the answers and give immediate feedback and clarifications based on the exercises. Stacey and Wiliam (2013) reviewed using Information and Communication Technology (ICT) as an assessment and evaluation tool to make it possible to collect instant feedback and analyse individual competencies and needs. The findings based on the data collected enable the teacher to diagnose and eliminate misconceptions, identify the areas that the students have difficulties understanding, and address these learning gaps before moving on to more complex concepts. Teachers may also readjust the pace and fine-tune the lesson delivery based on feedback from the assessment results.

A topic could be taught over few weeks and concluded with a topical test. The questions and assignments are designed with reference to various cognitive complexity based on Bloom's Taxonomy: remember, understand, apply, analyse, evaluate, and create. (Bloom, B.S 1956). The use of digital tools and game-based learning platforms such as Kahoot and Mentimeter makes the assessment and evaluation process fun and engaging.

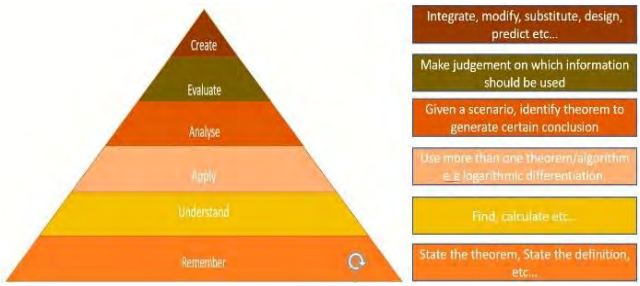


Figure 3 Bloom's Taxonomy for Assessment

Through bite-size assessments such as written or practical tests, quizzes. mini projects, coursework components and performance tasks, the teachers can identify stronger students and explore the peer teaching strategy – assign students with better performance to guide their weaker peers. Peer coaching is a win-win strategy - students with poor performance benefit from one-to-one coaching while the stronger students enhance their understanding of the subject from teaching their peers (A. Koh, 2018). Peer tutors tend to become more confident with self-esteem improved.

Measures

There are two sets of data collected, of which both are quantitative data. The first set of quantitative data is based on the final scores obtained using the two different assessment approaches; while the second set of quantitative data is a survey conducted at the end of the fifteen weeks of lessons to gather the students' and teachers' perceptions on their learning experience using the bite-size assessment approach.

Results and Discussion

The results show a significant improvement in overall academic performance. Failure rate decreased from 7.9% to 3.6% (DES) and 30.8% to 12.5% (DECC)[1]. The number of students who scored grade B and above increased by 6.8% (DES) and 12.5% (DECC) (see Figure 4). This shows that the bite-size assessment approach produces promising results and is applicable for a different cohort of students.

[1] The module is common to a few diplomas that have a different profile of students and that it was happenstance that due to the profile of DECC students, more of them face challenges in mathematics.

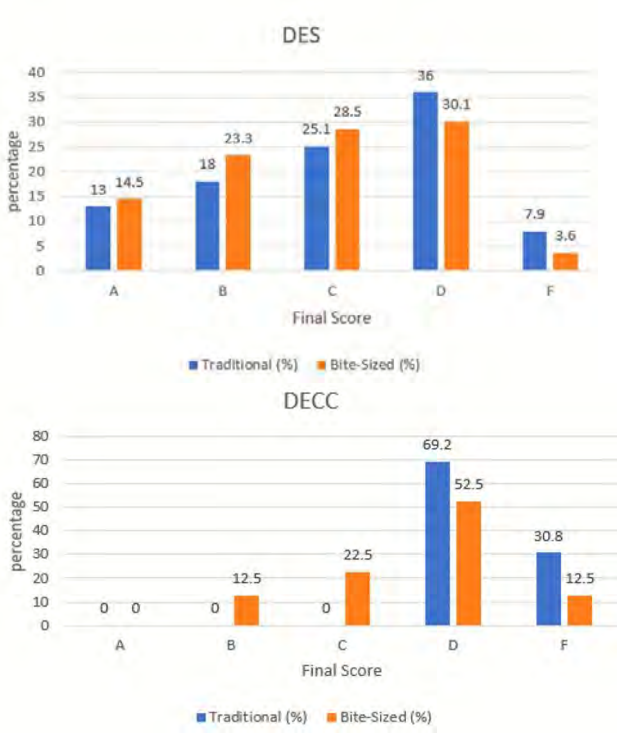
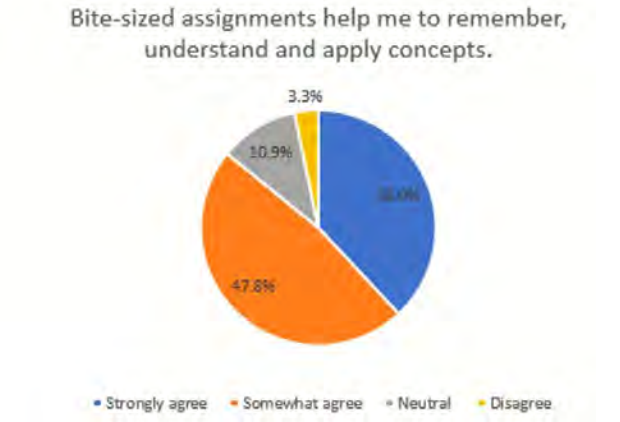


Figure 4 Final score (Traditional vs. Bite-Size Assessment Approach)

The survey reflects positive results on students' learning experience. The findings suggest that bite-size assessments enhance the learners' retention of knowledge and enable learners to monitor and regulate their learning. Students expressed that bite-size assessments provide an avenue to identify the areas that need their attention. Timely and constructive feedback helps them to firm up ambiguous concepts. Knowing the gaps allows them to set constructive goals to excel. Students build a habit of regular revision to become self-directed learners who are responsible for their learning progress. Learners become more confident and participate more actively during class discussions. Learning becomes more enjoyable. As a result, the learners are motivated to keep going on their learning journey.



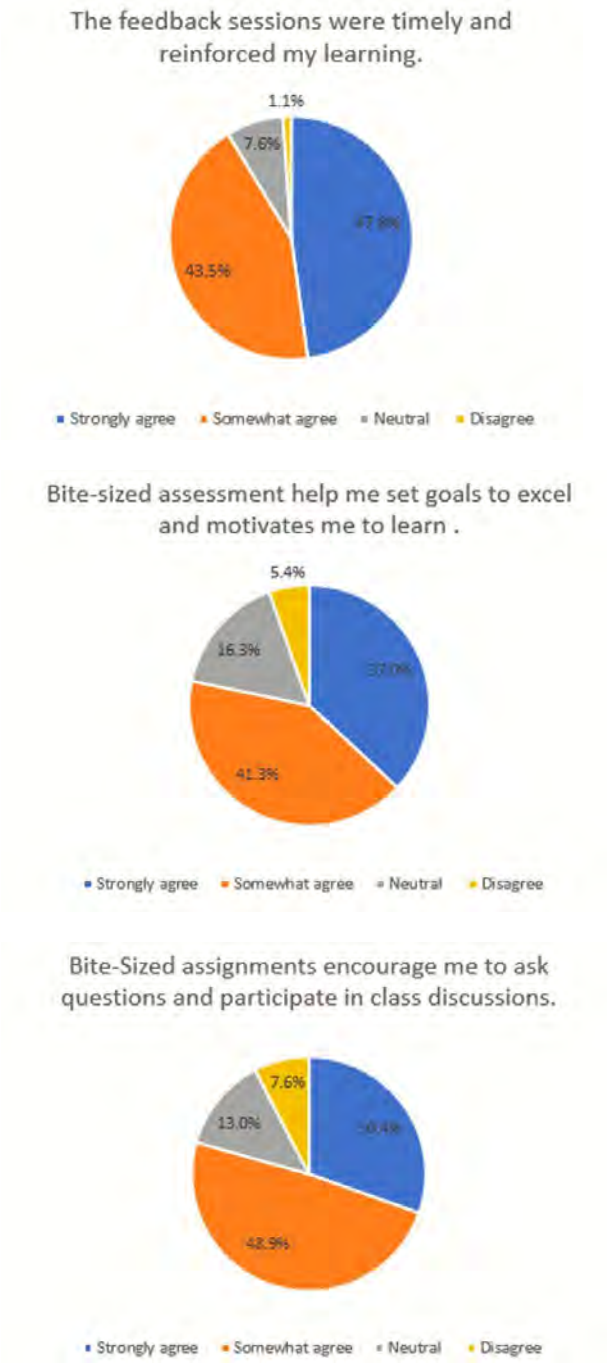


Figure 5 Survey on Bite-Size Assessments

From the teachers' perspective, bite-size assessments provide useful feedback for timely intervention to close the gaps. Students are seen to be more focused during the lessons. During class discussions, more students ask questions and engage actively during class activities.

Challenges in Doing Bite-Size Assessments Approach

Multiple bite-size assessments, in particular class tests, should be spread across the semester to provide students with sufficient time to learn. Chambers (1992) suggests that an appropriate workload is a key aspect of sound studying and learning. Kember (2004) proposes that students can be actively encouraged to work longer hours to achieve the desired outcome if the assessment, teaching style, and curricula are well designed and managed. In view of these, we need to manage the overall assessment load on students mindfully to avoid raise stress for the students as students have to juggle tests, homework, projects, and other activities during the week.

Conclusions

The study shows that the bite-size assessments approach offers many advantages over the traditional assessment method. It is well-received from both the learners and the teachers. The statistical improvement in the final scores and the survey results both suggest that the bite-size assessment approach is more learner-friendly. Although this paper is primarily based on education experiences made within a mathematic module, this strategy could be generalised to most education courses.

References

Bloom, B.S., Engelhart, M.D., Furst, E.J., Hilland, W.H., & Krathwohl, D.R. (1956).Taxonomy of educational objectives, *Handbook I: Cognitive Domain*, New York: David McKay, vol. 19, pp. 56.

Chambers, E. (1992) Work-load and the quality of student learning, *Studies in Higher Education*, 17(2), pp. 141–153.

Clark, R. C., Nguyen, F., & Sweller, J. (2005). *Efficiency in learning: Evidence based guidelines to manage cognitive load*. Pfeiffer.

Kember, D. (2004) Interpreting student workload and factors which shape students' perceptions of their workload, *Studies in Higher Education*, 29(2), pp. 165–184.

Koh, A. (2018). The learning benefits of teaching: A retrieval practice hypothesis. *Applied Cognitive Psychology*, Vol 32, Issue 3.

Shavelson, R. J (2006) *On the Integration of Formative Assessment in Teaching and Learning: Implications for New Pathways in Teacher Education*

Stacey, K & Wiliam, D 2013, 'Technology and assessment in mathematics', M A Clements, et al. (Eds.), *Third International Handbook of Mathematics Education*, Springer, New York, pp. 721-751.

Wyer, P. C., Keitz, S., Hatala, R., Hayward, R., Barratt, A., Montori, V. Montori & Guyatt, G. (2004). *Tips for learning and teaching evidence-based medicine: introduction to the series*. Canadian Medical Association Journal, 171(4), 347-348.

THE ROLE OF QUALITY ENHANCEMENT AND STAKEHOLDERS' ENGAGEMENT IN FACTILITATING STUDENT MOBILITY

S.T. Kwok*[a] and C.F. Yuen[a]

[a] Quality Enhancement and Accreditation Office, Vocational Training Council, Hong Kong

*stellakwok@vtc.edu.hk

Abstract

Globalisation radically diminishes geographic distance and increases cross-broader connectivity. Engineers of the future workforce need to have an international outlook and competencies to collaborate and work across both national and international borders. To facilitate students' mobility (both inbound and outbound), different stakeholders have contributed to quality enhancement of education institutions and ensured that learning programmes are academically and professionally recognised across boarder. This paper is a viewpoint article aiming to illustrate the ways different stakeholders have played in enhancing student mobility. It also facilitates reflection and discourse on quality assurance practices with a view to enhancing the values and attractiveness of Vocational and Professional Education and Training (VPET).

A variety of stakeholders is engaged to ensure continuous quality enhancement of VPET programmes, thereby cultivating high-calibre engineering professionals who can excel in the international arena. Examples of key stakeholders covered in this viewpoint paper are the government, employers and industries, accreditation authority and professional bodies, education institutions and students. Instead of engaging in a bureaucratic relationship, these stakeholders collaborate and go through an ongoing review, discussion and capability building process. This paper also discusses the distinctive paradigm shift to workplace learning and assessment, and online learning programmes, as well as the roles that they can play in facilitating mobility across higher education systems in different countries. The conclusions include insights to quality enhancement so as to correspond to the ultimate goal of facilitating mobility of students and ensuring graduates are equipped to work anytime in a globalised workplace.

Keywords: *vocational and professional education and training, quality enhancement, student mobility, international recognition of qualifications, transnational programmes*

Introduction

Since the introduction of Bologna Process in European countries, mutual recognition of degrees and qualifications has been considered as an important part in national education reform, which based on principles such as student mobility and equal access to higher education. It also drives the move from top-down reactive quality assurance to bottom-up proactive quality enhancement in higher education. Since then quality has been valued as an integration of institutional innovation, academic tradition and social relevance, as well as freedom of student choice in terms of individual mobility (Gvaramadze, 2008).

Amongst various disciplines, engineering plays a pivotal role in the development of human society and is not restrained by geography or artificial borders. Multinational corporations, small and medium enterprises and freelance engineers strive in the global market to improve human living standards and create a better future. Nevertheless, in the interest of public well-being and safety, not least professional standards, engineers are restrained by respective national regulations and licensure. To enable engineers to work in the globalised market, education institutions need to nurture students with an international vision, and equip them with knowledge and skills that are essential to the future world of work, and internationally recognised qualifications.

To support mobility of students and the workforce, the Education Bureau (EDB) of the Government of the Hong Kong Special Administrative Region (HKSAR) and the European Qualifications Framework Advisory Group conducted a comparability study of the Hong Kong Qualifications Framework (HKQF) and the European Qualifications Framework (EQF) (Joint Technical Group, 2016). This study facilitates mutual understanding of qualifications between Hong Kong and European countries, thereby promoting the mobility of students and the workforce for lifelong learning and career development.

In Hong Kong, a number of transnational engineering programmes are equipping students with practical skills

needed both in the local and overseas arena. For example, similar to government-funded universities in offering self-accredited engineering programmes, self-financing VPET providers, such as the Technological and Higher Education Institute of Hong Kong (THEi) and the School for Higher and Professional Education (SHAPE) of the Vocational Training Council (VTC), offer alone or collaborate with internationally renowned overseas universities (e.g. Australia and the United Kingdom) to offer accredited transnational engineering bachelor's degree programmes. At sub-degree level, a number of higher diploma engineering programmes offered by the Hong Kong Institutes of Vocational Education (IVE), operated and offered locally, are duly recognised by overseas professional associations, thus providing industry-recognised credentials to enhance student employability overseas.

As literature asserts, such transnational education and overseas professional recognition enhance the cultural capital of students (Zhang 2009), expand career opportunities (Leung and Waters, 2013) and brought students into international networks that enable further mobility (Collins, 2014). Apparently, programmes of the VTC do prepare students for a global and competitive career in engineering. The development of online learning programmes further enhances these possibilities. With the use of technologies and virtual communication means, online programmes go further to break the geographical barriers, overcome the constrains of time and costs and facilitates flow of knowledge and instant exchange of ideas.

Notwithstanding a larger pool of engineers duly and mutually recognized across countries, the demand of engineers still outpaces supply in many countries, including Australia, United States, European and developing countries (Scoy, K.V. 2021; U.S. Bureau of Labor Statistics, 2014; UNESCO, 2021). Professionally recognised engineering programmes that provide students with industry-demanded technical skills and transferrable soft skills are essential to further enhance students' mobility. This certainly requires the shift from quality assurance to quality enhancement within education institutions to ensure that quality programmes are always provided to nurture graduates for the global engineering industry.

Objectives

Consolidating literatures and the experience gained from quality enhancing vocationally oriented engineering programmes, this viewpoint article applied the stakeholder theory to illustrate the ways different stakeholders have contributed to enhancing student mobility in Hong Kong. Such contribution includes but not limited to i) creating a conducive environment to student mobility through policy and funding support; ii) developing and managing learning programmes that are academically and professionally recognised locally and internationally, iii) offering workplace learning and assessment that promote students' employability, not least iv) online programmes that could expose literally all students to the international landscape. This article also facilities reflection and discourse on quality assurance practices, thereby enhance the values and attractiveness of VPET.

Theoretical Framework

A stakeholder refers to any person or group that can affect or is affected by an organisational action, strategy or project (GPPAC, 2015). Stakeholder theory emphasises that it is mandatory for an organisation to consider and integrate needs of all its stakeholders in order to maintain social responsibility and fairness, and create values to a common goal (Chapleo and Simms, 2010; Marić, 2013; Nwajiuba, 2020). In the higher education of many developed countries, it is proven that structured cooperation among stakeholders is required for effective performance of institutes (Danson and Todeva, 2016). In the current context, the government, the employers and industries, accreditation and professional bodies, education institutions, and most importantly students, enable continuous enhancement in the quality of VPET programmes provided, so that work-ready graduates are nurtured to meet the needs of economies and international labour markets (Hack-Polay, Igwe, and Okolie, 2020).

Roles of Quality Enhancement and Stakeholders Engagement

Quality Enhancement

The concept of quality is widely used in academic institutions for many years. From "*fitness for purpose*" to "*effectiveness in achieving institutional goals*", quality has been taken as a means to achieve intangible targets, *inter alia*, in terms of comparability, learning and sometimes in transformation of students or staff. Over the years, higher education institutions have focused on bringing various learning and teaching related activities up to a standard through close monitoring, objective evaluation and rigorous review. Recently, quality enhancement becomes a new focus to bring about continual improvement in the effectiveness of learning programmes (Elassy, 2015). In short, quality enhancement refers to raising standard to a higher degree, intensifying or magnifying it (Williams, 2016). To achieve this goal, higher education institutions need to take the responsibilities for purposely develop and enact a more holistic internal quality assurance system to drive continuous improvement. Such structural enhancement relies on the contribution and support from various stakeholders in particular to enhance students' education experience, knowledge, skills and attitudes (Gvaramadze, 2008).

Quality assurance of the whole assessment cycle of the programmes being offered is essential but not sufficient to guarantee student mobility. Hence, an integrated team that comprises a variety of stakeholders is required to establish shared academic standards as well as joint quality assurance structure for achieving the goals of mobility, quality assurance and internationalisation of transnational programmes.

Government

The Government is one of the major stakeholders in Hong Kong. The HKSAR Government provides a variety of funding to VPET students to facilitate their participation in different outbound activities, including study tours, volunteer service projects and international conferences. The support not only facilitates students' mobility but also fosters closer ties with international counterparts. For instance, starting from the 2014/15, the Government provides annual funding for post-secondary institutions offering full-time locally accredited undergraduate programmes (including transnational degree programmes) to subsidise financially needy students of such programmes to participate in international exchange activities. The Government also grants Reaching Out Awards to equip students with an international vision and broaden their exposure to multicultural environment abroad. In 2020, the Government furthered the effort by establishing the Greater Bay Area Youth Employment Scheme. This scheme supports young people to work and pursue their career in the cities of the Greater Bay Area (GBA) of China.

Apart from the HKSAR Government, the Chinese Central Government also provides supports to stimulate student mobility. Recent examples included 18 new measures formulated by the Shenzhen Municipal People's Government in March 2021 to facilitate Hong Kong youth to live and set up new business in Shenzhen. These new and innovative measures included supporting Hong Kong students in internship, traineeship, and employment in Shenzhen, and enabling them to benefit from the corresponding subsidies, residence permits and housing securities policies in the fast-growing GBA.

While public funding has remained a pivotal element of HKSAR Governments' strategy to maintain and promote mobility of talents, long-term policy support that contribute to a cultural change in the VPET sector where international student mobility becomes a natural and integral part of all learning programmes deserve more attention. Reference can be drawn from the recent White Paper to the Norwegian Parliament. In this white paper, a holistic approach to integrate mandatory student mobility in higher education is described (Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education, 2020).

Employers and Industries

Multinational corporations, employers, professional and industry associations demand and appreciate for more international experience from students. International exposure diversifies students' knowledge and skills and often drives innovative ideas. It also helps build important business and diplomatic bridges around the world and bring positive impact to long-term competitiveness of companies. Alike the role of governments, employers and industries serve as resource-providers and engage in a variety of means to facilitate student mobility.

In Hong Kong, VPET providers signed a number of agreements with corporations so as to enhance collaboration and increase student employability and mobility through internships and visits. Employers and industry representatives are also consulted and engaged in programme development and curriculum design, learning and teaching activities, supervising students in projects and internships, and contribute to programme accreditation. For example, Training Boards whose members come from multinational corporations, small and medium enterprises, are established to formally advise the VTC on manpower trends and industry development. Employers are formally engaged in the quality enhancement process, for instance, as external examiners of specific programmes, members of programme validation panels, and expert members of external accreditation exercises to ensure that VPET graduates meet industrial, societal and international expectations.

With reference to the best practices and successful experiences in many countries abroad, the VTC introduced a web-based workplace learning and assessment (WLA) platform starting from 2019/20 to facilitate the acquisition of professional skills among engineering students. Through participating in WLA, employers and industry trainers help engineering students to integrate learning with job attachment. Since the online assessment platform can be used to assess students' performance and skills real-time without the limitation of geographic location, overseas employers can also be engaged and help institutions to track student progress and facilitate students' mobility. The feedback collected from the employers and industry trainers in these learning and teaching activities can also enhance the quality of programmes such that the curriculum and training contents are on par with the needs of the globalised engineering industry.

Accreditation and Professional Bodies

Higher education has gone global than before. Recognition of programmes by international accreditation authorities and professional bodies plays a key role in facilitating mobility of engineering students and graduates. In Hong Kong, learning programmes must

be accredited by the Hong Kong Council for Accreditation of Academic and Vocational Qualifications (HKCAAVQ) to qualify for an official recognition under the HKQF. Separately, the engineering profession is governed by The Hong Kong Institution of Engineers (HKIE), which also accredits programmes that meet the outcome standards criteria. Through mutual recognition agreements, such as the *1989 Washington Accord* and *2001 Sydney Accord*, signed between the HKIE and other engineering professional bodies overseas, graduates of local HKIE accredited programmes can be assured in attaining substantial equivalency of accredited engineering programmes among the respective signatory countries. These international accords also represent transnational recognition of accreditation decisions and ascertain that graduates from accredited programmes in one country or region are recognised in another (Accreditation.org, 2021).

To equip graduates with qualifications that are recognised by both HKCAAVQ and professional bodies (e.g. HKIE, Royal Institution of Chartered Surveyors), hence being mutually recognised by EQF, overseas higher education institutes and/or professional bodies, VPET providers in Hong Kong need to go through a minimum of two separate external accreditation exercises in every cycle of validity period. This requires multiple resources, *inter alia*, human resources, financial resources, time, and repetitive involvement of various stakeholders (e.g. employers, graduates, students, institutional management, programme teams and teaching staff). To further facilitate the accreditation process, efforts to define, integrate or endorse a set of common criteria for the accreditations of HKCAAVQ and professional bodies must be intensified at the highest possible level. Corresponding organisations with the core tasks of quality assurance in higher education also need to expand their roles in developing an overarching international as well as transnational universal education standards. In this context, members of International Network of Quality Assurance Agencies in Higher Education (INQAAHE) and the European Association for Quality Assurance in Higher Education (ENQA) cooperate for concrete planning and implementation. This better informs international recognition of qualifications between international quality assurance agencies.

Education Institutions

Education institutions bring a network beyond regional boundaries and jurisdictions. Various supports and infrastructures are in place for engineering students to study and work abroad, including financial aids and system for credit transfer. International alumni network is a source of rich opportunities within specific engineering sector, which are often missed where no institutional strategy in place to tap into the network.

New technologies, demographic shifts, rapid urbanisation, resource scarcity and climate change will create new engineering processes, giving rise to millions of new jobs. At the VTC, a variety of transnational programmes are developed to facilitate local students in obtaining equal qualifications conferred by overseas universities at their subsidiary campuses in Hong Kong. Many existing qualifications (both local and transnational programmes) are also recognised by overseas professional bodies, for instance, the Royal Institution of Chartered Surveyors. Graduates of these programmes apparently meet the professional competence requirements overseas (i.e. hard skills), are able to enter global markets and articulate to international higher education institutions. Apart from hard skills, the VTC also places a premium on developing students' soft skills, including their design thinking skills, problem-solving skills, teamwork, where they can continuously adapt and acquire new knowledge (lifelong learning) and essential human skills. More importantly, these initiatives cannot be achieved without the quality enhancement culture and robust quality assurance system in VTC, which rely heavily on a vigorous Quality Policy. Such policy is driven by the Academic Disciplines, programme leaders and teaching staff, who take charge of the programme and curriculum development, not least contextualisation of international practices during learning and teaching.

Education institutions worldwide have now extended their links of collaboration beyond student exchange, to student projects, industrial attachment, transnational programmes and research. Apart from continuously enhancing the quality standard of these activities and programmes, VPET providers have to strengthen collaboration with international institutions and industries in order to identify and formulate new strategy to facilitate students' mobility, in both formal programme/module-level study and informal exchange activities. An example was at the outbreak of COVID-19, technology-enabled virtual exchange has paved the way forward to massifying mobility among students and graduates.

Students

The recognition of students as a key stakeholder of higher education first appeared in the literature in 1974 (Douglas, Mc Clelland and Davies. 1993). Nowadays, students for legitimate reasons are the most important stakeholders in the quality enhancement system. Their feedback on learning and teaching, support services and enabling resources are essential. For instance, students who completed WLA can help to identify the gap between industry needs and actual running in on-campus learning and teaching. Those who have had experience in overseas training or placement can help to identify key transversal skills that are most needed for international labour market. Apparently, students' feedback is a strong driver to programme improvements.

In the context of quality enhancement in the VTC, students' feedback is regularly collected through student feedback questionnaires at module, programme and campus level. Students are also always encouraged to share views on their international learning experiences at various formal (e.g. staff-student liaison meetings, committees and boards) and informal (e.g. seminars and workshops) occasions. In future, taking Switzerland as an example, VPET providers may consider providing training to student representatives before engaging them in the quality assurance process (Schneijderberg and Risse, 2008; Elassy, 2013). Training ensures that students understand their roles, express their insights and knowledge and bring even more valuable perspective to enhancing programme quality.

Online Programmes – Mobility for All in Future

Recognition from professional bodies, especially those from overseas, is of paramount importance to VPET. Earning overseas credentials means that students' capabilities and job readiness are sufficiently evaluated and recognised outside Hong Kong, thus facilitating employability and mobility. Blended learning, the thoughtful fusion of face-to-face campus-based and online learning experience, has been adopted by many higher education institutions to maximise students' learning motivation and effectiveness. Amid the COVID-19 pandemic, apart from blended learning, online assessment that could assess stated learning objectives/outcomes is more crucial than ever as it allows learners to demonstrate their competence and capabilities without any limitations. However, in the current education landscape, not all online programmes (i.e. those with both online learning and assessment) provide qualifications. Thus, even in the post-COVID era, structured and rigorous online learning programmes that continue to maintain standards of education and are internationally recognised will offer more opportunities for students to obtain overseas credentials without actually travelling abroad.

Starting from 2018, the HKCAAVQ has provided accreditation services for online learning programmes, which are defined as those having more than fifty percent of instruction delivered online. This allows local and non-local online learning programmes offered in Hong Kong to secure credibility of qualifications under the HKQF. In spite of the availability of such accreditation system, there is still much for VPET providers and other higher education institutions to consider as they move towards blended teaching or fully online. These considerations include requirement of professional bodies issuing industry credentials (i.e. whether online learning programmes can also be accredited), student engagement (e.g. access to technology and interaction), pedagogical strategies (e.g. to facilitate collaborative tasks and acquisition of relevant soft skills such as teamwork) and technical difficulties (e.g. digital literacy of students, functionality of software in terms of cheating and plagiarism detection).

Although it may appear that a lot of issues are attached to the development of online learning programmes, the perks of it cannot be ignored. There are always solutions to fix these difficulties. For example, the HKIE can consider combining their accreditation for online programmes with the existing system of the HKCAAVQ. Technical difficulties can be solved through training students' digital skills, integrating and applying different cheating and plagiarism detection systems in the institution's learning management system. Through addressing these considerations and focusing on ways to support learners, the transition to online programmes can be seamless for all stakeholders concerned, thereby facilitating sustainable mobility of students.

Conclusions

The rise of the knowledge society has led to fierce competition for talents worldwide. Students with skills in demand and ability to work anywhere will prosper. Through quality enhancement processes, various stakeholders of VPET can and should do much to help: enhancing quality of programmes, easing the routes to and incentivising student mobility, and increasing international recognition of qualifications. This paper outlines experiences of the VTC with its impacts on student mobility. Such experiences were created and shaped collaboratively by the Government, employers and industries, education institutions, accreditation and professional bodies, and students. This paper also calls for a keen and concerted effort among all stakeholders to maintain global competitiveness of the engineering students.

Acknowledgements

The authors are thankful to Dr Albert Cheuk, Director of the Quality Enhancement and Learning & Teaching at the VTC for sharing his pearls of wisdom during the course of their work.

References

Accreditation.org. (2021). *Mutual Recognition Agreements*. Retrieved from https://accreditation.org/accords/mutual-recognition-agreements

Chapleo, C., & Simms, C. (2010). Stakeholder analysis in higher education: A case study of the University of Portsmouth. *Perspectives, 14*(1), 12-20.

Collins, F. (2014). Globalising higher education in and through urban spaces: Higher education projects, international student mobilities and trans-local

connections in Seoul. *Asia Pacific Viewpoint, 55*(2), 242-257.

Danson, M., & Todeva, E. (2016). Government and governance of regional Triple Helix interactions. *Industry and Higher Education, 30*(1), 13-26.

Douglas, J., Mc Clelland, R. and Davies, J. (1993). The development of a conceptual module of student satisfaction with their experience in higher education. *Quality Assurance in Education*, *16*(1), 19-35.

Elassy, N. (2013). A model of student involvement in the quality assurance system at institutional level. *Quality Assurance in Education*, *21*(2), 162-198.

GPPAC (2015). *Multi-Stakeholder Process for Conflict Prevention and Peace Building: A Manual.* Retrieved from http://www.mspguide.org/sites/default/files/resource/gppac_mspmanual_interactive_version_final_jan2016_1.pdf

Gvaramadze, I. (2008). From Quality Assurance to Quality Enhancement in the European Higher Education Area. *European Journal of Education*, *43*(4), 443-455.

Hack-Polay, D., Igwe, P. A., and Okolie, U. C. (2020). Room for improvement: A study of overconfidence in numerical skills among British graduates. *Industry and Higher Education, 34*(1), 50-61.

Elassy, N. (2015). The concepts of quality, quality assurance and quality enhancement. *Quality Assurance in Education, 23*(3), 250-261.

Marić, I. (2013). Stakeholder analysis of higher education institutions. *Interdisciplinary Description of Complex Systems: INDECS, 11*(2), 217-226.

Nwajiuba, C. A., Igwe, P., Akinsola-Obatolu, A. D., Icha-Ituma, A., and Binuomote, M. O. (2020). A stakeholder approach: what can be done to improve higher education quality and graduate employability? *Industry and Higher Education*, 1-21.

Scoy, K.V. (2021). Why the demand for engineering graduates is on the rise. Retrieved from https://www.topuniversities.com/student-info/careers-advice/why-demand-engineering-graduates-rise

Joint Technical Group. (2016). *Comparability study of the Hong Kong Qualifications Framework (HKQF) and the European Qualifications Framework for lifelong learning (EQF)*. Hong Kong: Education Bureau.

Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education (2020). *White Paper on Student Mobility: A Summary*. Retrieved from https://diku.no/en/news/white-paper-on-student-mobility-a-summary

Schneijderberg, C. and Risse, M. (2008). Training of students as experts for external quality assurance – the Swiss experience. *In Trends in Quality Assurance, A Selection of Papers from the 3rd European Quality Assurance Forum, Corvinus University, Budapest* (pp. 20-22).

U.S. Bureau of Labor Statistics (2014). *What does the S&E job market look like for U.S. graduates?* Retrieved from https://nsf.gov/nsb/sei/edTool/data/workforce-03.html

UNESCO (2021). *Engineering for Sustainable Development: Delivering on the Sustainable Development Goals – UNESCO Engineering Report*. P. R. China: Central Compilation and Translation Press.

Williams, J. (2016). Quality assurance and quality enhancement: is there a relationship? *Quality in Higher Education, 22*(2), 97-102.

Zhang, Z. (2009). Education, Migration, and Cultural Capital in the Chinese Diaspora: Transnational Students between Hong Kong and Canada1. *International Education, 38*(2), 103.

On the road of Industrial Collaborative Project-Based Learning in Engineering Education at THEi: A Successful Pilot Case

K.L. Pun, Simon H.F. Wong and Roger T.H. Ng*,

Faculty of Science and Technology, Technological and Higher Education Institute of Hong Kong (THEi), Hong Kong, China

*rogerng@thei.edu.hk

Abstract

Project-based learning (PBL) is a teaching method in which students gain necessary knowledge and skills by working on a real-world project for a considerable period of time to investigate and respond to a complex problem. Adopting PBL in the tertiary education has been proved beneficial to students. In the Vocational Training Council (VTC) 3-Year Strategic Plan for 2020-2023, PBL is therefore promoted to be a major learning and teaching strategy for effective delivery of skills-based training across different disciplines. The PBL defined by the VTC has four essential elements, namely (i) student-driven, (ii) real-life, authentic and inter-disciplinary, (iii) collaborating with industry, and (iv) integrating with the quality assurance system.

THEi as a member institute of the VTC, which is committed to nurturing talents for today's society by offering vocationally-oriented and tailor-made degree programmes developed with a strong linkage with the industry, follows the direction of the VTC on adopting industrial collaborative PBL in our teaching strategy. This paper presents a successful pilot case of adopting PBL, in close collaboration with the industry, in the Final Year Project module of the THEi's Bachelor of Engineering (Hons) in Building Services Engineering (BEng-BSE). In 2019, a BEng-BSE student effectively solved a real-world problem using his knowledge and skills learnt in the study at THEi with the full support from the government and a private BSE company. It is worth mentioning that the paper arisen from this collaborative project had obtained the Hong Kong Institution of Engineers (HKIE) Outstanding Paper Award for Young Engineers/Researchers 2020.

In light of the successive adoption of industrial collaborative PBL in BEng-BSE, the curricula of the engineering programmes of THEi will be enriched in the near future as PBL enables students to develop the key competencies in Vocational and Professional Education and Training (VPET) in the 21st century.

Keywords: *building services engineering, engineering education, industrial collaboration, project-based learning, vocational and professional education and training*

Introduction

Project-based learning (PBL) is a teaching method in which students gain knowledge and skills by engaging in a cumulative activity for a continued period of time to investigate and solve problems leading to a final practical outcome (BIE, 2014). Over the decade, PBL has been widely used in kindergartens, primary schools, secondary schools, as well as in the tertiary education, particularly the sector of engineering education, across the world (Ruikar and Demian, 2013; Fernandes et al., 2014). PBL provides students with valuable learning experience to integrate classroom knowledge and the various skills, e.g. critical thinking, problem solving, collaboration and self-management skills, which are essentially required in the real world. With so much evidence indicating that PBL can effectively bring lots of benefits to students' learning, the VTC highlights in its 3-Year Strategic Plan for 2020-2023 the direction of applying industrial collaborative PBL in the teaching approach. THEi is a member of the VTC and thus strictly follows the instruction. Starting from AY2018/19, BEng-BSE of THEi has adopted industrial collaborative PBL in the delivery of the Final Year Project module. A research paper arisen from a final year student's project which was collaborated with the government and a private BSE firm using PBL obtained the HKIE Outstanding Paper Award for Young Engineers/Researchers 2020. The experience gained in this successful pilot case of adopting industrial collaborative PBL in BEng-BSE of THEi is shared in this paper.

Background

Being the largest vocational and professional education and training (VPET) provider in Hong Kong, the Vocational Training Council (VTC) is committed to providing a valued choice to school leavers and working adults of the city to acquire values, knowledge and skills for lifelong learning and enhanced employability, as well as providing constant support to the industries for their human resources development. In response to the rapidly growing demand of professionals who are equipped with tertiary education for continuously supporting the long-term development of Hong Kong, THEi was established

in 2012 by VTC to offer vocationally and professionally-oriented degree programmes for nurturing local talents of different industries. With the significant industry inputs, up to now, a total of 22 tailor-made degree programmes have been launched at THEi. All the programmes provide students with meaningful industry attachments in local firms for them to gain first-hand experience of working in the real world.

Launched in 2015, this 4-year BEng-BSE programme aims to develop students to be highly skillful in designing the building services systems and be problem-solvers to meet the ever-changing challenges in the industry. It also aims to equip students with the essential knowledge and skills of BSE technologies, with an emphasis on using "projects" as the main assessment method to reflect the actual industry practice. BEng-BSE is fully accredited by the HKIE, recognised by the UK's Chartered Institution of Building Services Engineers (CIBSE), and recognised by the Electrical and Mechanical Department (EMSD) of the HKSAR Government as satisfying the academic qualification requirements for the purpose of registration as Grade C electrical worker. Figure 1 shows the block diagram of the programme structure and curriculum.

Figure 1: Block diagram of THEi BEng-BSE programme structure and curriculum

Different from the typical degree programmes offered by other local universities or institutes, the BEng-BSE of THEi uniquely offers a non-credit bearing module named "Industrial Attachment" for every Year 3 student during the summer break. It is a work-integrated learning module which aims to provide students with the chance to gain professional experience and apply theories to real-life situations. It also aims to inspire students to analyse and provide constructive critique on industrial practice, and facilitate the execution of the Final Year Project in the students' last year of study. Currently, BEng-BSE has over 80 industrial partners which provide every student with an at least 480-hour work placement opportunity.

Besides, the BEng-BSE of THEi also offers a module called Final Year Project (Applied Research Project) in the students' last year of study, which is a module for evaluating the effectiveness of the learning outcomes of the programme. This module enables students to develop critical thinking skills and problem-solving skills through doing applied research projects, encourages students to carry out critical investigation, analysis and synthesis in the professional context and the integration of knowledge and skills learnt, and promotes students' creativity and ability to generate new ideas. This module also aims to inspire students to keep abreast of developments in the relevant profession and pursue independent and life-long learning.

In line with the VTC 3-Year Strategic Plan for 2020-2023 on the adoption of PBL in the teaching approach, starting from AY2018/19, BEng-BSE has extended the industrial connection built up in the module of Industrial Attachment to the module of Final Year Project (Applied Research Project).

Project-Based Learning (PBL)

Project-based learning (PBL) is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to a complex question, problem, or challenge (BIE, 2014). There are many benefits of implementing PBL in teaching. For example, students can usually engage with the PBL projects actively that provide real-life relevance for learning. The skills that they learnt via PBL can solve problems that are crucial to them and their communities. PBL in nature leads to deeper understanding and greater retention of content knowledge which facilitates students to apply what they have learnt in new situations. Besides, PBL allows to integrate real-life problems with content knowledge and applied skills that can engage students in sustained and collaborative real-life investigations. It is known that a successful project can be transformative for students. PBL enables students to experience the impact of a real-life project that can in turn give them a sense of purpose. How to take initiative, work responsibly, solve problems, collaborate in teams and communicate ideas are all the skills valuable in today's workplace and in life. Last but not least, PBL can help students to develop these skills that every employer is looking for (VTC, 2020).

Currently, PBL is being widely adopted in different education levels, from kindergartens to primary schools, to secondary schools and to the higher education sector. Despite its popularity, the rapid upsurge of interest in PBL that possibly leads to a wide variation in the quality of project design has arisen the concern of some scholars.

In order for teachers to ensure that PBL is done well, BIE (2020) established a comprehensive, research-based model for PBL, called "gold standard", to help the teachers to measure, calibrate and improve their practice. Having acquired the knowledge and understanding and success skills through PBL for achieving the students' learning goals, seven essential project design elements were included in the gold standard, namely "challenging problem/question", "sustained inquiry", "authenticity", "student voice and choice", "reflection", "critique and revision" and "public product". The VTC also defines PBL of its version which contains four basic elements, namely (i) student-driven, (ii) real-life, authentic and inter-disciplinary, (iii) collaborating with industry, and (iv) integrating with the quality assurance system. Besides, for engaging students in PBL, the VTC provides teachers with seven tips (VTC, 2016) where their main concepts are extracted in the below paragraphs.

1. Entry Event

Student's interest in learning can usually be aroused by launching a project with an "entry event", which can be a video, a seminar, a lively discussion, a field trip or a piece of correspondence that forms a scenario, in order to inspire students to realize why they need to acquire the learning content and practice skills for them to perceive the task as personally meaningful that they want to do it well. An entry event enhances students' motivation and initiates questioning.

2. Driving Question

A driving question is the heart of the project; a good driving question can give students a sense of purpose and challenge. It can be an abstract question that ties the learning outcomes to an open-ended question of the appropriate difficulty level, challenging students' minds whilst not intimidating them.

3. Student Voice and Choice

The more student voice and choice are allowed; the higher learning engagement can usually be obtained from the students. Allowing students to have a say in a project can create a sense of ownership among them. Students would therefore feel more committed to the project and are willing to work harder. A number of options can be provided for students to select how to solve the problem. They can also exercise their judgment in deciding the project's topic, writing a driving question, dividing work among the team members and employing resources to work out a feasible solution to the problem.

4. 21st Century Skills

PBL can equip students with problem-solving skills, critical thinking skills and collaboration skills, which are commonly known as the "21st century skills". While responding to the driving question, students need to apply higher-order thinking skills for analysing the real-world situation, proposing solutions and expressing their views in both written and oral forms. While working on the project in a team, students need to find ways to communicate and collaborate well with the team members. Meanwhile, teachers can provide guidelines to help students review their own progress, and encourage them to take immediate actions for improvement and reflect on their critical thinking and problem-solving skills. These records enable students to explain how the project was designed and implemented to the public.

5. Inquiry and Innovation

In order to respond to the driving question, students are required to ask questions, allocate resources, discover answers, and then ask more and deeper questions. This process repeats itself until a satisfactory answer comes into sight. The idea will then be tested before arriving at a conclusion. The active and in-depth process of inquiry marks the birth of a new answer to the driving question or an innovative solution to a problem.

6. Feedback and Revision

Through continuous feedback and revision, work of high quality can usually be attained. Students can seek teachers' direct feedback and ask peers for constructive comments with reference to the rubrics. They can also invite trade experts to provide critique from an authentic, real-world point of view on the project work. Constant revision can then be made to refine the idea if necessary.

7. Product Presentation

Presenting an idea publicly would definitely raise the students' motivation to improve the quality of the project work. When students are asked to present or display their work to the public audience, they tend to strive for better performance.

Towards PBL

In the VTC 3-Year Strategic Plan for 2020-2023, PBL is promoted to be one of the major learning and teaching strategies for effectively delivering skills-based training across different disciplines. Since the PBL defined by the VTC stresses the importance of industrial collaboration, since AY2018/19, BEng-BSE has adopted PBL in the module of Final Year Project (Applied Research Project) with industrial collaboration. The following paragraphs describe the steps that were taken by the programme team in delivering the module using industrial collaborative PBL based on a successful pilot case.

Step 1: Engage an industry partner and generate project idea together

Before the commencement of the Final Year Project (Applied Research Project) module, the programme team

sought opportunities from the over 80 BSE firms, which have long and good partnering relationship with BEng-BSE in the Industrial Attachment module, for providing real-life projects that could involve the BEng-BSE final year students to work on as their final year projects. One of the BEng-BSE industry partners established by an alliance of building services engineers, environmental professionals, energy management specialists positively replied the programme team that they wished to work on a real-world project with a BEng-BSE final year student.

A conventional double parabolic reflector is generally made of aluminum that provides high specular reflection but low diffuse reflection. This physical property would cause uneven light distribution on the surfaces lit up by the aluminum reflector, and thus reduce the efficiency of light reflection. In 2018, the industry partner invented a new nanotechnology optical reflective coating which has been proved in laboratory that it has the ability to enhance the wide angle reflection and therefore provide a better performance of diffuse reflection of the incident light. The company wondered if the lighting energy efficiency and lighting quality could be improved after putting the nano optical coating onto the reflector surfaces of the luminaires. This idea was fully supported by the EMSD of the Hong Kong Government such that they allowed the company to verify this proposition in an office of the Siu Ho Wan Government Maintenance Debut office.

As THEi BEng-BSE final year students completed a core module called Lighting Technology and were well equipped with the essential knowledge and skills of light measurement in indoor spaces, they wished to have pilot collaboration with BEng-BSE and provide a student with a real-world project, i.e. to measure the lighting energy efficiency and lighting quality in the EMSD office using luminaires with traditional aluminum coating and with nano optical coating respectively. This was also the scope of work of the student's final year project. The industry partner had a team of 4 coming from different professions including a building services engineer, an environmental specialist, an energy management expert and a research manager. They were engaged in different checkpoints of the project to promote authenticity. It was needed for the student to discuss with and report to the team the progress of the project regularly.

Step 2: Consider project timing and duration

The industry partner planned to start their project on 1 November 2018 and end it on 13 March 2019, lasting for 14 weeks or one semester-time, which was in perfect alignment with the normal duration of the module of Final Year Project (Applied Research Project) as stated in the syllabus and long enough to engage the student in solving this real-life problem.

Step 3: Consider project complexity and scope

The programme team discussed the complexity and scope of the project with the industry partner before the kick-off. It was agreed that the scope of work would be lighting-related and thus BSE-related. As the student had completed the module of Lighting Technology, he could make good use of his learnt knowledge and skills in the measurements of illuminance level and lighting energy consumption; however, there would still be challenges for the student in measuring discomfort glare caused by the luminaires. The student was also required to conduct statistical analysis based on the measured data and apply the knowledge and skills he had learnt in another BEng-BSE module called Numerical Methods of Analysis. The flow chart of the industral collaborative PBL project is shown in Figure 2.

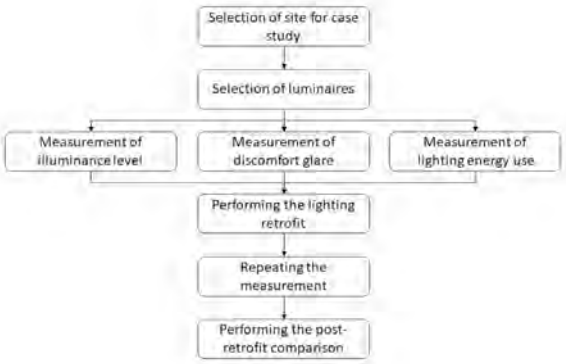


Figure 2: Developing procedures of the project

Step 4: Set Learning Outcomes

Since this industrial collaborative PBL project was attached to the module of Final Year Project (Applied Research Project), the learning outcomes of the project were identical to those stated in the module syllabus, such that on completion of the project, the student is expected to be able to:

- critically analyse literature and research information relevant to the project theme;
- formulate a structured research methodology for the applied research and inquiry into the project;
- conduct investigations and generate ideas for the project work through integration of fundamental and specialised knowledge in wide domains;
- manage the applied research project and formulate solutions for investigative work with consideration of the related issues, professional engineering practices, ethics, and the need for sustainable development;
- command professional standards in documentation/ organization of information, and present deliverables in a professional manner; and
- reflect on commitment to engineering profession and the needs for life-long learning.

The 21st century skills, e.g. critical thinking, problem solving, communication, creativity, collaboration, self-management, as well as global and culture awareness, were all taken into consideration in the rubrics.

Step 5: Define final product

The student should write a comprehensive report and give an oral presentation on all the details of the project delivered using PBL for his Final Year Project. Both the industry partner and the EMSD would review and make comments and recommendations on his written report. It was expected that the results on whether the nano optical coating could have positive impact on lighting energy efficiency and lighting quality would be revealed in the written report and presentation. Sufficient assessments were provided to prove that the student had achieved the module learning outcomes.

Step 6: Align with PBL Gold Standard

To arouse the student's interest in learning from this industrial collaborative PBL project, an "entry event" in form of group discussion among the project supervisor, the team from the industry partner and the student was launched. The discussion was about the significance of improving building energy efficiency, the contemporary common methods of reducing lighting energy use and the measurement methods of lighting quality.

There is a rising call from the society for improving building energy efficiency and enhancing indoor lighting quality. Some guidelines such as LEED in the US and BEAM in Hong Kong stress the reduction of lighting energy consumption in buildings by limiting lighting power density (LPD) with lighting controls while others such as WELL Standard specify requirements of indoor lighting quality on illuminance level and discomfort glare control for a healthy indoor environment. Technology for improving lighting energy efficiency but simultaneously does not yield visual discomfort or sacrifice the lighting quality is in great demand,.

Currently, lighting energy efficiency enhancement is usually achieved by the technological advancement in the lamps of the luminaires, i.e. replacing the incandescent or fluorescent lamps with LEDs. While the increasing use of lamps with a higher efficacy has lowered the LPD of the indoor lit spaces effectively, the maximum allowable LPD in offices in multiple energy efficiency guidelines has been further lowered by over 10% in the last decade, e.g. EMSD Code of Practice for Energy Efficiency of Building Services Installations. Regarding the lighting quality enhancement, it usually involves the continuous maintenance of sufficient and uniform illuminance level on the task area and the avoidance of visual discomfort glare within the field of view (CIBSE, 2012).

The student was asked to explore the possibilities and hinted that both lighting energy efficiency and lighting quality could be enhanced simultaneously by using new materials on the lighting reflectors during the discussion. This entry event was used to let the student understand why he needed to conduct the project and propose a good "driving question" – how can we verify using luminaires with nano optical coating has positive impact on lighting energy efficiency and lighting quality?

Since this driving question was raised by the student himself, it created a sense of ownership and engagement inside him. The student reflected on knowledge and skills that he had previously studied in the module of Lighting Technology into his proposal. With critical thoughts, he made sustained inquiries to the teacher and the team of the company on his concerns of the project, such as the scope of work, the timeframe, the resources allocation and the development process. The teacher and the team provided a list of options for him to answer his questions. The student drafted a schedule with milestones and suggested the methodologies for the measurements of lighting energy efficiency and lighting quality in the office. "Student voice and choice" were listened and respected and his proposal established the authenticity.

In this industrial collaborative project using PBL, the student had to deal with a real-life question of evaluating the impact of the luminaires with nano optical coating on the lighting energy efficiency and the lighting quality in an actual office together with the various specialists and engineers of the BEng-BSE industry partner. The process involved problem-solving skills, critical thinking skills and collaboration skills. All of them belong to the "21st century skills". The process was weekly reviewed by the teacher as well as the team of the company based on the intended learning outcomes and assessment rubrics of the Final Year Project (Applied Research Project) module and the internal guidelines of the company. The student would record all the comments from the different parties and take follow-up actions. He also jotted the key issues down for explaining the design and implementation of the project for his written report and oral presentation at the end of the module.

The student originally proposed to divide the entire measurements into two parts: (i) pre-retrofit, i.e. before the use of luminaires with nano optical coating, and (ii) post-retrofit, i.e. after the use of luminaires with nano optical coating. He selected to quantify the performance of the lighting energy consumption by two metrics: (i) daily energy consumption using a clamp-on electricity meter at the sub-circuit board of the lighting installations, and (ii) the LPD by dividing the total circuit wattage of the fixed lighting installations by the internal floor area of the office. His proposal was discussed and accepted by the teacher and the team of the company. He analysed the data obtained during the pre-retrofit and post-retrofit. As for the lighting quality, the student decided to measure illuminance and uniformity at the workplane level of 0.8 m above the ground as recommended in CIBSE (2012) at 27 locations of the office using a calibrated illuminance meter. The student determined the measurement points in a rather systematic manner. He divided the office into 59 squares based on the false ceiling grid arrangement, and every centre point of four ceiling grids was chosen as the measurement points resulting in 27 measurement points.

Visual discomfort glare due to the luminaires is also important in evaluating the indoor lighting quality. Glare is the sensation induced by bright areas in a person's view and too much glare may cause visual discomfort to the

occupants. Discomfort glare is commonly quantified by Unified Glare Rating (UGR) (CIBSE, 2012):

$$\mathrm{UGR} = 8 \log \left(\frac{0.25}{L_b} \sum \frac{L_s^2 \omega}{p^2} \right)$$

where L_b is the background luminance (cd/m^2) and L_s is the luminance of the luminous parts of each luminaire in the direction of the observer's eyes (cd/m^2). The smaller the UGR value, the less is the degree of discomfort glare.

As one of the lighting quality parameters, the student concerned the impact on the degree of discomfort glare caused by the luminaires after nano optical coating was used on the reflector. He raised an "inquiry" in a weekly meeting to the teacher and the team of the company, "To estimate the degree of discomfort glare of an indoor space using the UGR equation, there are two common methods: (i) to apply computer software to simulate the discomfort glare level in the lit environment, but then the simulation may deviate from the real environment, or (ii) to measure the background luminance and the luminaire luminance physically using a calibrated luminance meter; however, this conventional method is a time-consuming point-by-point measurement, prone to random errors and suffers from some inevitable assumptions. It sounds that neither method is the best. Which method is more preferable to be adopted in this project?" In response to this student's deeper question, the teacher recommended the student to study the novel technique of high dynamic range (HDR) photography (Jacobs, 2007) for obtaining luminance of each pixel across the visual field and learn to master this technique for doing the measurement of discomfort glare. The student did a literature review on the application of HDR photography for evaluating discomfort glare due to the indoor electric lighting. He also did some trial tests to validate the reliability and accuracy of this technique in obtaining luminance. With the confidence in applying the HDR photography in the discomfort glare measurement, the student proposed this alternative solution to the team of the company as well as to the EMSD. The details of the measurement processes and results were recorded in Cheng et al. (2020).

The student commented on the measurement results that after using the luminaires with nano optical coating, both the daily lighting energy consumption and the LPD of course remained unchanged, but the illuminance level and uniformity on the task area increased and the UGR value slightly decreased despite yet above the standard value. The results were given to the industrial partner as well as the EMSD for comments. Some "feedback" was received. The student was asked what the impact on the lighting energy efficiency and lighting quality would be if one of the lamps was taken off after the luminaires were painted with nano optical coating. The student conducted further measurements accordingly and made a "revision" in his report so that the daily lighting energy consumption and the LPD reduced, the illuminance on the task area decreased but the uniformity increased. As for the UGR, it further decreased, now within the standard.

A paper prepared by the industry partner based on the student's Final Year Project report and arisen from this industrial collaborative PBL project was "published" in the HKIE Transactions (Cheng et al., 2020) and had obtained the HKIE Outstanding Paper Award for Young Engineers/Researchers 2020.

Conclusion

This paper shares the experience of a successful pilot case of adopting PBL, in collaboration with the industry, in BEng-BSE at THEi. How the industry was engaged for implementing PBL was discussed. The delivery method of this industrial collaborative student's final year project using PBL was also introduced. In light of the successful adoption of PBL with industrial collaboration in BEng-BSE, the curricula of the engineering programmes of THEi will be enriched in the near future such that PBL could enable students to develop the key competencies in VPET in the 21st century.

References

BIE (2014). What is project based learning (PBL)? Retrieved from http://bie.org/about/what_pbl

BIE (2020). Gold Standard PBL: Essential Project Design Elements. Retrieved from https://www.pblworks.org/blog/gold-standard-pbl-essential-project-design-elements

Cheng, J.Y.C., Wong, N.C.Y, Ho, T.W.L., Kwong, H.F., Ng, R.T.H. & Cheung H. (2020). A case study of lighting retrofit to improve building energy efficiency and lighting quality by using luminaires with nano optical coating. *HKIE Transactions*, 27(4), 156-165.

CIBSE (2012). *Code for lighting*. London: Chartered Institution of Building Services Engineers.

Fernandes, S., Mesquita, D., Flores, M.A. & Lima, R.M. (2014). Engaging students in learning: Findings from a study of project-led education. *European Journal of Engineering Education*, 39, 55-67.

Jacobs, A. (2007). High dynamic range imaging and its application in building research. *Advances in Building Energy Research*, 1(1), 177-202.

Ruikar, K., & Demian, P. (2013). Podcasting to engage industry in project-based learning. *International Journal of Engineering Educatio*n, 29, 1410-1419.

VTC (2016). *Seven tips for successful project-based learning (PBL)*. Hong Kong: Centre for Learning and Teaching, Vocational Training Council.

VTC (2020). *Handbook on conducting project-based learning*. Hong Kong: Quality Assurance and Accreditation Office, Vocational Training Council.

STUDY PATH MODEL FOR IMMIGRANT ENGINEERS

A. Hartikainen[*,a], M. Tauriainen[b,] a, M. Kivimäki[c], P. Paukkala[c], T. Hirard [b] and H. Kamppari[a]

[a] University of Turku, Turku, Finland
[b] Turku University of Applied Sciences, Turku, Finland
[c] Tampere University of Applied Sciences

*anita.hartikainen@utu.fi

Abstract

Many immigrants in Finland struggle to find employment that corresponds to their level of education. The reasons can be the lack of networks, insufficient Finnish language skills or the content of their degree. At the same time, Finnish employers have a constant need for experts in different fields of technology and engineering. In the Become an engineer in Finland project a new study path model is designed for highly educated immigrants who have completed a degree in engineering abroad, need to supplement their qualifications, and develop their professional Finnish language skills to find employment in their own field. The project identifies the existing competencies of the participants and strengthens their working life skills. The project implemented two pilot trainings, a preparatory training, and a diploma of higher education. The study path is designed based on experiences and feedback collected from the students and teachers. The model allows quick access to working life without completing a new degree. The study path model can also be applied in other higher education institutions, as well as in other fields of study.

Keywords: *engineering, education, higher education, immigrants, qualifications*

Introduction

Many immigrants have already completed a university degree before coming to Finland. However, finding employment and utilizing skills is often difficult. International experts struggle to find employment that corresponds to their level of education. The reasons can be the lack of networks, insufficient Finnish language skills or the content of their degree. (Busk, Jauhiainen, Kekäläinen, Nivalainen & Tähtinen, 2016). At the same time, Finnish employers have a constant need for experts in different fields of technology and engineering (Hellgren & Marjanen, 2017). These challenges are being tackled by Turku University of Applied Sciences, Tampere University of Applied Sciences and Brahea Centre at the University of Turku in the Become an engineer in Finland project, funded by the European Social Fund. This project began in September 2019 and will be completed in December 2021.

Compared to original population, not least due to language barriers, it has become evident that immigrants often have difficulties in finding a job corresponding to their abilities and possibly their own, earlier acquired training or education. It is difficult for the target group to network in Finland and supporting the formation of networks is not self-evident in universities. Also, employers do not know how to contact professionals with an immigrant background (Busk, Jauhiainen, Kekäläinen, Nivalainen & Tähtinen, 2016). In addition, compared to applicants with a Finnish background, there are only few selected applicants with an immigrant background in the degree programmes.

Many of the higher educated with an immigrant background apply for a new university degree, or other training in Finland. In the project, the partners design a new study path model for immigrant engineers who have completed a higher education degree in engineering abroad, are required to supplement their qualifications, and would like to develop their professional Finnish language skills to find employment in their own field. The aim of the project was to identify the current qualifications of the participants and to obtain information on the current working life skills of immigrant engineers, as well as to design precise training and guidance to strengthen these skills. This avoids years of extra studies and allows a quick entry into working life.

In addition to designing the study path, the project consists of pilot modules in which a group of immigrant engineers participates in preparatory studies and a diploma of higher education. During their studies in the pilot modules, the students increase their knowledge in the Finnish working life, strengthen their mathematics, Finnish and English language proficiency, and significantly increase their prospects for employment.

The progress of the pilot group is monitored, and the effectiveness of the measures is assessed throughout the project. With the experience from the pilot modules, the project group develops a study path, which supports the recognition of immigrants' expertise and accelerates their access to employment. This study path model can also be applied in other higher education institutions, as well as in other fields of study.

This paper focuses on describing the implementation of study modules, and the study path model, created by students' and teachers' experiences and feedback.

New path to Finnish working life for graduates with an immigrant background

The new study path model consists of a) preparatory training, b) diploma in higher education studies and c) practical training (part of higher education diploma studies). The education is for immigrants with a foreign technical degree, for example engineers and other higher education graduates who have not yet found a clear path to the Finnish working life. All the applicants had to possess a technical background, such as mechanical engineering, information communication technology, construction engineering, or similar.

The pilot module planning started in the beginning of the project. The curricula had to be developed quickly, as the call for applications was opened already in October 2019, only one month after the project began. In the preparatory studies the results of another project, Getting ready – A higher education preparatory program for immigrants (Stenberg, Hirard, Autero & Korpela, 2019), which aims to develop the national recommendations for online training courses for immigrants who wish to apply to study in higher education institutions, could be utilized and further developed for engineering education.

Support services are offered to the students during the studies. The support services included training in applying for employment, student counselling on different paths to higher education studies, and information on Finnish language certificates. Personal study plans were also designed together with a teacher, who is a professional in the field of engineering.

Preparatory training

The first pilot training implemented in the project was preparatory training. The studies consisted of four courses: Study skills (5 ECTS), Finnish for engineers (15 ECTS), Mathematics for engineers (5 ECTS) and English language (5 ECTS).

Eleven students were enrolled for the training. They had a background in various engineering fields such as ICT engineering, mechanical engineering, energy and environmental engineering, and civil engineering. The participants had to have independent user level B1 in the Finnish language in The Common European Framework of Reference i.e., CEFR (Council of Europe, 2001). The aim of the preparatory training was that the students would increase their skills to level B2 for that they have sufficient proficiency in the Finnish language when they participate in the diploma of higher education studies. In functional language learning (Dufva, Suni, Aro & Salo, 2011; Lantolf, 2011), the focus was on learning the language in real language situations and success in communication (Hofstede, 2005; Hofstede, 1993). Finnish language skills are extremely important in finding employment in Finland. Although there are companies where the working language is English, it is easier to find employment, and integrate into Finnish working life and society, when the applicant has an adequate level of language proficiency. (Juusola, Nori, Lyytinen, Kohtamäki & Kivistö, 2021; Eronen et al., 2014)

Since all the training within the preparatory training module were conducted in the Finnish language, the applicants were submitted to participate in a Finnish language test. The preparatory training entrance examination was implemented in accordance with the recommendation on admission criteria for universities of applied sciences 2020 (Studyinfo, 2021), with a written part and, as an oral part, a group discussion. The language test was conducted entirely by Finnish language professionals. The purpose of this is to ensure that the chosen immigrants would possess sufficient Finnish language skills (B1 minimum). According to the recommendation on admission criteria for universities of applied sciences, proficiency level B1 in Finnish and eligibility for higher education were considered to affect the student selection.

The first part of the training pipeline was preparatory training. During the preparatory training the participants receive sufficient training in the Finnish language for the following engineering studies implemented in Finnish, and improve their vocational and technical vocabulary. Additionally, the participants need to rehearse their basic mathematical skills, which together with the enhanced Finnish and English language proficiencies are both needed later during the actual diploma of higher education studies. Conjointly, as the students participate in the preparatory training, they come to enhance their overall learning skills, which makes for a lifelong asset for them.

After the preparatory training is accomplished, for some of the students the preparatory training has acted simply as a path for acquiring improved Finnish language skills, after which they continue their endeavours on getting a job on their own. Some of the students may carry on independently and apply in a nationwide entrance examination to continue their actual engineering studies, as all those born in Finland would do.

If the student is interested in developing their skills further, they also have an option to apply for the diploma in higher education study module, which will be rewarded with a university of applied sciences diploma. The idea behind the diploma in higher education studies is to verify any technical training or education that is acquired abroad, and would be updated and complemented to correspond to Finnish engineering education.

The preparatory studies were the first part of the pilots and completed in one study term in spring 2020. The studies consisted of Finnish and English language and engineering mathematics courses, as well as an introduction course to Finnish university studies. The whole module was implemented virtually as distance learning, except for the orientation day in the beginning of the studies.

Diploma of higher education

In the second pilot module, the diploma of higher education studies, which was completed in one academic year, the immigrant engineers followed an individual study plan, which enabled them to complement their expertise in areas where they had gaps or needs to update their qualifications. This module was implemented both as virtual and contact studies, depending on their choice of courses.

The planning of the second pilot began in the spring term 2021, and the diploma of higher education was chosen as the best option for the implementation. The Diploma of Higher Education consists of 60 ECTS university-level studies building competencies needed by customers and work communities to develop their operations. There was a separate call for applications for the diploma of higher education pilot. Seven students were chosen according to the language skills and previous education. From the seven students, five participated in the preparatory studies, one has participated in preparatory studies for a while, and one student was new.

The training programme started in August 2020 with a common online orientation. The students chose their studies according to their personal curricula in their study field. There was a common online platform, and teacher tutor for the whole group, and in the beginning of the studies also a student tutor.

To be granted access to the diploma of higher education pilot, a participant must (again) demonstrate a sufficient level of language proficiency (at least B1, in the preparatory training requirement). As described earlier, the language proficiency level of applicants was tested in a face-to-face engineer working life related, simulated discussion. This time, the entire language test was conducted by Finnish language professionals and engineering studies professional.

Once language capability has been proven, the first step on the diploma of higher education studies was that a personal study plan will be composed for each student with the tutor teacher based on their strengths and preferences. The personal study plan enables an individual, more value-adding study path for each participant. The objective of the second pilot training was to improve the proficiency related to the industrial, technological and other engineering area, and to strengthen both working life skills and vocational competence in the Finnish language.

The study plan and its coherence with the student's ambitions has tremendous importance personally for the student, which is why it was shaped between the student and a lecturer with technical insights from the same field that the student has earlier knowledge from. The professionals of the project team made a general curriculum, which allowed the students to make their personal study plans. During the process they were guided by teachers from their own field of study.

Once the study plan was perfected, the students had been appointed a tutor teacher, who is meant to guide the student in any situation during the diploma of higher education studies. Such occasions may cover for instance specific questions relating professional studies or getting an internship place in a company in an appropriate technical field. In the beginning of the studies there were also a student tutors for peer support and to provide guidance in study-related issues.

Practical training

Probably the most important part of the second educational pilot was the practical training period in and during the last quarter of this module.

Since the practical training is meant to take place in an enterprise related to the student's professional field, and since the student is obliged to individually acquire the training place, the students were prepared for the applying during the diploma of higher education studies. The preparation may cover subjects such as how to update the curriculum vitae to comply with what it is usually accustomed to be like in Finland, successful ways of contacting the company and how one should represent and pitch oneself to the target company.

The scope of internship is 10–15 ECTS. Students will complete internship in the summer of 2021. The study rights for the diploma of higher education will last until the end of August 2021.

Results

Once the diploma of higher education studies has successfully surpassed, study credits cover the planned 60 study credits' worth and the practical training has been completed, the student will receive the diploma of higher education. It is in the form of a study register, summarizing the surpassed study contents.

At the end of the preparatory part of the pilot, the students were asked to give feedback on the programme by a survey and there were also feedback interviews in December 2020. Five students responded to the survey and four of them were interviewed. The students found the studies well organised, and the atmosphere in the preparatory studies to be good. Their language skills improved. All respondents were not sure if the preparatory training had increased their possibilities for employment. Their professional skills had developed moderately. It seems that the improvement of language skills increases students' professional self-confidence.

Students mostly had positive experiences with preparatory training, and they felt they benefited from it in different ways. Extensive exercises in writing and reading as a part of the Finnish language training, especially those related to the profession, were considered necessary for later studies, and their completion gave self-confidence and confidence in their own skills. The strengthening of language skills and a

sense of competence was reflected, for example, in the good grades of university studies.

Some of the students had excellent English language skills, so they did not participate in the English language teaching at all in the preparatory training. Others would have more English lessons. In the diploma of higher education studies, some of the courses are conducted in English, and the development of language skills has been useful in completing them. At the same time, perceptions of the level of English language proficiency required in higher education and students' own development needs have become clearer. Also, the mathematics studies felt beneficial. For some students, using Excel and utilizing it in various learning tasks were new things.

Online training taught a lot about e-learning and higher education compared to the students' previous experiences. In the preparatory training the participants learned to use the same digital tools that were also used in the diploma of higher education studies. Especially online meetings and collaboration with others became familiar.

The preparatory training developed teamwork skills. Studying together supported everyone's learning. Students were motivated to perform better when they got to know the outputs of other students and saw the competence of others and its development. It was ideal to study in a small group where all students have the same level of language skills.

Feedback from the diploma of higher education students will be collected in May 2021. Due to prior information from a previous interview collected in December 2020, one of the challenges with the diploma studies has been that the university diploma is not yet widely in used in higher education institutions nor generally familiar to the personnel. Students have often had to explain to the teacher at the beginning of the course why they are on the course and what is their right to study. Some felt that they had not been adequately considered by teachers, and there was a lot of independent work, while others felt that they were in the same position as degree students.

The coronavirus pandemic and distance learning have made it difficult to get to know teachers and students in the same field. Peer support and sense of community remained low. In addition, getting answers to questions sent by teachers via email can sometimes take quite a long time, which has increased students' sense of insecurity.

The students had the experience that the benefits of a previous degree completed abroad are low in Finland, and as such it does not help in finding employment in a profession corresponding to education. Therefore, they considered completing a diploma of higher education as a good opportunity to update and supplement their own skills. The students thought that completing the diploma would open opportunities for employment either directly during the training, after it or through completing a Finnish degree.

During the training, the students had begun to believe that employment in their own field in Finland was possible, even though it had previously seemed distant, and some had already given up. Students are constantly and actively looking for a job.

If the door to employment does not open even after graduate education, students saw the possibility of applying for a degree and thereby strengthening their skills and employment opportunities as another option.
Figure 1 describes study path options for engineers who graduated abroad. The path described in the paper leads the student through preparatory training to diploma of higher education studies and then either directly to working life or to complete the entire engineering degree. Path studies and separate application for engineering degree programs are options for applying for degree studies, in addition to the general joint application.

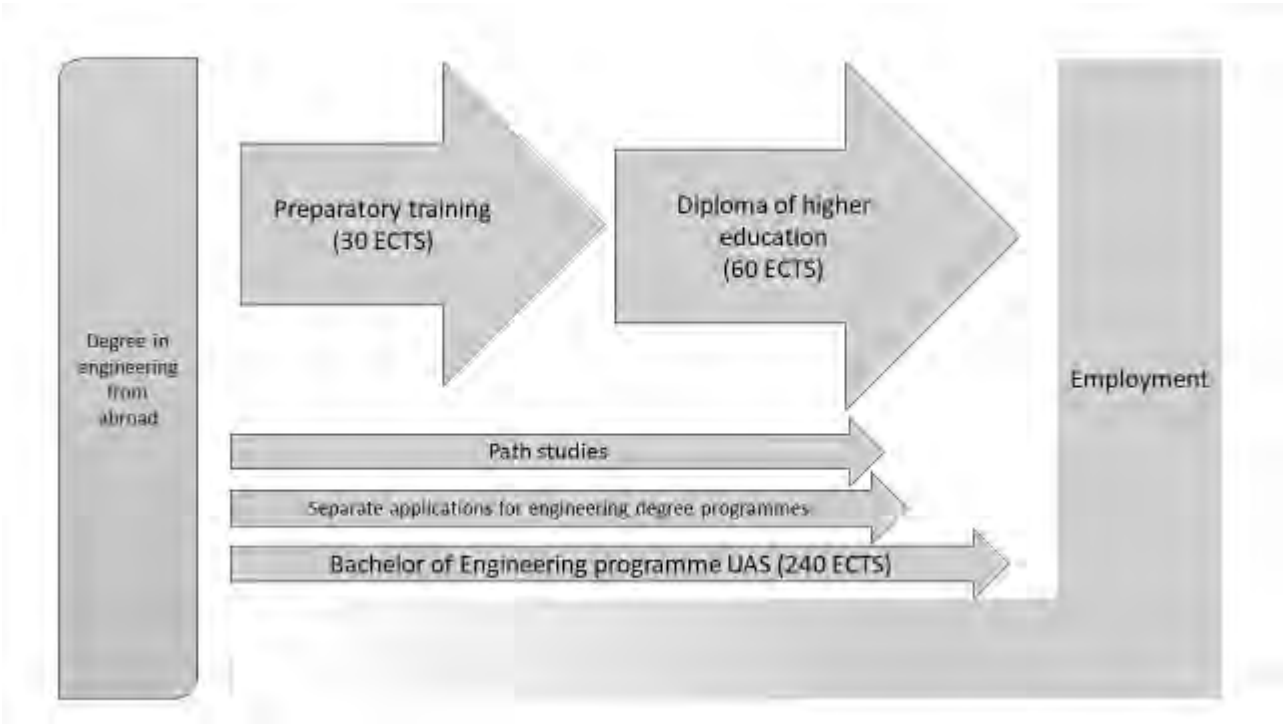


Figure 1. Study path model for immigrant engineers to achieve qualification and personal study paths in Finnish Universities of Applied Sciences.

Discussions

Immigrants want to integrate into the Finnish working life. They however need targeted competence for working life needs and often additional Finnish language studies (Juusola et al., 2021). A new study path works as a bridge to the Finnish working life and society.

Some immigrants may have worked as engineers or otherwise being employed on a technical field of their expertise in their home countries for a long time and thus it is important to use their work contribution in Finland. It is also economically wise to capitalize on the value-added knowledge of the immigrants and not let e.g., prejudice or language barriers to hinder this.

The experiences of the students show that the preparatory education has supported their progress to graduate studies and their success in these studies. A diploma of higher education benefits students not only by developing skills and strengthening self-confidence, but also by increasing employment opportunities.

The study path developed in the project and the pilot trainings provided information on the professional skills of engineers and other similar graduates with an immigrant background in technical fields, proficiency in the Finnish language, integration and employment opportunities and aspirations, and other detailed questions. The pilot training provided new information on how to develop engineering trainings and available courses to reach the labour force potential of engineer immigrants with the aforementioned background. It also underlined the bottlenecks and difficulties that the target audience had experience when trying to become employed.

Conclusions

Due to findings of the inquiry to pilot training participants, the pipeline presented in this writing is considered a novel way to enhance the integration of immigrants into Finnish society. The model itself can and should be taken into use nationwide and to improve the attractiveness of the Finnish labour market and GDP.

Higher education institutions must continue to develop the study and career counselling, and personalize study plans of specialists with an immigrant background. Study path options, such as university diplomas should be further developed. Thus, immigrants who are highly educated or interested in higher education will have the opportunity to update and supplement their proficiency and at the same time develop vocational language skills. The study path model for immigrant engineers presented in the paper is one solution to the problem. The Finnish workforce is aging rapidly, and in this way international experts can access the labour market.

Based on the pilot implementation of the study path model, attention should be paid to the counselling of students in the diploma of higher university studies. In higher education institutions it is important to be aware of that the planning and implementation of the guidance process requires allocated resources, and that it is worthwhile to define the responsibility for supervision specifically for the unit implementing the training. At the same time, it is important to provide information about the diploma of higher education to the teachers of the unit and the personnel of the entire organization.

Universities of applied sciences need to offer students Finnish language teaching especially in the language of

their own professional field. Access to internships enhances the bridging possibility to working life. Cooperation between companies and universities or other institutes should be easy and flexible. Companies should be provided with more information, for example on language and cultural awareness and guidance on hiring immigrants for work. Despite of all efforts made before, experiences gathered during the training pilots prove that immigrants nevertheless need active support and trainings, and procedures need to be further developed.

References

Chames, J. & Lieberman, L. (1965). Differences between normal and clinical groups in judging, evaluating and associating needs. *Journal of Clinical Psychology*, 21, 145-156.

Busk, H., Jauhiainen, S., Kekäläinen, A., Nivalainen, S., Tähtinen, T. (2016). *Immigrants on the labour market – A study of the working life on immigrants arriving in Finland in different years.* Publications of the Finnish Centre for Pensions 06/2016.

Council of Europe. The CEFR Levels. (2001). Retrieved from https://www.coe.int/en/web/common-european-framework-reference-languages/level-descriptions

Dufva, H., Suni, M., Aro, M. & Salo, O-P. (2011). Languages as objects of learning: language learning as a case of multilingualism. *Journal of Applied Language Studies 5*, vol 1, 109-124. Retrieved from https://jyx.jyu.fi/dspace/handle/123456789/27270

Eronen, A., Härmälä, V., Jauhiainen, S., Karikallio, S., Karinen, R., Kosunen, A., Laamanen, J-P. & Lahtinen, M. (2014). Maahanmuuttajien työllistyminen – Taustatekijät, työnhaku ja työvoimapalvelut. MEE Publications: Employment and entrepreneurship 6/2014. Retrieved from https://tem.fi/documents/1410877/2859687/Maahanmuuttajien+ty%C3%B6llistyminen+10022014.pdf

Hellgren & Marjanen (2017). FITech Osaajatarvekysely. Alueen yrityksiin syksyllä tehty osaamistarveselvitys.

Hofstede, G. (1993). Cultural Constraints in Management Theories. Vol. 7 No. 1. University of Limburg, Maastricht: Academy of Management Executive.

Hofstede, G. (2005). Cultures and organizations. Software of the mind. New York: McGraw-Hill.

Juusola H., Nori, H., Lyytinen, A., Kohtamäki, V. & Kivistö, J. (2021). Foreign students pursuing a degree in Finnish higher education institutions. Why the students came to Finland and whether they are interested in working in Finland after graduation. Eurostudent VII article series. Publications of the Ministry of Education and Culture, Finland 2021:14.

Airas, M., Delahunty, D., Laitinen, M., Shemsedini, G., Stenberg, H., Saarilammi, M., Sarparanta, T., Vuori. H., & Väätäinen, H. (2020). Background matters. Students with an immigrant background in higher education. Finnish Education Evaluation Centre (FINEEC) 2:2020. Retrieved from https://karvi.fi/app/uploads/2020/01/KARVI_T0220.pdf

Lantolf, J. P. (2011). Integrating sociocultural theory and cognitive linguistics in the second language classroom in E. Hinkel Eds). *Handbook of research in second language teaching and learning.* Vol 2. 303-318. New York: Routledge.

Stenberg, H., Hirard, T., Autero, M. & Korpela, E. (2019). Metropolia University of Applied sciences. Retrieved from http://urn.fi/URN:ISBN:978-952-328-176-9

Studyinfo. Recommendation on admission criteria for universities of applied sciences. (2020). Retrieved from https://studyinfo.fi/wp2/en/higher-education/polytechnics-universities-of-applied-sciences/polytechnic-uas-bachelors-degree/recommendation-on-selection-criteria-for-universities-of-applied-sciences-2020/

CONSIDERATION OF THE SPECIAL COURSE FOR ASSISTIVE TECHNOLOGY ENGINEER DEVELOPMENT IN COLLABORATION WITH MEDICAL INSTITUTIONS

Mitsuhiro TANIWAKI [*,a], Takashi YOSHIKAWA [a] , Mikio DEGUCHI [b], Yoshikazu MINAMOTO [c] and Masafumi IMAI [c]

[a] National Institute of Technology, Niihama College, Department of Mechanical Engineering, Niihama, Japan
[b] National Institute of Technology, Niihama College, Department of Electronics and Control Engineering, Niihama, Japan
[c] National Institute of Technology, Niihama College, Department of Electrical Engineering and Information Science, Niihama, Japan

* taniwaki@mec.niihama-nct.ac.jp

Abstract

Manufacturing education in collaboration with medical institutions is very important and useful.
National Institute of Technology, Niihama College (NIT, Niihama College) offers a two-year systematic curriculum as the "Special Course for Assistive Technology Engineer Development (AT course)". This is the process of learning the basic knowledge of Medical welfare engineering, and manufacturing based on the needs of clinical field. In the AT course, problems in clinical environment are given as themes, and students take the initiative in working toward solving the issues while receiving advice on fluids, controls, sensors, programming, etc. from teaching staffs. However, it is difficult to imagine the problems in clinical environment, and multifaceted viewpoints, ideas, and knowledge are required to solve the problems. Also, in clinical environment, it doesn't matter who made it. Furthermore, in order to create products that can be used in clinical environment, it is necessary to have "technology" and "strategy" that enable high-quality manufacturing as well as the functions required by users. It is not possible to nurture engineers who can make practical things only by school education, and social implementation education in collaboration with the local community is necessary.
Therefore, as the AT course, we built an education system in collaboration with medical institutions. In addition, this system is designed to nurture engineers who can "manufacture with care" and to create an environment where they can learn manufacturing from various perspectives.
This report provides an overview of the AT course and examples of actual efforts. Also summarize student efforts and feedback from clinical institutions, consider changes in student awareness before and after taking the course, and describe the benefits of collaborating with medical institutions. As an example of our efforts, we will introduce a proposal for an efficient ventilation method in a rehabilitation room using CFD (Computational Fluid Dynamics).

Keywords: *Manufacturing education, systematic curriculum, social implementation education, Assistive Technology, collaboration with medical institutions*

Introduction

NIT, Niihama College has been providing social implementation manufacturing education in collaboration with these institutions based on the needs of medical and welfare sites, utilizing the long-term holiday period since 2012. This education system was rewarding and satisfying for the students, but it had two challenges. One of them was to impose an excessive burden on students amid time limitations. In addition, contrary to the student's sense of accomplishment, the evaluation from the clinic site was that it was not possible to complete the product to the satisfaction that "thank you for your efforts.." That is to say, on a medical institution side, they took time and cooperated in a number of ways, such as requesting the cooperation of facility residents, etc., but they eventually did not reach the level of manufacturing in which they could continue to use it, and it was becoming difficult to maintain their cooperation in social implementation education.

Therefore, under the motto of "First, make one person smile!", students with each specialized knowledge gathered, learned basic knowledge of medical welfare engineering, and newly opened the "AT course " as a systematic curriculum for two years (4th to 5th-year in the regular course) in manufacturing based on needs from the clinic site.

Developed curriculum

(1) Direction

Rather than "finishing with an evaluation of something (a work) produced in time," which is common in previous manufacturing classes, the aim is to create something that can be socially implemented by adding improvement based on the voices after use in the field. The curriculum was structured with the aim of the training of engineers with a wide field of view which can satisfy "design specifications", "product specifications", etc., having various viewpoints as buyers, operators, and users by practicing "craftsmanship that satisfies the target people".

Furthermore, such human resource development requires not only engineering, but also "knowledge" about people and diseases, such as physiology and the aftermath of dementia and stroke, as well as "technology" related to manufacturing, in addition to "strategy" tailored to the target audience, and "mental" capable of dealing accurately even when encounter a difficulty. For this, "human power" such as "inquiry mind", "recognition of diverse values", "belief (behavioral philosophy and engineer ethics)" is indispensable. In this course, by practicing and exercising these human abilities, we aimed at human resource development in which people can sometimes answer "give hope in manufacturing to people" through fierce arguments, compromises, and compromise proposals within the team.

(2) Curriculum

The students who have taken the courses are those who wish to attend in the 4th grade regardless of the subject to which they belong, and most of them have no knowledge of medical and welfare related matters. Therefore, the curriculum structure was arranged as follows.

(a) [Introduction to Assistive Technology] (First half of 4th-year)
To learn basic knowledge such as physiology and welfare tools.

(b) [Practice in Assistive Design] (second half of 4th-year)
Understand the needs of the field and consider proposals for solving problems. At the same time, incorporate the opinions of field staff and narrow down suggestions for improvement.

(c) [Practice in Clinical Equipments Development] (First half of 5th-year)
Actually make medical and welfare equipment.

(d) [Practice in Assistive Technology and Co-op] (5th-year summer holiday period)
Have the facility staff use the equipment they have produced, receive evaluations, and make improvements.

(e) [Introduction to Medical Welfare Technology] (second half of 5th-year)
Students will learn the "plan for conducting a clinical trial," "calculating the number of samples," and "statistical evaluation methods" necessary when they enter society.

Thus, it is possible to learn by stepping from the lecture of basic knowledge to the training and production stage. In addition, the report through (a) to (d) is prepared, and feedback is provided so that 4th graders can tackle it as a new theme (in part as a continuation theme) in the next fiscal year (in reality, from the second half of 4th-year).

Issues and Countermeasures

(1) Basic Lessons

In order to proceed with manufacturing while exchanging opinions between medical workers who are making various contrivances for the patient's top priority and students who have little knowledge of medical and welfare related matters and who do not know actual patients, many students give up such as "impossible," "cannot be helped," and "cannot be done" due to the difference of values, and it was considered important in the classroom study that the contrivance would not be so. And, in the problem solving, it was made to be a basic classroom in order to be able to come up with an idea, while conscious of contrivance of mistake operation prevention and importance of the maintenance more than the function which the user needs.

Specifically, [Introduction to Assistive Technology] made use of the merits of a small number of classes to touch simulated experiences of elderly and lower limb paralysis patients and accessible design products, etc., and to incorporate the experience of caregivers. As for the feelings of actual patients, the "Technical College AT Engineer Skills Standards Guidebook" (KOSEN-AT Network, 2018) and other materials were used to provide as much reality as possible to the feelings and approaches of people with illnesses and functional disabilities. Then, after finishing manufacturing, [Introduction to Medical Welfare Technology] aims to acquire knowledge and skills useful in the field of research and craftsmanship after graduation by learning about "a plan for conducting a clinical trial," "calculating the number of samples," and "statistical evaluation methods," etc., which are necessary for evaluating the problem-solving works produced.

(2) Practice

In the one-year practice subjects for solving problems, the following three major problems arise when actual production is carried out. Therefore, it seems to be difficult to actually take them as curriculums even if many schools understand that they are useful.

(A-1) Because students belong to more than one department, some students do not have a foundation for how to proceed with manufacturing, and there are students who have not made practical applications even though they have specialized knowledge. Therefore, individually-tailored support is required, making it difficult to secure time for such time and production (work).

(B-1) It is very difficult to secure time for work such as handicrafts and programming and to explain the progress to non-engineers such as hospitals. The ability to explain to non-engineers is also an achievement goal, and the materials that students prepare are focused on what they have done, and they try to convey the programs and particular mechanisms in detail, but the explanation that the field requests is for the on-site staff to be able to explain to third parties, such as patients, how to confirm the accuracy and reliability, and what kind of output will be produced if they do what they do in a flow chart way. Therefore, it is necessary to point out and improve the explanatory materials prepared by the students many times. In consequence, it became the instruction time of those during the class, and the production time of the product became the time out of the class, and the burden of the student was considerably increased.

(C-1) It is necessary to have the manufactured products evaluated (used) by hospitals, etc., and to finish them up to the products that can be used by improving them based on them. However, even a well-conceived product, as shown in Section (B-1), would be unfinished if there was no time to improve it. Therefore, the feedback of the evaluation must be given until the product with some improvement is shown, but it cannot be done. This ended with "I tried, but it wasn't good" with only expectations for the hospital, making it difficult to keep in touch with the hospital on an ongoing basis.

In response to these issues (A-1)-(C-1), the following are being implemented as of the third year of the AT course.

(A-2) In the practices, the support system by three teachers is always taken, one each from the Department of Mechanical Engineering, Department of Electrical Engineering and Information Science, and Department of Electronics and Control Engineering. By this, practical support of circuit design and manufacture, program design and manufacture, and hardware manufacture of casing and equipment are carried out, and the realization is made to be a system which finishes it. On the other hand, the production time is small for one class per week (90 minutes), but in order to avoid excessive overtime burden on students, some students have secured production time by making it a graduation research guidance teacher's consent and making it a graduation research theme. And, The curriculum has been changed so that AT course students in the Department of Mechanical Engineering can perform tasks in the AT course as tasks for the existing subject " Mechanical Design and Drafting". As a result, it has become possible to finish the production drawings (2D drawings) in the AT course to the level which can be ordered to the external organization, and to perform stress analysis using 3D CAD in parallel.

(B-2) The production time was solved by ensuring the cooperation with the outside of the AT course as shown in (A-2), and instruction on explanatory materials, etc., which are important thought and skill in the AT course, was decided to be carried out.

(C-2) In the production of AT course, it is necessary to satisfy the standard which each seeks from the difference of the standpoint of the three parties. However, if you oversatisfy some specifications, it becomes defective on the other hand, and you cannot meet the required standards. Therefore, it is necessary to realize it and to give feedback in the field. Then, a system was established to supplement by opening a co-op practice as an intensive lecture, in which the preparation by the training subject for one year is done, and the summer holiday period is utilized, and the improvement proposal for evaluation and feedback in the hospital is proposed, examined, and improved.

(3) Performance evaluation

Regarding the evaluation of manufacturing, the Department of Mechanical Engineering has used CUDBAS method (Mori, 1998), etc. to identify skills to be acquired, etc., and has been evaluating the evaluation by putting a weight on the items corresponding to the grade. (Yoshikawa, et al., 2007) However, the AT course is a problem solving according to needs from the field, and the degree of difficulty also varies from group to group, so the evaluation of skills, etc. is insufficient. Furthermore, in evaluating the thinking, ingenuity, and efforts for "making things that are better for users," in the AT course, in which students from multiple departments are enrolled, the weight of what can be done for that task within the group varies greatly from student to student. Also, as for the evaluation of the result (production), if it can be produced, it will pass, and if it cannot be produced, it will be failure, so it will be concentrated only on the work.

Here, in medical and welfare equipment, there are "A: Patient: Evaluator of the main function of the device through physical contact with the device" and "B: Person who operates the device and interacts with the patient and the device" as end users, and "C: Management: Buyer" as well, and each position is different, so naturally, the value standards also differ. For example, A makes the elimination of distress, fear, and anxiety an important criterion of value. B evaluates the ease of operation and maintenance to prevent erroneous operation, and the short start-up time. Then, C emphasizes the low running cost, installation space, initial expenses, no special skill staff, effects on patients by equipment introduction, etc. rather than the operational ease in the maintenance. These assessments are often a requirement for conflict. Under such circumstances, no matter which solution the student makes emphasized, if there are any major drawbacks in either A, B, or C, they will not be used. Therefore, it is necessary to satisfy all the requirements of the three parties, and discussions with the field are particularly important at the stage of idea selection prior to production. In addition, in the field as well, compromises for the selection of the idea of the second point are required for all four parties based on the technical aspect, not the persistence of the initial request.

Based on the above, we set the target of attainment as follows.

[1] Industrial design can be added to existing designs that satisfy functions

[2] Understanding and designing fail-safe and fool-proof designs

[3] Can produce actual machines and summarize them in a report

Regarding evaluation methods, by evaluating them in submissions (briefing materials, etc.), reports, and portfolios (work reports for each class, etc.), it is not possible to evaluate efforts within and outside of time and to rely on members, and a method in which differences in evaluation occur even within the group is used.

Evaluation using these methods has been well received by students, saying that it is fair as well.

Examples of Efforts

Examples of challenges based on needs from the clinics are shown below.

[Proposals for Efficient Ventilating Methods in Rehabilitation Rooms Using CFD]

In indoors where many people are active, ventilation is required as appropriate to arrange the indoor environment. Especially at present, it is required to ventilate constantly as a countermeasure for the prevention of the COVID-19 infections. However, ventilation during midsummer and midwinter is large temperature difference between the outside air and the room temperature, not only a large energy loss by giving priority to ventilation, it causes a large variation in room temperature. Variations in indoor temperature can be a source of discomfort, in addition to increased risk of heat stroke and heart attack. Therefore, it is required to ventilate efficiently while adjusting the air conditioning by cooling and heating.

In this challenge, the efficiency improvement of ventilation with cooling and heating is examined for the existing rehabilitation room under the cooperation of the rehabilitation hospital.

Students' efforts include conducting numerical simulations of the indoor environment, and proposing a method that can minimize the temperature change in the room and ventilate efficiently by examining the location and wind direction of the circulator in the rehabilitation room with cooling and heating. On the other hand, medical institutions are asked to ventilate according to the method proposed by the students, and evaluates the actual measurement of the room temperature and the condition when using the rehabilitation room by questionnaire, etc., and giving feedback. Based on these results, we are working to develop a system that can easily propose the installation location and wind direction of circulators required for ventilation and decreasing room temperature differences, even in a variety of rehabilitation rooms.

Discussion

(1) Evaluation on the clinical site

This time, because the hospitals we are collaborating with are medical corporations rather than universities and other research institutes, no revenue other than medical treatment was recognized, and it was very difficult for the staff to secure time for verification tests because of labor standards constraints. Then, the clerical procedure method, etc. was pioneered in order to be able to receive the commission from the joint research and the outside organization. As a result, in the hospital until now, though it was negative for the labor except for the treatment to the patient, the problem in the rehabilitation technique surfaced, and it was possible to move toward the possibility of the solution. Specifically, a device development team (working group) was formed in the hospital, which led to awareness of medical manufacturing for patients, handicapped people, and society. In addition, a system leading from evaluation by medical research to commercialization was made by medical-engineering cooperation shown in Figure1.

(2) Student evaluation

The results of a questionnaire survey after attending the AT course are shown in Figure 2. The questionnaire is divided into three groups, namely "4th-year: 4th-year students who conducted a manufacturing exercise for six months," "5th-year (from 4th-year): students who

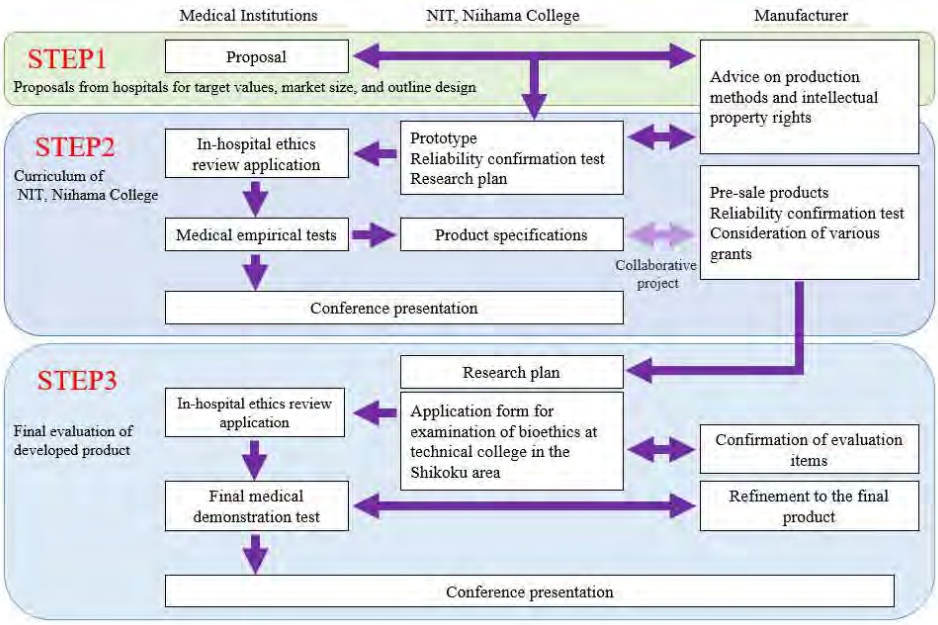


Figure 1. System that leads to established commercialization

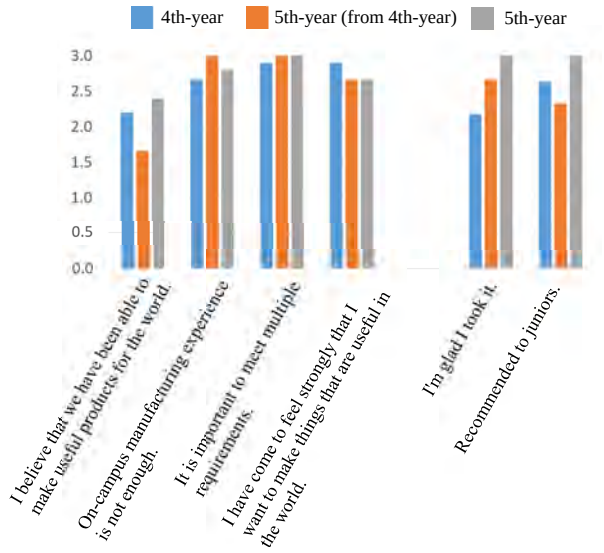


Figure 2. Post-class Questionnaire (Learning after Student Attendance)

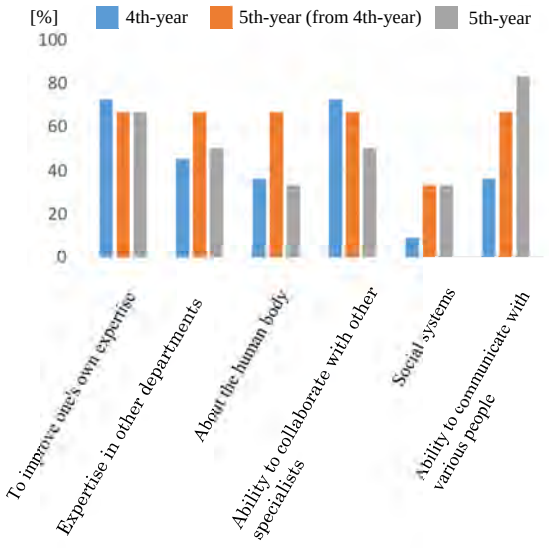


Figure 3. Enthusiasm for post-course learning

completed an AT course (all 6 credits)," and "5th-year: students who did not conduct manufacturing exercises, but students who learned the planning and evaluation of medical device development for 5th-year students in lectures," and it shows the results of evaluations with a maximum of three points at five levels in each question.

From Figure 2, those who completed the AT course (5th-year (from 4th-year)) rated lower than those in the other groups for "being able to make useful things in the world." This is probably due to the fact that we were able to recognize by feedback from the actual site that there were deficiencies that would not reach practical use if we had not devised them yet. Even in the free description of the student questionnaire, there were several comments such as "it is necessary to think about the user side, not just the creator side" and "it is not something that everyone is satisfied with, and it is important to make things that meet the user's demands". From this, it can be seen that without feedback from the hospital, it becomes the complacency state of the engineer. In addition, by receiving feedback, it was pointed out that the experience of manufacturing within the college, which had been conducted in the classroom, etc. so far, would not be able to be used in the real world, and it can be said that by this experience, the students were able to learn about the severity of craftsmanship.

Furthermore, the score for "I'm glad I took it" exceeded 2.5, while the score for "I recommend taking it to juniors" was low. When asked about this, they said, "It's pretty hard to complete, so if you didn't want to do it yourself, it won't last for two years, so I wouldn't recommend it to you." From this fact, it seems that further contrivance and improvement of the curriculum are necessary.

(3) Curriculum and Systems

The curriculum is structured so that students can learn from the lectures of basic knowledge through to the training and production stages. In addition, as described in Section 3.2, collaboration with existing subjects has enabled students to obtain outputs by compensating for production time, etc., and to greatly encourage students' growth through co-op education with hospitals using intensive lectures as an outcome.

Questionnaire results asking changes in students' willingness to learn after the course are shown in Figure 3. The questionnaire, similar to Figure 2, is organized into three groups and represents the percentage of people who answered "necessary" for each question. From Figure 3, in the responses of students completing the AT course (5th-year (from 4th-year)), the scores for "human body" and "expertise in other departments" are high as necessary learning in the future. In order to solve problems in assistive technology, knowledge such as "the human body" is required, and it is desirable that several students from different departments of affiliation have some "expertise of other departments" when working in groups. Therefore, in the AT course, which aims to foster engineers with a broad perspective, it is a very favorable result that the graduated students felt the necessity for these things, and it can be said that in the future, they obtained a very valuable and important sense (experience) in carrying out manufacturing.

Conclusions

The following conclusion was obtained as a result of opening AT course of all 6 credits for 2 years from 4th graders, regardless of the subject of affiliation, and carrying out manufacturing curriculum by medical-engineering cooperation for 3 years.

(1) It could be proposed as one of the schemes and systems for continuing cooperation with medical institutions which are not research institutes such as universities.

(2) It was clarified that it could be carried out by carrying out the cooperation with the existing subject in order to reduce the burden on the student by the AT course adding to the manufacturing (PBL) subject of each subject.

(3) Students who have completed all courses can learn about the severity of manufacturing and experience the importance of specialized knowledge in other departments.

References

Kazuo Mori (1998). Development of CUDOBAS and its Outlook. *Research on Human Resources Development*, 16 volumes, 109-128.

KOSEN-AT Network (2018). Technical College AT Engineer Skills Standard Guidebook. 2-98.

Takashi Yoshikawa, Yoshinobu Kamada, and Yoshihumi Taniguchi (2007). Engineering Design Education Method in the Department of Mechanical Engineering, Niihama College of Technology. *Lecture Paper College of Engineering and Industrial Education*, 238-239.

JOBITTI –COLLABORATION BETWEEN HIGHER EDUCATION INSTITUTES AND INDUSTRY WITHIN BIOSCIENCES -QUALITY MANAGEMENT AS AN EXAMPLE

A.E.E. Norström*[a], T. Hovinen[a] and S.L. Soini[b]

[a] Turku University of Applied Sciences, Turku, Finland
[b] Institute of Biomedicine, University of Turku, Turku, Finland

*anne.norstrom@turkuamk.fi

Abstract

Jobitti-project (https://jobitti.utu.fi) is a Finnish government funded key project where the focus was set to enhance the collaboration between the higher education institutes (HEIs) and industry. In the Jobitti project HEI personnel strives to develop the education in disciplines such as biotechnology, biomedicine and medicine education, and quality management systems within those fields. These goals are planned to be reached by creating and enabling effective collaborative networks between the participating Finnish HEIs providing education in the field, as well as companies and international collaboration partners. While E-learning is a key element in Jobitti also the HEI personnel participating in the project has been trained in this field. Although development of online courses being a main topic since the project beginning, has the development work never been as motivating as during the COVID-19 pandemic.
Multiple new online courses have been created in order to increase the selection and flexibility in the curricula of the participating HEI's. Alternative study paths within single curricula have been created as the possibility to include courses from other HEI's is enabled. The collection of courses is presented on an open website and the courses will be available globally for all students and company employees interested in the field. The companies collaborating in the Jobitti-project have expressed their need for *i.e.* online quality management training for the employees. All participating companies have been involved in the creation of the online courses by providing input to the relevant content of the courses. Due to the fast changes within the future working life the education in the HEI's must answer to new and still unknown needs of different types of engineering and expert profiles. Education and research within the field of bioengineering and biosciences provide a potential source for new innovations and a possibility for entrepreneurship. In this paper we describe how our project has established a close cooperation with bioengineering, biomedical and medical industries in order to lower the barrier for internship recruitments and to facilitate the students' transfer to working life.

Keywords: *University-industry collaboration, Quality management, Job shadowing, E-learning, Curricular planning*

Introduction

Higher education institutes (HEIs) are preparing the students for the working life. This transition faces challenges on how to fulfil the requirements of bioscience industry. The pace of change in the required skills and competences will increase. However, our education may not be able to respond to these challenges in a timely manner. Therefore, effective thinking about how to manage and respond to these challenges in our educational systems is urgently needed. In order to better facilitate the transition of students to employment, Jobitti, a project funded by Finland's Ministry of Education and Culture, with its consortium universities, was set out to enhance the collaboration between the HEIs and industry.

Specifically, the purpose of this collaborative project was to improve the effectiveness of university-industry collaboration by creating online training courses and providing a platform for students and companies. The Jobitti-project group consisted of four higher education institutions, University of Turku, Åbo Akademi University, University of Eastern Finland and Turku University of Applied Sciences. Our project aims to provide a good starting point in a form of one website which presents the various new online courses on biosciences created during the project for the Finnish bioscience students and companies on the field. A part of the project focuses on courses in quality management, discussed in this paper. We are looking for flexible delivery, close relationship with industry and the need and ideas for specialized courses. Besides providing a list of new online courses available for the students, the purpose of the website is to assist the students to increase their knowledge about the industry. In addition, the website helps employer and other stakeholders to gain a

better understanding of different study programs and their content as well as graduate degrees within biosciences. The site could serve as an information channel between interested companies and stakeholders and collects data about internships, summer jobs and open position opportunities. The Jobitti project seeks to establish collaboration opportunities and exploit synergies between the HEIs and industry within biosciences and build up an educational resource that would enhance the students' chances to successfully transfer to working life.

Curricular planning

The project formed a steering group that consisted of representatives from all four HEIs and five companies active in the biomedical field and interested in the quality related topics. The purpose of a steering group was to follow the ongoing activities and the progress of the project and to discuss and give feedbcak to the project. Suggestions of further activities, opinions and wishes were registered and then discussed in the working group meetings. The steering group met twice a year. For successful collaboration, communication needs to be regular, well implemented and progress reports should be made available at many stages of project while communicating the benefits may lead to future collaborations (Avasthy et al. 2019).

The activity of the steering group has helped the project to address interesting ideas and solve potential upcoming problems. One important point mentioned by the company professionals in the steering goup was that instead of learning outcomes favoured in higher education, generic skills and competencies need to be also acquired during the learning process also indicated by Braun & Brachem (2017). The steering group activities have also brought the representatives of different HEIs closer together and has led to a fruitful and beneficial collaboration, where all HEIs have their own field of interest and activity and no competition within the activities were seen.

In addition to collaboration between the higher education institutes and industry Finnish governmental programme also highlights the importance of having the international students to remain in Finland after graduation and to utilize their skills and expertise for the benefit of our labor market. Based on the feedback of the graduating students, especially that of international ones, it is obvious that students do not know well the companies of their potential career field. Therefore, they are neither familiar with career opportunities nor duties and responsibilities in different positions in local companies. We took these comments into consideration and engaged students' opinions to our curricular planning by designing the course for 'Job shadowing' where student follows and observes a trained and experienced employee of their chosen field for doing their daily job activities and duties. Pre-assignments of this course included read up about the company profile and managing confidentiality, contacting the company, finding a receiving employee for shadowing and finally signingof the Non-Disclosure Agreement together with a responsible employee of the company. Interestingly, even despite the pandemic, all students (N=5) that were willing and able to pave their way for piloting this course were international students. According to their reflections in the learning diaries Job shadowing provided a real-life experience of the working environment in the corporate world. It also helped to build connections with people of their interest field and to get an idea about the requirements to be a part of the desired job in a company after graduation.

Company survey

The Jobitti project was initiated with a survey targeted at companies working in the field of biosciences. Its aim was to find out specifically what quality related knowledge was required when hiring new employees. The survey also asked about companies' perception of the trends affecting the future of quality management.

The content of the company survey:

1. Company name
2. Industry
3. Your position in the company
4. Revenue of the company and amount of employees
5. Quality systems used in the company*
6. Is quality education provided in the company (internal/external)
7. What kind of quality education is required from the new employees?
8. How do You think the required knowledge will change in the following 10 years?
    a. quality control
    b. general knowledge
    c. attitude

Pedagogy

In Jobitti, each teacher chose the suitable pedagogical model for their own course. The only prerequisite was to do it online. However, at the beginning the teachers had some hands-on training how to use the new digital tools and platforms for designing and building the courses. Use of learning analytics to get feedback from the courses regarding student participation and assessment of their learning was also highly recommended. Some of the courses operate independently as stand-alone courses without teacher guidance, and in others, the teacher is present regularly or their online presence is scheduled in advance for specific time points only. Even normal, scheduled lectures were possible, but they were carried out online. Previous Finnish projects concerning web course designs were utilized (eAMK and Tasa-arvoinen oppiminen 24/7 Hiltunen L. & Lattunen, P. (2017). Both of these projects have produced materials to support teachers to implement digital learning.

The course design and testing phase utilized peer review by colleagues. A form, with 20 questions relating to the structure of the online course, was used to aid the peer review. The subjects to be evaluated included for example clarity of the course structure, layout and instructions of the online implementation, adapted to the level of the target group, copyright issues, visual appearance and easy accessibility of the course, the use of learning analytics, diversity and clarity of tasks, and student-teacher interaction in the course. Student feedback was collected from each course and implementation. In the feedback questions the students were typically asked to give feedback of the clarity of the course as well as individual tasks and assignments. Also, a text form field was in use.

Results

The survey was answered by 17 companies. The industries of the companies were mainly related to different phases of drug development and production, as well as the diagnostic industry. Companies specialising in consulting were also involved. Respondents included CEOs, quality managers, managers and specialists. The size *i.e.,* employee numbers of the companies interviewed varied widely. However, companies of different sizes were uniformly represented: there were five companies with fewer than 10 employees, there were six companies with 10-50 employees, and six companies with more than 100 employees.

Majority of the companies (13) provided quality training for the employees organized and the form of the training was highly dependent on the size of the company. Most often, the supervisor was responsible for familiarizing the new employee with the company's quality issues and rquirements. If the company was working according to a collection of "Good Practice" quality guidelines and regulations (GxP, where x represents the Manufacturing/Laboratory/ Clinical) the frequency of the education was specified by the system requirements. The Consultant companies educated other companies and received their up-to-date knowledge by following closely the recent development in the branch.

In most of the company answers (7) was the basic knowledge of the GxP mentioned as well as the basic understanding of quality thinking and quality standards. Also, the understanding of the entire quality concept and the certification principle was found to be important. The knowledge requirements for the new employees were naturally highly dependent on the tasks these persons have in the company. Tasks such as documentation, validation and continuous learning were mentioned. On the other hand, some answers emphasized that quality knowledge requires growing into the task and takes time. In the planning work of the online courses the company wishes were taken into account. The courses start developing students' quality thinking from basic knowledge of quality management systems. Similarly, developing of the quality thinking needs to start from the metrological quality point of view. The scope of the course syllabus is gradually widened by introducing other quality management systems to achieve the whole picture. Quality management systems discussed in courses include systems compliant with ISO standards (e.g. ISO 9001, ISO 14001), as well as systems based on regulatory requirements such as Good Manufacturer's Practice (GMP) and Good Laboratory Practice (GLP) Quality related courses developed during Jobitti and their recommended order of progression are shown in Figure 1.

Table 1. The number of students who participated in quality courses during the project and estimation of participants for autumn (*).

Course	Students
Basics of Quality and Standards	90
Statistics	47
Quality Control Tools	62
Quality and Metrology	114
Lean Basics	53
Principles of lean	23
GMP in Pharmaceutical Industry	32
Good Laboratory Practise	10-15*
Medical Devices, ISO 13485	10-15*
Quality Tools	25-30*
Quality Management	25-30*

As discussed above, the collection of courses designed, built and piloted during the Jobitti project (Fig.2) are

presented on a website managed by Turku University (http://jobitti.utu.fi/). This website is an informative frontpage, where the courses of interest can be accessed by the students in HEI's as well by the companies. From the frontpage the student will be guided to the actual online learning environment, the joint learning platform (Moodle) of Finnish HEIs' https://digicampus.fi. However, individual HEIs may also use their own learning platforms which may vary between the participating HEIs. Altogether, 421 students have participated in the course so far (Table 1). In addition, four more courses will start in the autumn 2021. A total of 70-90 students is expected to participate in piloting the first implementation of the upcoming quality courses. In the future, the student numbers are expected to increase when there will be participants from outside the piloting HEIs and study programs, such as summer workers, new employees, the ones looking for continuing professional development or career change.

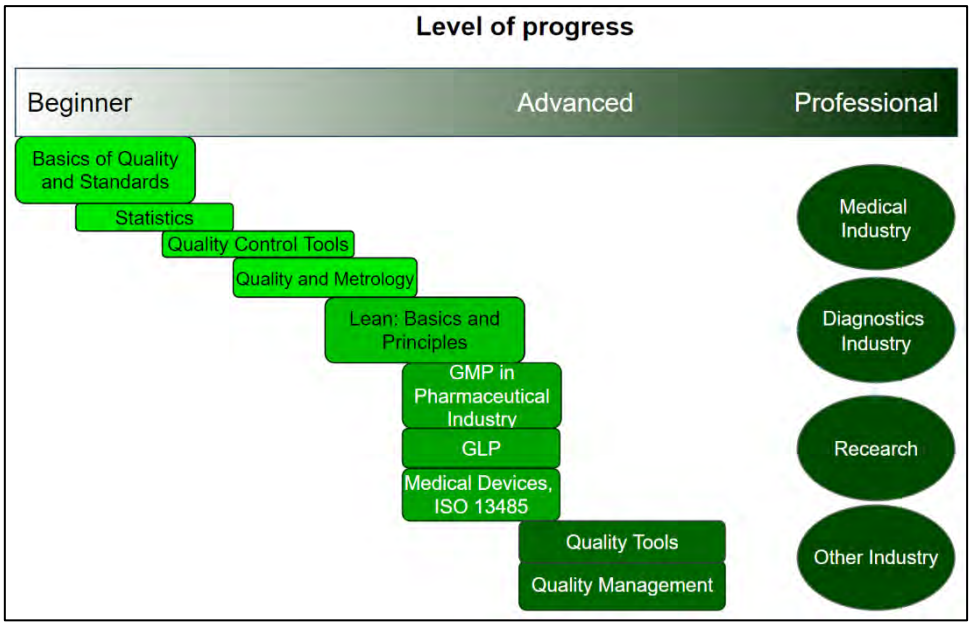


Figure 1. Quality related courses developed during Jobitti and their recommended order of completion. The industrial sectors mentioned on the right are the primary target sectors of these courses.

Discussion

The Jobitti project of creating web-based courses within biosciences started already before the world in spring 2020 was struck by the COVID19 pandemic. Thus, the courses planned and generated within the project have been to some extent available for the students on the web during this challenging year. This pilot phase of the Jobitti-project will be completed at the end of June, 2021and the rest of the courses will be launched by the end of the year. However, the online courses generated during the project will be available for the next five years. Consequently, the collaboration between the teachers in the participating HEIs will continue. The courses are either incorporated into curricula or are offered as elective studies of the various study programs in the partner HEIs. These decisions were naturally made from the HEIs' point of interests.

The web-based courses affect the students in several ways compared to the traditional classroom courses. Efforts had to be made in both planning the course content as well as the pedagogical approach. The courses and the tasks should be designed so that they are unequivocal and can be completed in a timely manner. Naturally, the challenge should be adequate for the students, and also the teacher's time needed to teach the online courses, should fall within the range of reasonable workload expectations.. For example, real-time assessment, such as peer review commonly used method in classroom courses, should be created in a way that it is possible to correct the peer reviews so that they are sufficient but not incorrect, and steer the discussions on the correct path. In online courses this method can be challenging as the teachers are not attending all discussions and the students are not experts and are still learning. The challenge in designing online/blended courses is to find activities that have at the same time appropriate technical solutions, are within the capabilities of instructors, and satisfy the preferences of learners. Coman et al. (2020) found in their recent study that the coronavirus pandemic has generated changes in the teaching-learning process in HEIs and has influenced the interaction between teachers and students. They reported issues with the student motivation, technical issues, followed by teachers' lack of technical skills and their teaching style improperly adapted to the online

environment. These findings are directly applicable to the online studies in general and when the inevitable technical issues have been solved one after the other and the final results have been encouraging. From the student's perspective, the variety of courses has naturally extended beyond their own study and/or campus areas. Another goal for the project was to be able to generate a set of courses that can be offered to the companies. The courses can then be arranged according to the needs and timetables of the companies. Another way for the companies to utilize the generated courses is to send the employees in need of education to participate in the degree program of Industrial Quality Management (IQM). The degree program consists of online quality courses generated during the project. The participation in the degree program can also be used as an update of quality education for the employees.

In the survey, the interviewees were asked to envision future changes within quality control aspects in their own field of industry. The following topics would, according to the answers be of considerable importance in the future. First, the quality knowledge will in the future be required from the entire company staff while other tasks such as big data management will only be managed by specified persons. Furthermore, the quality control in the future may be specified more company wise. This will challenge the content of general quality education. The meaning of the risk-based approach in quality management is also a growing trend. In the future, quality by design and statistical analyses in quality control are dominant. The quality control methods are changing to computational methods to control and improve quality when proactive quality management is needed. Also, it seems that the requirements are getting more demanding and it should be noted that all employees need knowledge concerning quality. When the attitude towards quality management knowledge was found out, the opinion was that the hospital pharmacies, universities, product development as well as the maintenance departments should get involved in the GxP-thinking. As a general comment related to attitudes, employees should be reliable, be interested in following the continuous change in the field and be innovative. Finally, it was anticipated that the number of regulations and bureaucracy will increase.

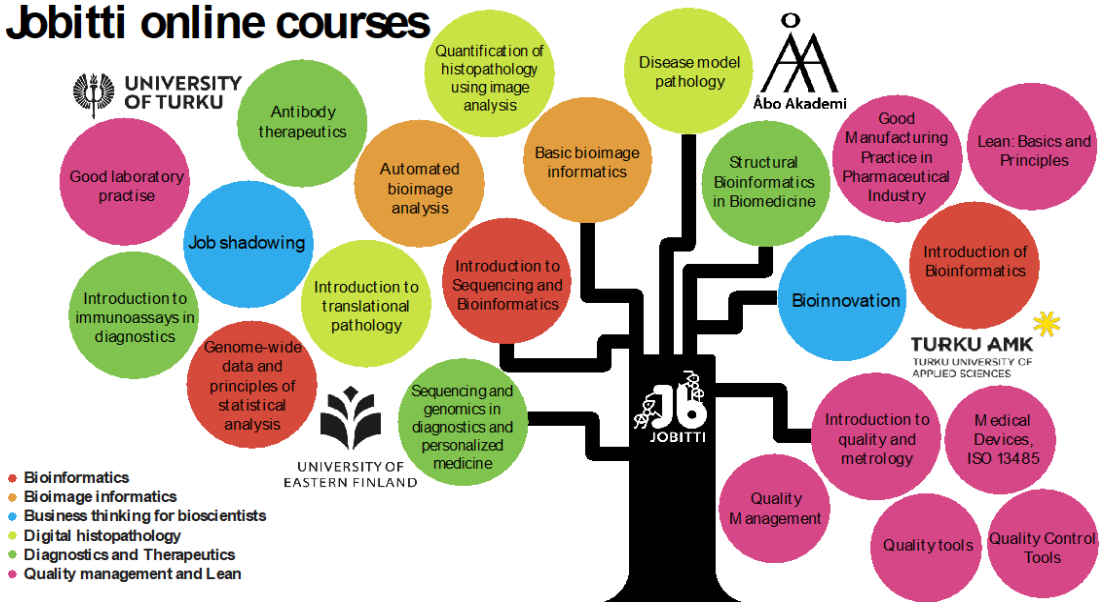


Figure 2. Courses developed in the Jobitti project

Conclusions

In this paper we have described means how governmental funding has improved the collaboration of partner universities and facilitated university-industry collaboration. As prompted by industry needs, quality management courses were chosen to be developed. This university – industry interaction has also helped the universities to focus on their own strengths on producing the courses. In addition, instead of promoting their own interests in collaboration with industry universities have now approached and listened to the needs of companies together. This is a meaningful way to foster cross-institutional studies between multiple HEIs, universities and universities of applied sciences. Over 20 online courses were developed through a collaboration between four Finnish universities, their international partners and with the assistance of companies in bioscience industry. The courses will be available under Digicampus.fi online learning platform. As collaboration is something that happens between people, we have built up an active

productive network that will continue to pursue sustaining collaboration.

Acknowledgements

We wish to acknowledge funding support from the Finland's Ministry of Education and Culture and we wish to thank our Industrial Partners for the fruitful collaboration, as well as all our Jobitti project's HEI partners.

References

Awasthy, R., Flint, S., Sankarnarayana R. & Jones R.L. (2019) A framework to improve university–industry collaboration. *Journal of Industry-University Collaboration* Vol. 2 No. 1, 49-62. DOI 10.1108/JIUC-09-2019-0016

Braun, E., Brachem, J-C. (2017) The labour market's requirement profiles for higher education graduates (2017). In Kyndt, E., Donche, V., Trigwell, K., & Lindblom-Ylänne, S. (Eds.). *Higher Education Transitions: Theory and Research* (pp. 209-218). Routledge. https://doi.org/10.4324/9781315617367

Coman, C., Gabriel Triu, L., Mesesan-Schitz, L., Bularca, M.C. (2020). *Online Teaching and Learning in Higher Education during the Coronavirus Pandemic: Students' Perspective.* Retrieved from https://www.mdpi.com/2071-1050/12/24/10367.

Hiltunen, L. (2017). Verkko-opetuksen suunnittelu – webinaarisarja 24/7 Tasa-arvoinen oppiminen –hanke Retrieved from http://247oppia.azurewebsites.net/wpcontent/uploads/2018/01/Oppia247_PEDA_tyokirja_2017.pdf

Retrieved form eAMK, https://www.eamk.fi/en/frontpage/

Sustainable Development in Education

INITIATIVES IN MARITIME EDUCATION CLASS FOR THE PURPOSE OF IMPROVING MOTIVATION TO LEARN GENERAL SUBJECTS

K. Yamada[*,a]

[a] Department of Maritime Technology, National Institute of Technology, Toyama College, Japan

*keisuke@nc-toyama.ac.jp

Abstract

The Department of Maritime Technology trains human resources who will be responsible for shipping in Japan in the future. In recent years, the Japanese shipping industry has been facing a problem of shortage of Japanese ocean-going seamen. It is an important issue for Japan, an island nation, to secure and develop excellent seamen for the sustainable development of the nation.

In recent years, the diversification and sophistication of skills required for seamen are accelerating. On the other hand, it is also true that many students lose confidence due to the difficulty of keeping up with the skills required for them. Moreover, most of them, during their lower grades, give up their dream of traveling around the world ocean. Against these backgrounds, this initiative aims to produce as many students as possible who can continue the efforts necessary to become ocean-going seamen. This report will provide some examples of ingenious exercises in special subject, Introduction to Marine Engine, which is offered for first-year students.

It is important to be careful when conducting professional education from the age of 15, even though special subjects are based on general subjects, some students easily make light of general subjects. In order to be able to improve their abilities even after graduation, it is necessary to make a foundation for learning. Furthermore, to be active as seamen, they are needed not only academic skills but also variety of abilities, such as communication skills as a typical example. In this initiative, an instructor focused on the following abilities; information gathering skills, data analysis skills, and an international sense. Exercises include group discussion, competition or presentation. An instructor consciously creates exercises that require knowledge utilization of both special subjects and general subjects. Students have come to understand that these subjects are closely related. As a result, it is possible to suppress the tendency of students to easily select subjects. From the results of the questionnaire, it was also confirmed that students' attitude toward learning general subjects improved.

Keywords: *Maritime education, General and special subjects, Knowledge utilization, Learning motivation*

Background

The Department of Maritime Technology is training navigators and engineers who can play an active role in ocean-going vessels. Japan relies on imports for much of its energy resources with more than 99 percent by weight on sea transport. For these reasons, securing seafarers to operate ocean-going vessels is an important issue for Japan that is indispensable to national economic security. However, as shown in figure 1, the number of Japanese ocean-going seamen was about 38,000 in 1980, decreased to about 5,000 in 2000, and has recently changed to about 2,200.

In Japan, an objective has been set to increase the number of ocean-going seamen by 1.5 times in the ten years since 2018. The Japanese government, related organizations and maritime educational institutions are making various efforts to achieve this objective. In colleges of technology (KOSEN), faculty members teach students the attractiveness of the work of ocean-going seafarers in classes, provide marine education for junior high school students and younger. We have tried various approaches, but it is likely that we will not achieve our objective without further improvements.

Fortunately, the author is in charge of all grade classes, and can watch students grow up in the five and a

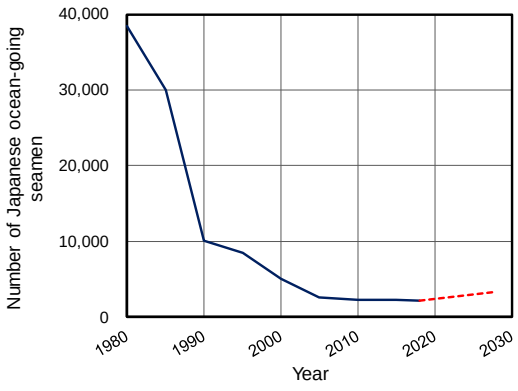


Fig.1 Changes in the number of Japanese ocean-going seamen and future mid-term objective.

half years before graduation. I'm worried that, as their grades increased, many students give up their dreams to become a ocean-going seamen, even though they had strong aspirations at the time of admission. My investigations revealed that the main reasons for giving up their dreams are long boarding periods and lack of academic ability and qualifications. Looking further into the reason of the latter, during the lower grades the students misjudged that general subjects were not necessary and had neglected to study. As a result, students were unable to develop their basic skills, and making it difficult to accommodate specialized subjects in higher grades.

Since I realized this fact, I have come to feel that it is important for students to study general subjects in lower grades in order to complete higher grade subjects. Therefore, initiatives are being made in the class for first graders to enable students to recognize the importance of general subjects themselves. This paper reports on the status of this initiative.

Overview of initiatives

In a class, Introduction to Marine Engines, the author teaches first graders the following themes:

-Composition of maritime industry
-Basics of hull structure
-Diesel engine
-Boiler
-Steam turbines and gas turbines
-Pump
-Propeller
-Mooring devices and steering devices

These contents are considered to be highly specialized for first graders. For this reason, students were only required to understand the basic level, and the classes were conducted with the aim of giving students interest, responsibility and self-esteem in engaging in the maritime industry. As mentioned above, after noticing the lack of motivation to study general subjects in 2017, one of the objectives was to make students aware of the relevance of specialized subjects and general subjects, and the range of activities has been gradually expanded. However, the contents of this subject are restricted by the STCW treaty and NIT's KOSEN MCC. Therefore, the author carried out some initiatives as part of regular classes.

In this paper, the word "related subjects" means English, social studies (geography, history, economy, etc.), physics, and nautical science. It mainly conducts exercises, and students output in various forms, such as presentations, team competitions, and class discussions. Table 1 shows the outline of the three-year initiatives.

The 1st year is the time when the concept of this initiatives began to be formulated. At the end of the year, only the survey was conducted. In the 2nd year, two pilot initiatives were carried out. In the 3rd year, five initiatives were carried out as introductory education (Trial 1), coffee breaks after midterm exam (Trial 2, 4), and homework during long vacation (Trial 3, 5).

Table 1 Outline of the three-year initiatives.

1st year (2017.4 - 2018.3)	
Feb.	Attitude survey on learning of general subjects

2nd year (2018.4 - 2019.3)	
Sep.	Trial 1 - Estimation of operating costs, etc.
Jan.	Trial 2 - Japan's energy situation
Feb.	Attitude survey on learning of general subjects

3rd year (2019.4 - 2020.3)	
Apr.	Trial 1 - Understanding the composition of the maritime industry
Jun.	Trial 2 - Free proposal for ships using new energy
Sep.	Trial 3 - Creation of cruise ship tour plans and estimation of operating costs
Dec.	Trial 4 - Propeller performance, stopping distance
Jan.	Trial 5 - Japan's energy situation
Jan.	Attitude survey on learning of general subjects

Case study

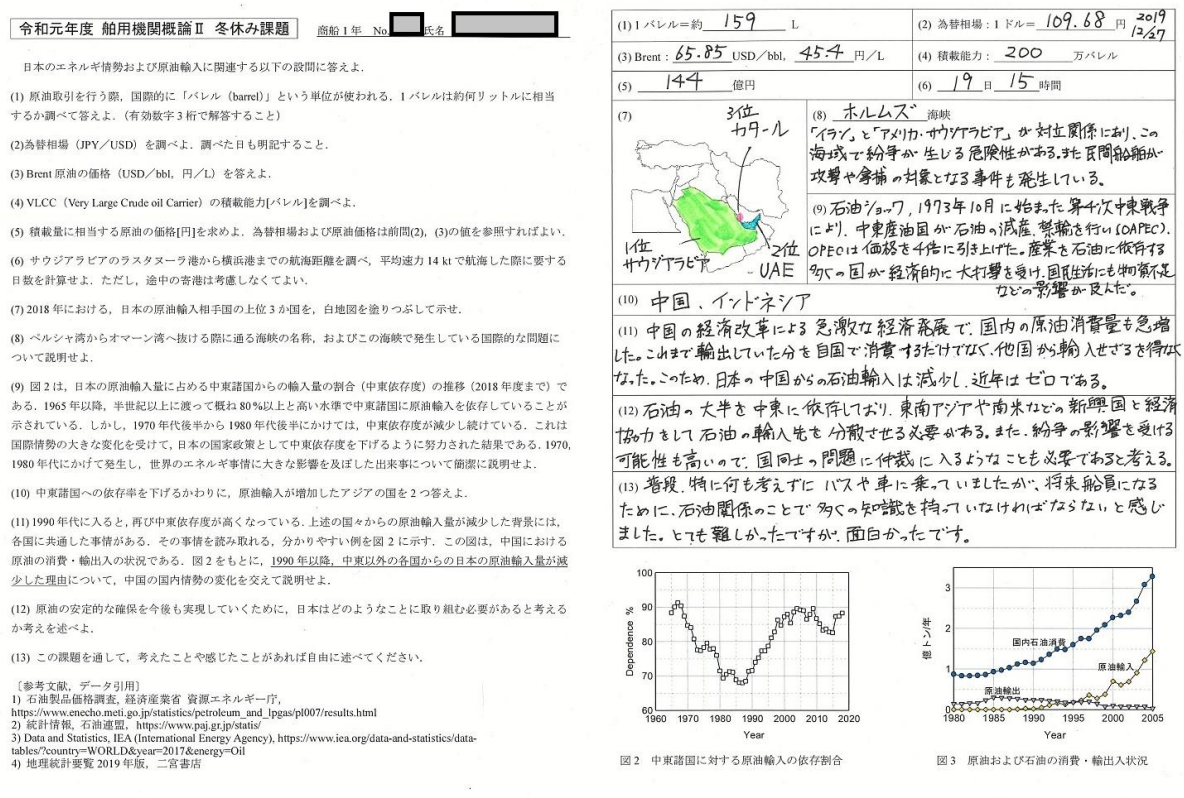
Here, as an example of the initiative, exercise about Japan's energy situation is shown in figure 2. This task was given as homework for the winter vacation. As mentioned at the beginning, Japan relies on imports by sea for most of its energy resources. The energy situation has changed dramatically in the last half century, and students need to know the past and see the future about energy situation. Against this background, the concept of this initiative (Trial 5) was set as follows.

Related subjects: Geography, modern history, economy, international relations, nautical science

Required skills: Information gathering and analysis skills, basic calculations for voyage planning and fuel consumption.

The questions are as follows.

(1) When trading crude oil, the unit of "barrel" is used internationally. Find out how many liters a barrel equals, and answer.
(2) Check the exchange rate (JPY/USD).
(3) What is the price of Brent crude oil (USD/bbl, yen/L)?
(4) Check the loading capacity of VLCC (Very Large Crude oil Carrier).
(5) Calculate the price of crude oil equivalent to the loading capacity.
(6) Investigate the cruising distance from Sastanura Port in Saudi Arabia to Yokohama Port and calculate the



令和元年度 舶用機関概論Ⅱ 冬休み課題　商船 1 年　No.　氏名

日本のエネルギ情勢および原油輸入に関連する以下の設問に答えよ．

(1) 原油取引を行う際，国際的に「バレル（barrel）」という単位が使われる．1 バレルは約何リットルに相当するか調べて答えよ．（有効数字 3 桁で解答すること）

(2)為替相場（JPY／USD）を調べよ．調べた日も明記すること．

(3) Brent 原油の価格（USD／bbl，円／L）を答えよ．

(4) VLCC（Very Large Crude oil Carrier）の積載能力[バレル]を調べよ．

(5) 積載量に相当する原油の価格[円]を求めよ．為替相場および原油価格は前問(2)，(3)の値を参照すればよい．

(6) サウジアラビアのラスタヌーラ港から横浜港までの航海距離を調べ，平均速力 14 kt で航海した際に要する日数を計算せよ．ただし，途中の寄港は考慮しなくてよい．

(7) 2018 年における，日本の原油輸入相手国の上位 3 か国を，白地図を塗りつぶして示せ．

(8) ペルシャ湾からオマーン湾へ抜ける際に通る海峡の名称，およびこの海峡で発生している国際的な問題について説明せよ．

(9) 図 2 は，日本の原油輸入量に占める中東諸国からの輸入量の割合（中東依存度）の推移（2018 年度まで）である．1965 年以降，半世紀以上に渡って概ね 80％以上と高い水準で中東諸国に原油輸入を依存していることが示されている．しかし，1970 年代後半から 1980 年代後半にかけては，中東依存度が減少し続けている．これは国際情勢の大きな変化を受けて，日本の国家政策として中東依存度を下げるように努力された結果である．1970, 1980 年代にかけて発生し，世界のエネルギ事情に大きな影響を及ぼした出来事について簡潔に説明せよ．

(10) 中東諸国への依存率を下げるかわりに，原油輸入が増加したアジアの国を 2 つ答えよ．

(11) 1990 年代に入ると，再び中東依存度が高くなっている．上述の国々からの原油輸入量が減少した背景には，各国に共通した事情がある．その事情を読み取れる，分かりやすい例を図 2 に示す．この図は，中国における原油の消費・輸出入の状況である．図 2 をもとに，1990 年以降，中東以外の各国からの日本の原油輸入量が減少した理由について，中国の国内情勢の変化を交えて説明せよ．

(12) 原油の安定的な確保を今後も実現していくために，日本はどのようなことに取り組む必要があると考えるか考えを述べよ．

(13) この課題を通して，考えたことや感じたことがあれば自由に述べてください．

〔参考文献，データ引用〕
1) 石油製品価格調査，経済産業省 資源エネルギー庁，https://www.enecho.meti.go.jp/statistics/petroleum_and_lpgas/pl007/results.html
2) 統計情報，石油連盟，https://www.paj.gr.jp/stats/
3) Data and Statistics, IEA (International Energy Agency), https://www.iea.org/data-and-statistics/data-tables/?country=WORLD&year=2017&energy=Oil
4) 地理統計要覧 2019 年版，二宮書店

(1) 1 バレル＝約 159 L　(2) 為替相場：1 ドル＝ 109.68 円 2019 12/17
(3) Brent：65.85 USD／bbl，454 円／L　(4) 積載能力：200 万バレル
(5) 144 億円　(6) 19 日 15 時間

(7) 3位 カタール，1位 サウジアラビア，2位 UAE

(8) ホルムズ 海峡
「イラン」と「アメリカ・サウジアラビア」が対立関係にあり，この海域で紛争が生じる危険性がある．また民間船舶が攻撃や拿捕の対象となる事件も発生している．

(9) 石油ショック，1973年10月に始まった第4次中東戦争により，中東産油国が石油の減産，禁輸を行い(OAPEC)，OPECは価格を4倍に引き上げた．産業を石油に依存する多くの国が経済的に大打撃を受け，国民生活にも物資不足などの影響が及んだ．

(10) 中国，インドネシア

(11) 中国の経済改革による急激な経済発展で，国内の原油消費量も急増した．これまで輸出していた分を自国で消費するだけでなく，他国から輸入せざるを得なくなった．このため，日本の中国からの石油輸入は減少し，近年はゼロである．

(12) 石油の大半を中東に依存しており，東南アジアや南米などの新興国と経済協力をして石油の輸入先も分散させる必要がある．また，紛争の影響を受ける可能性も高いので，国同士の問題に仲裁に入るようなことも必要であると考える．

(13) 普段，特に何も考えずにバスや車に乗っていましたが，将来船員になるために，石油関係のことで多くの知識を持っていなければならないと感じました．とても難しかったですが，面白かったです．

図 2　中東諸国に対する原油輸入の依存割合

図 3　原油および石油の消費・輸出入状況

Fig. 2 Example of student's answer (3rd year, Trial 5 - Japan's energy situation)

number of days it takes to sail at an average speed of 14 kt. However, port calls on the way do not need to be considered.

(7) Fill out the top three Japanese oil import partners in 2018 with a blank map.

(8) Explain the name of the strait on the way from the Persian Gulf to the Gulf of Oman, and the international problems that are occurring in this strait.

(9) Figure shows the change in the ratio of crude oil imports from the Middle East to Japan (Middle East dependence). Since 1965, Japan has relied on the Middle East for crude oil at a high level of about 80% for most of the half-century. However, from the late 1970s to the late 1980s, dependence on the Middle East continued to decline. This is the result of Japan's efforts to reduce dependence on the Middle East as a national policy in response to major changes in the international situation. Briefly describe the events that occurred during the 1970s and 1980s and had a significant impact on the world energy situation.

(10) From which countries did crude oil imports increase, instead of reducing dependence on Middle Eastern countries? Answer two countries.

(11) In the 1990s, dependence on the Middle East grew again. The background of the decrease in crude oil imports from Asian countries is the common circumstances of each country. The graph which can understand the situation is shown below. This graph shows the consumption and import / export of crude oil in China. Explain why oil imports from Asian countries have decreased since 1990, using graphs and changes in China's domestic situation.

(12) What do you think Japan needs to tackle in order to achieve a stable supply of crude oil in the future?

(13) Feel free to say whatever you think or feel through this homework.

First graders have a bit of knowledge about these questions, but they are not enough. Therefore, students start collecting information from the books and the internet. Some calculations are performed based on the obtained value. Here, basic calculation skills related to navigation and fuel consumption are required.

Students will also explain social issues such as the dependence on crude oil in the Middle East, the energy situation in Japan and other countries, and the issue of the Strait of Hormuz. In the last question, students were free to write about Japan's future energy strategy (12) and homework impressions (13).

Answers to these questions were given by designated students during class after the winter vacation. In the last question, students expressed various ideas. A lot of opinions were drawn from students and shared in the form of a general discussion on this issue. The author tried to explain the possible merits and demerits of the student's proposal and to promote the students' understanding.

Attitude survey

Over the three years, a survey was conducted on awareness of the relevance and importance of specialized subjects and general subjects. As mentioned above, the subjects set as question items are English, social studies, physics, and nautical science. Figure 3 shows the results of the questionnaire survey on each subject. A, B, C and D described in the figure 3 have the following meanings, respectively.

A: Strongly agree on relevance and importance
B: Agree
C: Disagree
D: Strongly disagree
The number of responses is about 40 in any year.

Survey result (English)

In the 1st year, few students were strongly aware of the importance for English and its relevance to specialized subjects, and half of the students didn't recognize the importance. In the 2nd year, a growing number of students strongly agreed or agreed on the importance and relevance of English. On the other hand, very few students disagreed at all. In the 3rd year, most students agreed with the importance and relevance of English.

Survey result (Social studies)

In the 1st year, few students were aware of the relevance and the importance for specialized subjects and social studies. In the 2nd year, pilot efforts were conducted, and some agreement was gained that maritime industry was closely related to social studies. In the 3rd year, most students agreed on the importance of social studies.

Survey result (Physics)

Originally, I explained the relationship between hull motion characteristics and physics. As a result, a relatively large number of students agreed with the importance of physics in the 1st year. In addition to the work on the table 1, the author has been conducting exercises with a focus on the association with physics, and awareness has been improving year by year.

Survey result (Nautical science)

In the future, in order for the engineer and navigator to work together on a large vessels, it is necessary to understand each other's work. Therefore, knowledge related to marine machinery, which are learned in the navigation course, was adopted in the class to promote mutual understanding between the engineer and the navigator. In the 1st year, many students questioned why they had to learn nautical science. As a result of continuing to improve the contents of this class, the necessity of mutual understanding can be understood at the first grade, and the results are shown in the 3rd year's survey results.

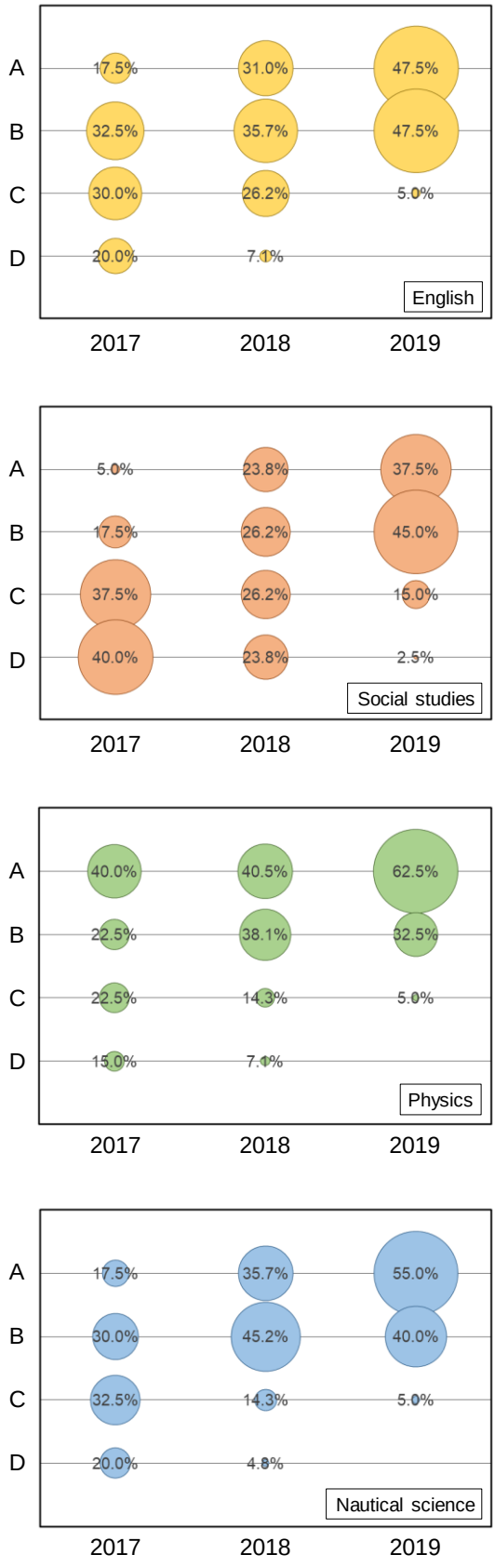


Fig. 3 Changes in students' awareness of each subject. (A: strongly agree, B: agree, C: disagree, D: strongly disagree)

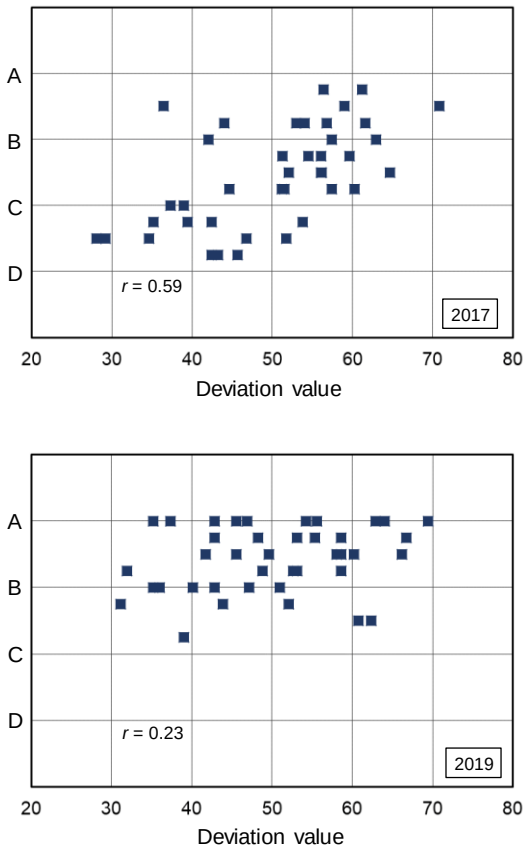


Fig. 4 Relationship between in-class deviation values and students' awareness.

Figure 4 shows the relationship between the in-class deviation value and the students' awareness. 2017 and 2019 results are compared. The deviation value was calculated from the comprehensive evaluation points of this subject, Introduction to Marine Engine. Although the number of students in the class is about 40, it is not enough to give accurete deviation values. So this value is shown as a reference for understanding trends. The vertical axis indicates the level of awareness of the relevance of the marine machinery and other subjects. The level is the average value of the four subjects described above.

In the 1st year (2017), students with higher deviation values tended to be more awareness of the relevance and the importance for other subjects. It was confirmed that there is some correlation between academic achievement and awareness of the relevance and the importance for other subjects. On the other hand, in the 3rd year (2019), this tendency became weaker, and the number of students who became aware of the relevance and the importance of marine machinery and other subjects increased regardless of the their deviation values. From this fact, it can be said that this initiative has achieved certain results.

However, the actual status of students' efforts in each subject and the transition of grades have not been confirmed. Another issue is that the differences in academic ability at the time of admission among generations cannot be taken into account. In order to accurately verify the effects of this initiative, it is necessary to continue research on changes in student learning and awareness.

Conclusions

In the class of specialized subjects for first grade students, efforts were made to raise awareness of the relevance and the importance of both special subjects and general subjects. A three-year survey of students' attitude has shown that their awareness of learning general subjects has improved as this initiative has become full-fledged. It is necessary to continue to conduct surveys on the status of learning activities and the degree of retention of each subject.

As mentioned at the beginning, the motivation for this initiative is to eliminate students who give up ocean-going seamen because of lack of learning due to incorrect selection of subjects. The achievement of this objective will be confirmed after 2023.

Through various initiatives, I will continue to teach students that both special subjects and general subjects are needed to improve themselves as a seamen in the future. Moreover, I want to contribute to the stable securing of excellent Japanese ocean-going seamen.

References

Agency for Natural Resources and Energy (2019). *Annual report on energy in FY 2018*. Retrieved from https://www.enecho.meti.go.jp/about/whitepaper/2019/

Agency for Natural Resources and Energy (2019). *Various statistical information - Oil and LP gas related*. Retrieved from https://www.enecho.meti.go.jp/statistics/petroleum_and_lpgas/

International Energy Agency (2019). *Data and statistics*. Retrieved from https://www.iea.org/data-and-statistics?country=WORLD&fuel=Energy%20supply&indicator=Total%20primary%20energy%20supply%20(TPES)%20by%20source

Japan Maritime Center (2019). *SHIPPING NOW 2019-2020* (pp. 44). Ocean-going seamen: Change in the number of Japanese ocean-going seamen.

Ministry of Land, Infrastructure, Transport and Tourism (2018). *Further Initiatives to Secure Quantities of Japanese Seafarers*. Retrieved from http://www.mlit.go.jp/maritime/maritime_tk4_000017.html

Ogosi, T. (2019). *Geographic Statistics Handbook 2019 edition Vol. 59*. Ninomiya Bookstore.

OPEN CLASSROOM APPROACH ENCOURAGING INTEREST IN ENGINEERING INSPIRED BY THE JAPANESE TRADITIONAL RIVER TRAFFIC "TAKASEBUNE"

K. Hosotani[*,a] and J. Morimoto[b]

[a] Dept. Integrated Science and Technology, NIT Tsuyama College, Tsuyama city, Okayama, Japan
[b] Wake Museum of History and Folk Materials, Wake town, Okayama, Japan

*hosotani@tsuyama.kosen-ac.jp

Abstract

Transportation by river traditionally relied on "Takasebune," sailing ships with a length of 15 m that played a key role in logistics in Okayama Prefecture in Japan until the early Showa period (1930s). Descriptions of these vessels in historical documents describe the harnessing of wind for sailing upstream. Records of past river traffic lead us to expect winds to blow stably from the estuary to the middle basin throughout the year in Okayama. In our previous research, the wind energy used by Takasebune was evaluated by field surveys and numerical simulations, and its capacity to assist sailing was confirmed. This result may also support educational activities exploring the use of renewable energy in the past. In this article, a public lecture on wind energy and its exploitation by Takasebune was proposed. It was expected to help address sustainability issues on a regional level by encouraging innovation. The open lecture was delivered annually for five years to elementary school students and adults living in Okayama. During the lecture, documentary evidence on the history of Takasebune was presented first, after which the scientific principles underlying the use of wind power were discussed. Then, experiments using boats and paper-cup windmills were conducted to consider the effective use of local winds. This combination of lecture and activity was intended to be applicable to a wide range of age groups.

Keywords: *sustainable energy, educational program, social study, Takasebune, windmill design*

Introduction

In elementary and junior high schools in Japan, social education provides students with the opportunity to learn local history and cultural features and, thus, to understand the characteristics of their local community. Recently, project-based learning (PBL) on the "innovation ecosystem," which focuses on local social issues and the creation of new local industries has been developed by local governments. In the standard school curriculum by the ministry of education of Japan (2017), study of the natural environment and the traditional culture of the local community are prescribed for the middle grades of elementary school. In junior high schools, teachers instruct on environmental and energy issues, which are foundational for a sustainable society. PBL-style interactive lessons have been employed in many classes to avoid a one-way medium of learning. PBL lessons, intended to foster innovative ideas leading to a sustainable society, are also being attempted in the field of engineering education. In this context, community learning has been combined with science and technology. For example, lessons involving study of local wind energy and practical interactive lessons on the relationship between roads and industries have been reported. Similarly, specialized lessons on disaster prevention in areas using virtual reality technology have been reported. As a unique local learning method, the use of advanced technology to teach about historic buildings or the history of disasters in a given community has been proposed (e.g. Fujii et.al., 2010). These lessons have the potential to impress upon participants a sense of affinity or attachment to their residential area. The combination of history and science in a lesson considering the energy balance of a technology otherwise encountered only in historical documents may be especially effective for sustainable social education. However, some difficulties remain in designing this combination lesson. Children may be more or less oblivious to the existence of old buildings in their area, and special effort may be required to motivate them. Furthermore, although class activities involving reading historical documents are widespread for general citizens and participants can get a glimpse of past local societies in medieval and early modern periods, it can be quite difficult for children to read and understand such documents. Conversely, participants interested in local history may not participate as actively in a component involving historical science, given that a basic knowledge of science is required. Perhaps for these reasons, there seem to be few public courses that combine social learning and science and technology while appealing to all ages. The aim of this study was to identify a theme for an open lecture that could respond to a wide range of age groups while encouraging the development of a sustainable society. Accordingly, we focused on the use of wind energy by traditional river traffic in Okayama Prefecture, western Japan (Figure 1), prior to the early Showa era (1930s). Many documents of

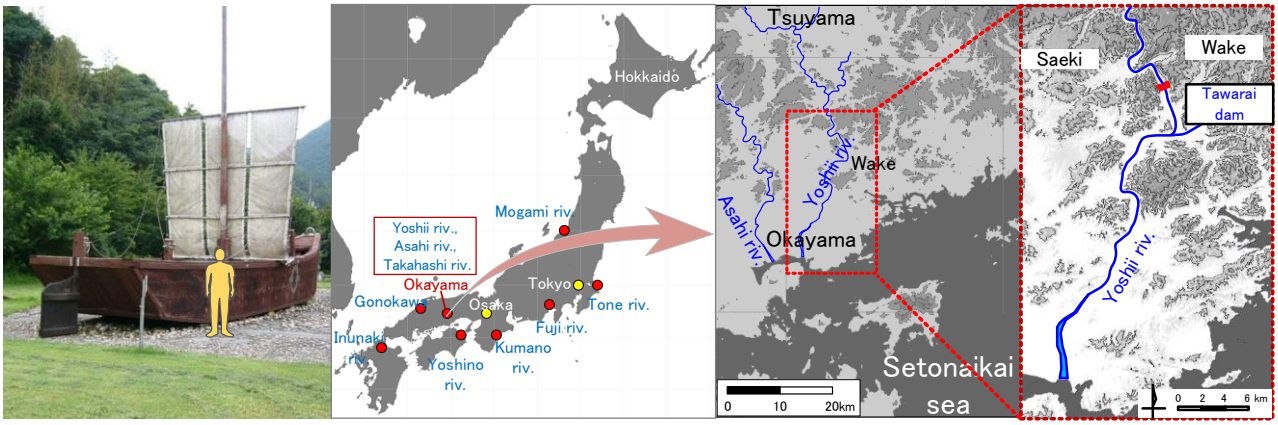


Fig. 1 Takasebune (reconstructed model) and location map of Yoshii River, Okayama, Japan

the period suggest that wind power was used for the operation of "Takasebune" as shown in Figure 1 to Figure 3. In a previous study, the use of wind by Takasebune on the Yoshii River in Okayama was evaluated by field surveys and numerical simulations, and the feasibility of exploiting this energy for sailing was confirmed (Hosotani et.al., 2012). The report showed, however, that windy areas and periods during which wind could be used to help power Takasebune were limited. For the purposes of a classroom activity on sustainability, a focus on local and regional wind energy might be a suitable example. Therefore, we developed an open lecture that considers the history of the region and how wind power was exploited to power Takasebune. The interactive lesson had a historical science section and an experimental section that were combined to accommodate a wide range of ages. This report first describes the characteristic wind conditions encountered by Takasebune on the Yoshii River in Okayama Prefecture, Japan. Then, the method of the open lectures delivered in Tsuyama City in the northern area of Okayama Prefecture and Wake Town in the middle basin are described. Finally, the state of the class and the results of the class questionnaire are reported.

Operation of Takasebune and Wind Conditions

(1) Takasebune of the Yoshii River

Japan, being located in the monsoon area and surrounded by the sea, has many rivers; therefore, transport by river was a major means of distribution until the early modern period. In Okayama Prefecture, western Japan, where there are three primary rivers with a width of 100 m, a river transportation system using a boat capable of sailing called a Takasebune (Figure 2 and Figure 3) was the main means of transportation between coastal and inland cities. Takasebune of the Middle Ages was small, but from early modern times a large, flat bottomed boat with a hull length of 15 m was used. According to historical documents, as many as 200 boats operated per river during the Edo period from the 1600s to the 1800s (e.g. Wake Museum of History (no date), Okayamagaku Research Association (2005), Okayama Pref.(1986)). One of the largest rivers in Okayama, the Yoshii River has a stream length of 133 km and a basin area of 2,110 km^2. Water reaches the Okayama plain along steep valley terrain from the Tsuyama basin in the north, surrounded by the Chugoku Mountains and the Kibi Plateau, and then discharges into the Setonaikai Sea. The distance between Tsuyama City and Okayama City, the main logistical termini, is 72.4 km, with Wake Town serving as a relay point between the two. River width varies from 100 m to 160 m, while the altitude difference between Okayama and Tsuyama is about 100 m. Regarding wind conditions in northern Okayama, an east to west wind prevails in the Tsuyama basin, which is about 30 km east-west and 10 km north-south. The wind is usually calm but stronger local winds known as Hiroto occur several times a year. Sea and land breezes are generated in the southern Okayama plain (Mori, Y. (1996), JMA report (2005)). The wind in the middle basin near the sea is not strong, but in the river basin, surrounded by slopes, the wind is affected by the topography.

(2) Documentary evidence on Takasebune

The 15 m-long Takasebune plying the Yoshii River traveled the 72.4 km between Tsuyama City and Okayama City in one week during the 18th century. The cargo capacity of the vessel was about 1 ton up river but about 6 tons down river. Typically, daily items and marine products were transported up river, while rice, charcoal, firewood, and tiles were conveyed in the opposite direction. If it traveled from Okayama to Tsuyama in three days, the boat's average speed would be expected to be 3 km/h. In the middle basin, where Wake Town flourished as a relay base, the Tawarai Dam was built for irrigation purposes. As seen in Figure 2, a photograph of Takasebune taken in Wake Town during the Taisho era, some boats were towed through a steep channel called "Sedoushi." Some boats terminated here, with their cargo being transferred to other boats anchored on the other side of the dam. Although the magnitude of the wind is not explicitly described in historical

documents, we can estimate both it and the human power involved in the Takasebune's operation using such documents and memoirs. For example, as shown in Figure 3, a drawing owned by a leading merchant "Okunike" depicts a Takasebune sailing upstream and shows boat crews gently pulling on a rope. According to the old records, two boats were connected when traveling upstream, and two men per boat pulled the tow ropes. Some data suggest that sailing was possible from the estuary to the middle basin around Wake Town. Conversely, it seems unlikely that sailing is possible in the mountainous area north of Wake Town. In the northern area near the terminus, sailing may have been undertaken in the presence of a basin-specific wind. Although vessels similar to the Yoshii River's Takasebune travelled many of Japan's rivers, (Figure 1), the documentary evidence provides no direct information on wind magnitude.

(3) Estimating wind power using historical documents

As shown in Figure 4, the resistance encountered by a ship sailing close to a riverbank, and avoiding turbulent areas, is expressed by the following equation.

$$\boldsymbol{D = C_D \frac{1}{2} \rho_w A V^2}$$

Here, A is the projected area (A = 0.6 m^2, as estimated for a cargo load of one ton). Treating the hull as a rectangular parallelepiped, the drag coefficient C_D was set at 2.0, and the resistance of the hull encountering a flow of water of about 1 m/s, as obtained from flow data, is estimated to be 600 N per boat. In contrast, the force of a boatman pulling a tow rope can be estimated from the body tilt angle (based on past pictures and photos, θ = 70° is estimated). A pulling force per person of F = 428 N is obtained from the rotational moment of the lower body. The validity of this value can also be confirmed from the frictional force $F = \mu N$ = 434 N between the shoes worn by the boatman and the stone pavement (herein, friction coefficient was estimated from student's report on "the physics challenge in 2015"). This pulling force may be likened to pulling a leveling roller and boatmen can pull the boats without slipping. The assisting wind force under sail is obtained by the following equation.

$$\boldsymbol{F = C_L \frac{1}{2} \rho_{air} S u^2}$$

Here, C_L is the lift coefficient, and the sail area S is 9 m^2. The lift coefficient with an attack angle of 10° is approximately C_L = 1.2. Thus, by working backward, the wind speed required to counteract the drag force of the water flow can be estimated as u = 4 m/s.

(4) Observed wind characteristics in the basin

Takasebune shown under sail in old documents suggests the possibility of wind power generation in valley terrain. In our previous study, wind characteristics of the Yoshii River basin were investigated by field observation and numerical simulation. As an example of the wind observation results, the time series of average wind velocities observed on the roof of the gymnasium in Wake Town in the middle basin are shown in Figure

Fig. 2 Takasebune on the Yoshii River, photographed in the Taisho period (owned by Wake museum of history)

Fig. 3 Takasebune sailing up river
(Source: Okunike pictorial record (2002))

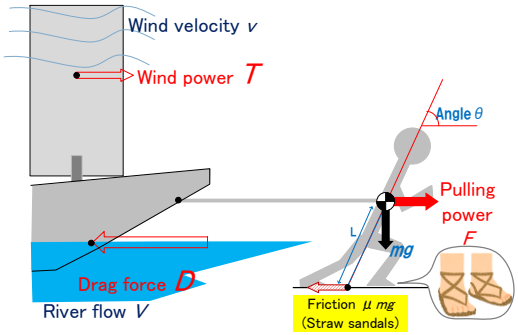


Fig. 4 Assisting force of wind and pulling force

5. Wind velocities of 2 m/s to 3 m/s of were obtained throughout the year during the day, while at night the winds tended to remain calm. The frequency of gusts was similar to that found inland, despite the location of the observation point in a valley. This wind behaviour can be regarded as a density flow associated with thermal circulation on land. The seasonal variation of wind flow fields was estimated using the "Mass-consistent model," which estimates wind speed between discrete observation points. Estimated surface wind vector fields (south wind and north wind) are shown in Figure 6. At Tawarai Dam, an inflow wind along the valley was observed. In the case of southerly winds, the wind flows along the river easily. Conversely, in the case of a northerly wind (typical during the winter or in the presence of a low-pressure air mass), the velocity in the valley is small. Inflowing winds along the river line do not develop in the northern area of the middle basin. As aforementioned, although wind energy could serve as an auxiliary power source for the Takasebune, wind energy in this area is unfortunately unsuitable for commercial wind power generation. Using

micro wind turbines with a wind receiving area of 1 m^2, an average wind energy density of about 18.2 W/m^2 was obtained, at an average wind speed of 2.5 m/s. This yields a power potential of 31.5 kWh. In any case, the annual average wind velocity in the Tsuyama basin is also small, about 2 m/s, with correspondingly small wind energy. Moreover, it is necessary to consider the gusts caused by the Hiroto wind.

Open Lecture "Takasebune and Wind Energy"

As aforementioned, wind characteristics in the Yoshii River basin are not suitable for commercial wind power generation, but the historical fact that local winds were used to help propel Takasebune could encourage interest in sustainability. To propose effective use of the wind requires creative ideas, which can be used for education that leads to technological innovation. For this study, an open lecture was designed, which aimed to combine elements of history and engineering on Takasebune for a wide range of ages.

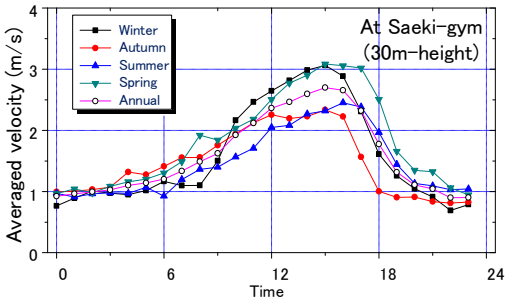


Fig. 5 Time series of average wind velocities

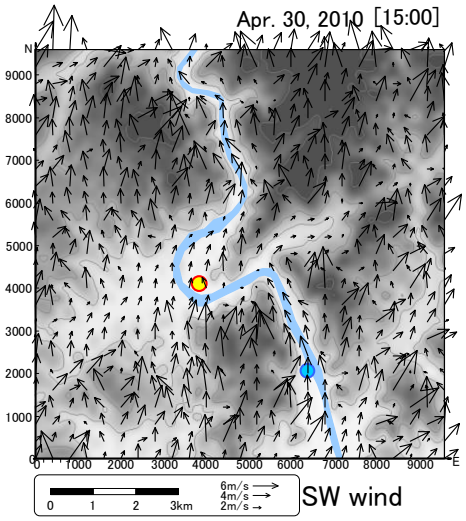


Fig. 6 Estimated surface wind in the middle basin (Hosotani et.al., 2012)

Table 1 Open lectures conducted and number of participants

Year	Place / organizer	Participant	Number of participant
2013	Wake town / Board of education	Elementary school student	31
2014	Wake town / Board of education	Adult (golden age)	15
2017	Tsuyama city/ Board of education	Elementary school student (6th grade)	25
2017	Tsuyama city/ Board of education	Elementary school student (4th - 6th grade)	13
2018	Tsuyama city/ Central library	Adult	60
2018	Misaki town/ Central library	Elementary school student	20
2019	Maniwa city/ Central library	Adult	20
2019	Tsuyama city/ Central children's center	Elementary school student (- 4th grade)	10

(1) Class form

Lectures were held in public venues organized by the Public Library and Board of Education in Tsuyama City in northern Okayama Prefecture and Wake Town in the central part of the basin. Classes were recruited into two categories based on age group. One group comprised elementary school students, while the other was for adults (mainly those aged 60 or older). Classes have been held every year since 2013, with a total of 194 participants, as shown in Table 1.

(2) Teaching materials

In each class, model ship and paper windmill kits were distributed to provide the elements of a fluid dynamics experiment. Figure 7a shows the Takasebune model used in the lesson. This craft model was made of laser cut 5 mm thick styrene board and was 18 mm in length. Participants attached paper sails and rudders to the boat and their creations were then propelled by wind from a fan. Figure 7b shows a paper-cup windmill. Participants made a notch in a paper cup (7 oz) to make a windmill blade and attached it to the holder. The holder is devised so that a vertical wind turbine can be converted into a horizontal wind turbine.

(3) Classroom approach

The open lecture was entitled "Wind energy used by Takasebune of the Yoshii River," and it was organized as a three-hour class. In the first half, the wind power used by Takasebune, as predicted from documentary evidences, was explained in a lecture that included discussion and quizzes. In the second half, participants considered how local winds could be used effectively through model boats and windmills. In historical science, biases created by misleading information based on speculation and hearsay can often present a serious challenge. In this class, the objective evaluation of results by actual measurement was explained carefully. Although the concepts of drag and lift required for sail design were explained without using equations as much as possible, it was emphasized that they are proportional to the square of the wind speed. Participants, both adults and children, made trial-and-error based sails and sailed their boats in a water tank equipped with a fan. In the class comprising elementary school children, the windmill-making in the second half was omitted, and the students were given time to paint their sails and to participate in a relay competition. In the windmill design session, participants built a windmill that matched the local wind and tested it in front of the fans. The instructor did not simply provide participants with typical answers but encouraged participants to communicate actively

with student assistants and to develop their own ideas. The resulting dialogue and discussion among the participants led to the creation of some unique ships and windmills. At the end of the class, a satisfaction questionnaire was conducted.

Classroom scene and questionnaire

(1) Classroom scene

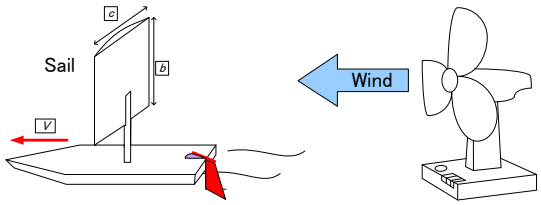
Figure 8 shows snapshots of the classroom scene. In each class, the instructor and student assistants walked through the classroom, using gestures and body language to express the size of the Takasebune and the speed of the winds they exploited. A quiz was used to explain wind and traction, so participants could intuitively imagine the amount of energy involved while having fun in a calm atmosphere. During a craft and experiment session, some participants were initially unable to move the ship and windmill but were eventually able to complete the model ship and paper windmill through trial and error. In the class for children, imaginative sails and a variety of windmills were created. One child told the instructor that he had made a unique windmill like a brush, conscious of the wind blowing in the area. By contrast, there were few original works in the classes for adults. Instead, participants eagerly talked about childhood memories of Takasebune during free discussion.

(2) Questionnaire and results

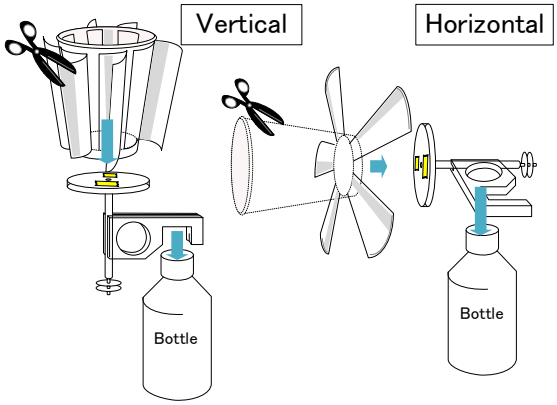
A questionnaire survey was conducted to evaluate the class and the possibility of using the local wind. The results of the questionnaire are shown in Figure 9 that is summarized by age groups. Satisfaction levels among both groups were very high, and the response "Neither" was given by only a few percent. Regarding the use of local wind, roughly half responded that it could be used in both groups; however, a larger number of adults responded "Neither." Although we asked participants to describe a novel idea for wind use, the number of responses was small. The answers described in the free text box included "Tourism resources," "Wind power plant," and "Driving force for sightseeing pleasure boats." Some comment pointed out the issues of this class that deal with both history and technology: "I attended this lecture after hearing about the history of Takasebune, but I was surprised to hear the story of the wind." Some answers indicate that trial and error was effective in this lesson, such as "I enjoyed thinking and wondering." Additionally, some answers praised student assistants for their support.

Conclusions

Documentary evidence includes not only memories of local culture and climate but also hints on energy sources that can be used in modern society. An open lecture that combined historical and social education with science and technology education on wind energy used by Takasebune in Okayama Prefecture was delivered to both children and adults. Lectures, crafts, and experiments that provide a physical example of the



(a) Takasebune model



(b) Paper cup windmill

Fig. 7 Craft kits

(a) Crafted boat

(b) Windmill test

Fig. 8 Classroom scenes

energy use described in historical documents were able to appeal to both children and adults. However, as demonstrated by the survey results, the lesson content did not always exactly match the participants' needs, suggesting that improvement is needed. In the future, a class will be held wherein child participants and adult participants are mixed in one classroom with college students being invited to participate as well. This lesson will also be held in other areas where Takasebune or similar vessels operated regularly.

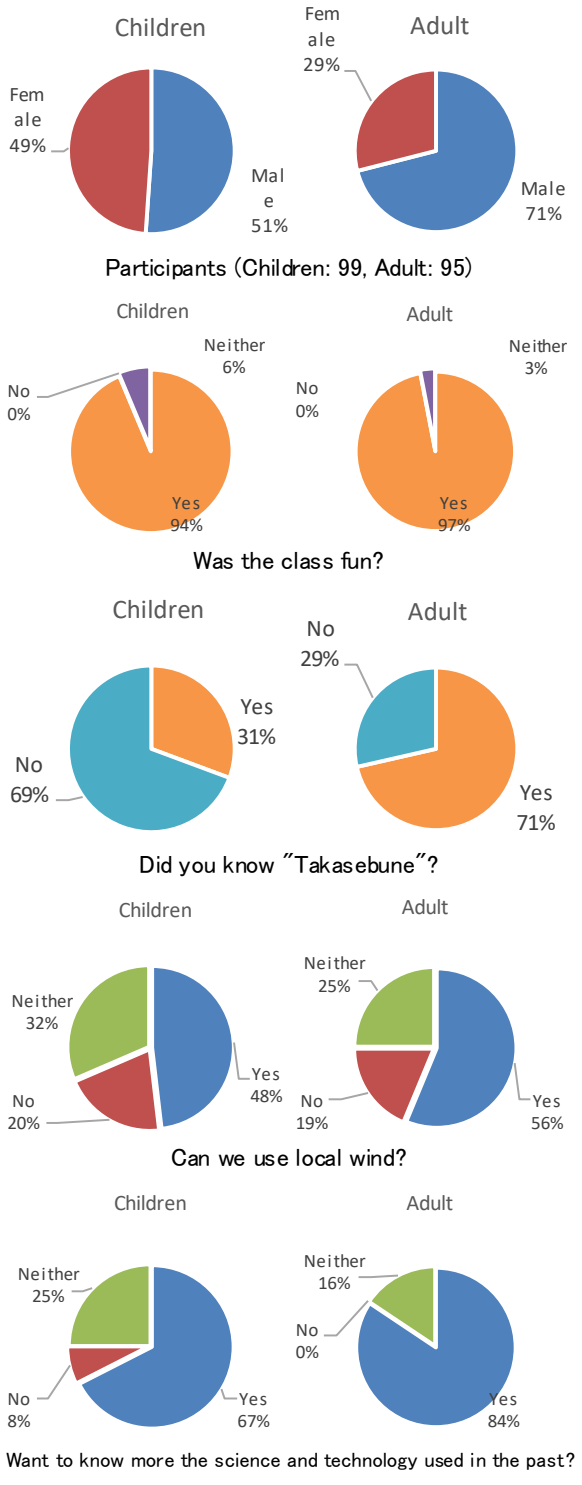


Fig. 9 Questionnaire result

References

Fujii, S., Karaki, K., Kudo, B., Ikeda, T., Okamura, M., Ogata, H., Takahashi, K., Taniguchi, A., Hibino, N., Horihata, Y., Hara & F., Matsumura, N.(2010), Significance and potential of collaboration between civil engineering and societal education, *Journal of Japan Society of Civil Engineers*, H, 2, 39-44 (in Japanese).

Hosotani, K., Morimoto, J. & Noguchi, T.(2012), Study on wind characteristics around midstream of the Yoshii River in Okayama in which the traditional traffic system called 'Takasebune' has operated, *Journal of Japan Society of Civil Engineers*, G, 68, 4, 213-223 (in Japanese).

Japan River Association (2002), Handbook of River, 427pp (in Japanese).

JMA (Japan Meteorological Agency) (2005), Retrieved from http://dl.ndl.go.jp/info:ndljp/pid/1933714(accessed 2020-04-29).

Ministry of education (2017), Curriculum guidelines "Elementary School", "Middle School" (in Japanese), Retrieved from https://www.mext.go.jp/en/index.htm (accessed 2020-04-29).

Ministry of Land, Infrastructure, Transport and Tourism (2008), Summary of the Yoshii River and basin, 90pp. (in Japanese).

Mori, Y. (1996), On the relationship between land-and sea-breezes and the pressure field in the Central Part of the Seto-Inland Sea District, *Tenki*, 43, 1, pp.33-41.

Okayama Pref. (1986), The history of Okayama, 7 (2) , 743pp (in Japanese).

Okayamagaku Research Association (ed.)(2005) , Rsesearch of Yoshii River 4, *Kibito Syupan*, ISBN-10 : 4860690850 140pp (in Japanese).

Okunike (2002), Okunike pictorial record (title in Japanese), 100pp.

The committee of Japan physics Olympiad (2015), Report of the physics challenge in 2015, Retrieved from http://www.jpho.jp/2015/2015-1st-chall-exp-report/index.html (accessed 2020-04-29).

Wake Museum of History and Folk Materials (no date), (titles in Japanese).

Educational Program to Develop Global Engineers based on Nagaoka CO-CORE Vision

Y. Tsuchida[*,a], Y. Ominato [a], S. Toyama [b], N. Aoyagi [c], S. Nakamura [d], H. Araki [e] and A. Suzuki [e]

[a] National Institute of Technology, Nagaoka College, Division of General Education, Nagaoka, Japan
[b] National Institute of Technology, Nagaoka College, Department of Electronic Control Engineering, Nagaoka, Japan
[c] National Institute of Technology, Nagaoka College, Department of Mechanical Control Engineering, Nagaoka, Japan
[d] National Institute of Technology, Nagaoka College, Department of Electrical and Electronic Systems Engineering, Nagaoka, Japan
[e] National Institute of Technology, Nagaoka College, Department of Material Engineering, Nagaoka, Japan

*ytsuchida@nagaoka-ct.ac.jp

Abstract

National Institute of Technology, Nagaoka College (NITN) has started the new educational program to foster students as global engineers. As SDGs are typical examples, there are various problems in today's world which could not be solved without cooperation of diverse people. In order to work actively in the world, not only the English language ability but also the cooperative competence is required. According to the investigation we recently conducted, students' TOEIC L&R test score has been increasing but there could be room for improvement: The evaluation of thinking ability is relatively low compared with the other abilities. Besides, the results of PROG test, which is one of generic skill assessment tests widely employed at universities in Japan and can assess generic skills such as interpersonal relationship management and problem solving, indicated that students in NITN have relatively low ability of cooperativeness and independent action. Furthermore, the survey we conducted on students' and teachers' needs showed that students want to experience the real feeling of success in English communication and teachers need to have the common goal for effective education. These facts gave us the insight that we could bring up NITN students to the next stage by developing the program, which can enhance students' abilities of thinking and cooperation. The thinking ability is very important and should be the common, cooperative and corelative core of the new curriculum so we named our new target "Nagaoka CO-CORE Vision" and started designing the course which can improve students' language ability, thinking ability and cooperative ability through actual practice and international educational activities. In this program, students are supposed to acquire cooperative ability through doing group works with people from different departments and attending PBL projects. To realize this, several modules of general English conversation class have reorganized into classes in which students can learn critical and logical thinking, constructive discussion, and the method of design thinking. In this study, the educational program development based on current state and needs analysis in NITN is discussed. Our approach could be used to enhance students' key competence effectively and efficiently involving international cooperation and new standpoints of module management.

Keywords: *cooperative ability, critical thinking, design thinking, problem based learning, project based learning*

Introduction

National Institute of Technology, Nagaoka College (NITN) has been making efforts to promote internationalization from an early stage of our school history. We started accepting international students in 1985. Since then, we have established academic partner schools overseas, and have developed mutual sending and accepting projects. Currently we have about 20 international students, approximately 2% of all the students, and temporarily about 30 students from Asian countries. In 2019, we started accepting fifteen-year-old Thai students in our Kosen's first year program. The welcome atmosphere of international exchange is

increasing, and students' interest in foreign countries is also increasing. The English ability of students is improving, however, it became clear that students want the feeling of being able to use English. This was the start point for us to improve our curriculum and develop a new education program to foster students as global engineers. In this research, we review our procedure to prepare, introduce the outline, then consider the educational effect of our program.

Methods

In preparation for the program development, we analysed the situation at that time based on some data: 1) TOEIC L&R Test result to know students' language ability, 2) PROG Test result to know students' generic skill level, and 3) Needs analysis on English education for students and teachers.

In NITN, all the fourth graders (the same age as the first graders in the university) take the TOEIC L&R Test. The change of the results is shown in Fig. 1.

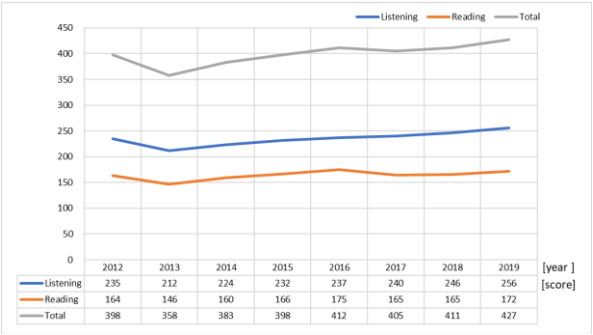


Figure 1: Change in TOEIC L&R Test Result in NITN (2012-2019)

In Fig. 1, Listening test scores improve steadily, while reading test scores show little growth. To find out the cause, we focused on "Abilities Measured" in TOEIC Test results. In the test results, the percentage of correct answers per ability type is indicated as Abilities Measured. This shows the percentage of correct answers for the five Listening and the five Reading abilities. Details of each item are shown in Table 1 and the change in Abilities Measured is shown in Fig. 2.

Table 1: Details of TOEIC L&R Abilities Measured

ID	Detail
L1	Can infer gist, purpose, and basic context based on information that is explicitly stated in short conversations, announcements, narrations, and similar.
L2	Can infer gist, purpose, and basic context based on information that is explicitly stated in longer conversations, announcements, narrations, and similar.
L3	Can understand details in short conversations, announcements, narrations, and similar.
L4	Can understand details in longer conversations, announcements, narrations, and similar.
L5	Can understand the goals and implied meanings of the speaker from phrases or text. (since 2017)
R1	Can make inferences based on information in written texts.
R2	Can locate and understand specific information in written texts.
R3	Can connect information across multiple sentences in a single written text or across multiple texts.
R4	Can understand vocabulary in written texts.
R5	Can understand grammar in written texts.

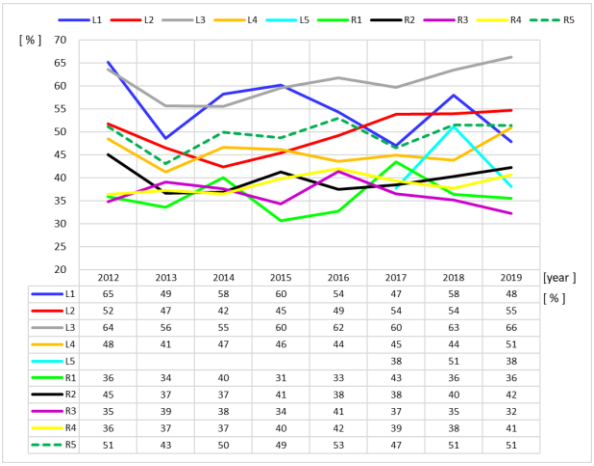


Figure 2: Change in TOEIC L&R Abilities Measured in NITN (2012-2019)

In Fig. 2, we can point out that R1 and R3 are gradually decreasing while L2 and L3 are constantly increasing. R1 requires the ability to make inference and R3 requires the ability to connect information. This is the reason why we decided to provide a new course which foster students thinking ability.

To analyse students' generic skills, we have adopted the PROG Test, which is one of generic skill assessment tests widely employed at universities in Japan and can assess generic skills such as interpersonal relationship management and problem solving. The test has two categories of the Literacy Test and the Competency Test. In NITN, the first graders, the fourth graders and the second graders of the advanced course take the PROG-

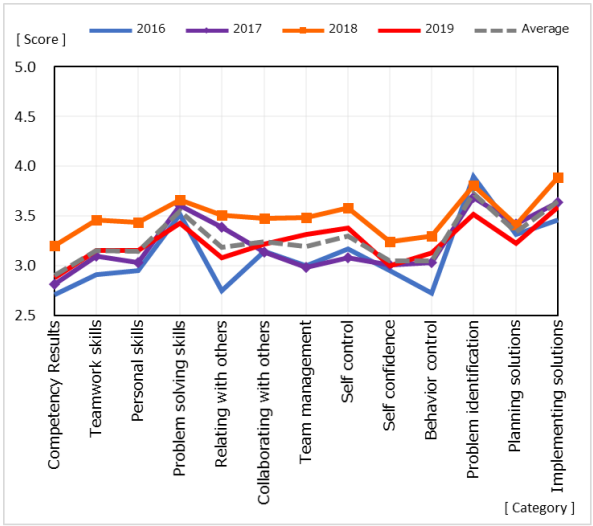


Figure 3: Change in main categories of PROG-Competency Test result in NITN (2016-2019)

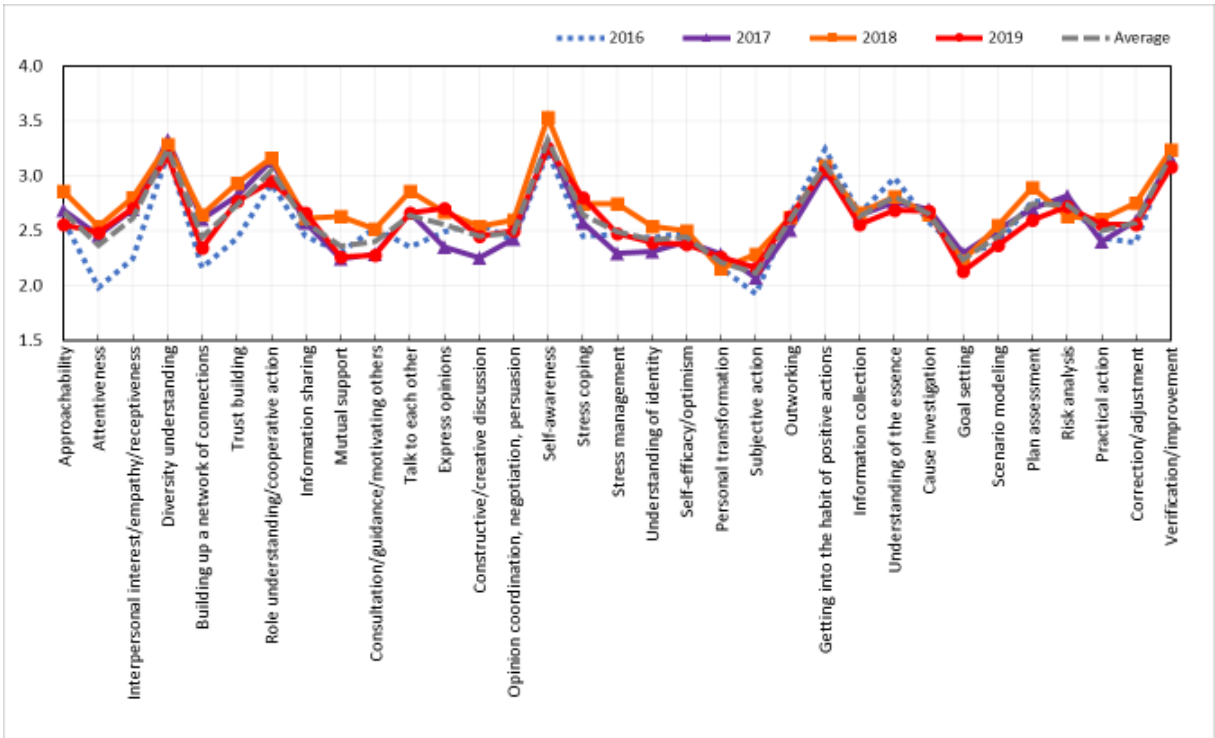


Figure 4: Change in sub categories of PROG Test Result in NITN (2016-2019)

Competency Test. The change we found from the results in the PROG-Competency Test main categories is shown in Fig. 3. The change we found from the results in sub categories is shown in Fig. 4. In the PROG test, the assessment is done at 7 levels and the average score of the Competency Test for university students in Japan is 3.2.

From Fig. 3, Teamwork skills, Personal skills and Self-confidence are lower than the Problem solving skills in NITN. Fig. 4 provides more detailed information. While Self-awareness is very high, Personal transformation and Subjective action are relatively low in every year. This means that students have a very strong consciousness, but they have little ability to take action and experience to do that. These data suggest us to provide an opportunity to utilize the skills they got and let them experience the achievement. From this point of view, some kinds of practical exercises in various fields should be prepared in our new educational program.

Just before starting the program design, we conducted a survey for students and teachers about English education. 752 students and 47 teachers answered through Google Form. In order to grasp our students' needs for English education, we asked them what kind of lectures we should offer, and the answers are shown in Fig. 5. For teachers, another question was provided which asked what their ideal image of their students in the future, and the answers are shown in Fig. 6.

In Fig. 5, almost 50% of the students requested the conversation class, and nearly 25% of them requested TOEIC Test preparation. This result tells us that students crave for the practical language ability to communicate and the real feeling of success in English communication.

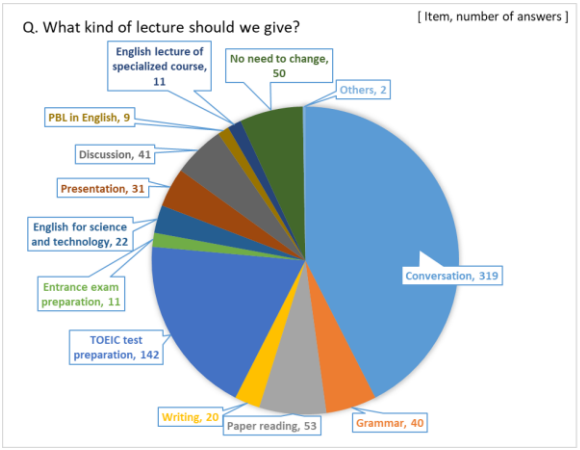


Figure 5: Questionnaire to students; "What kind of lecture should we give?"

From Fig. 6, almost one third of teachers in NITN also would like to require students to have the conversation ability in English. Also, they consider it important to have the presentation and discussion abilities as well. In addition, each teacher has their own opinion or policy for English education from the free description of the survey. It was revealed that individual teachers had strong interest in English education, but their directions were not unified.

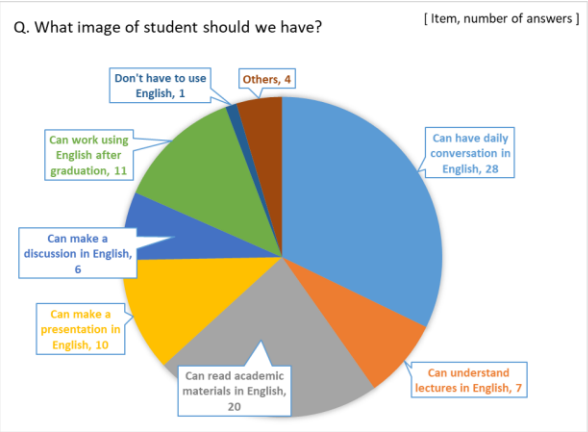


Figure 6: Questionnaire to teachers; "What is your ideal image of the students' English ability?"

Results and Discussion

From the analysis of TOEIC and PROG Test result and the needs analysis on English education, discussions among Kosen professors were held on the image of the global engineer required in the future society. In order to be able to "use English" as an engineer, it was concluded that a collaborative competency is essential in addition to a certain basic English language ability. To develop this collaborative competency, it is necessary to develop a curriculum that can develop the thinking ability and the ability to take action to realize the collaboration and generate the output. The thinking ability is very important and should be the common, cooperative and corelative core of the new curriculum so we named our new target Nagaoka CO-CORE Vision and started designing the course which can improve students' language ability, thinking ability and cooperative ability through actual practice and international educational activities. 1) Language & communication ability, 2) Thinking ability, 3) Ability to practice and 4) Ability to challenge; these four main abilities are the bases of the curriculum of our new educational program. In order to foster students' ability to take action, the program was designed to increase the amount of practical exercises as their school gradeds progress. The outline of the program in NITN is showin in Fig, 7.

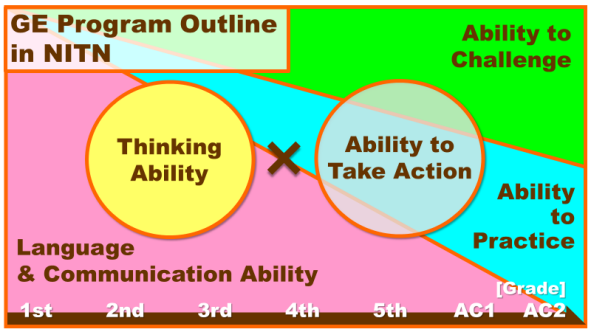


Figure 7: The outline of the new educational program in NITN

In the lower grades, the program was designed as a preparation step to develop a global mind that can play an active role in the world, with an emphasis on basic English ability and thinking ability. In the upper grades, we focused on practical skills and challenging skills, and provided many opportunities to output the knowledge and information so that the program can enhance students' experience. By linking the lower grades programs and the upper grades programs, we aim to develop "Kosen students who can work collaboratively in English."

In this program, students are supposed to acquire cooperative ability through group works with people from different departments and PBL projects. To realize this, several modules of general English conversation have reorganized into the essential thinking courses in which students can learn critical and logical thinking, constructive discussion, and the method of design thinking. The framework of the courses is shown in Fig. 8.

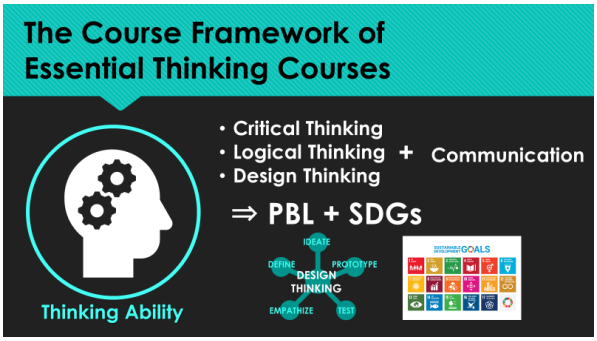


Figure 8: Framework of the essential thinking courses

Specifically, the essential thinking courses were designed so that students could practice their critical thinking, logical thinking, and design thinking abilities in the activities of problem-solving learning, and practically acquire the ability to discuss in English throughout the lesson. We designed the framework and planned the class procedure in 2019, then the new courses will start in the spring of 2020.

2019 was the first year of our new program. To motivate students, we conducted specialized classes in English by foreign teachers including teachers from partner schools. For this purpose, we newly welcomed two international teachers and they joined to design the framework of the essential thinking courses. To improve students' abilities to practice and challenge, we encouraged them to participate in overseas training and internships actively. To cultivate the internationality of students and encourage them to learn independently, we promoted the internationalization of the campus with role models of international students. We also provided an environment of e-learning and online English conversation both for students and teachers so that they could improve their skill to teach in English.

Table 2 shows the achievement status of the performance indicators. In the lower grades, though the degree of achievement is low in terms of students' experience of international collaboration, it is considered

that this project has increased students' interest in foreign countries. In the upper grades, the number of students who have experience to be abroad is very large. The number of active participation in overseas internships and participation in academic conferences and international conferences held overseas tend to increase significantly. The performance indicators have almost reached the target values in 2019, and it is considered that we have made a good start in the first year of the project.

Table 2: Performance indicator achievement

Indicator		Final goal in 2023	Goal in 2019	2019
Lower grades (1st to 3rd)	TOEIC L&R Test Score (3rd graders)	450	310	366 (+56)
	Overseas experience (3rd graders) [%]	16	6	6 (0)
	International collaboration experience (3rd graders) [%]	100	20	8 (-16)
	Competency of collaboration	4.0	3.4	3.4 (0)
Upper grades (4th to 2nd of the advanced course)	TOEIC L&R Test Score (5th graders)	510	410	426 (+16)
	TOEIC L&R Test Score (AC2)	615	425	410 (-15)
	Overseas experience (AC2) [%]	24	16	24 (+8)
	International collaboration experience (AC2) [%]	100	20	26 (+6)
	Competency of collaboration (AC2) [PROG Test score]	4.2	3.8	4.5 (+0.7)

Conclusions

Our new project organically positions the past achievements of international exchange activities in our educational program. The purpose of this project is to set a place for practice and foster students' collaborative competencies. In order to plan this program, we had the opportunity to look back on our efforts and discuss the future education with many teachers. We had many discussions and examined what kind of education is needed now and what kind of education is required in today's society. In addition to having a common vision, we were able to draw a new system diagram in our college for the effective project management. These support the realization of smooth start in the first year. Our approach could be used to enhance students' key competence effectively and efficiently involving international cooperation and new standpoints of module management.

Acknowledgements

This work was supported by Global Engineer Development Project (promoted by National Institute of Technology).

References

"Abilities Measured (Percentage of Correct Answers per Ability Type)," Official Score Certificate Format (TOEIC Listening & Reading Test), IIBC Official English Site, Retrieved from https://www.iibc-global.org/english/toeic/test/lr/guide05/guide05_01.html

"Student image observed from PROG," Materials for 2015 PROG Seminar, Kawaijuku group Official Site (Japanese), Retrieved from https://www.kawaijuku.jp/jp/research/prog/event/pdf/2015progtyo_4.pdf

PRACTICAL EDUCATION OF BIOLOGICAL DIVERSITY AND SUSTAINABLE MANAGEMENT OF ENVIRONMENT USING SMALL WETLAND ON CAMPUS

S. Miyakoshi[*,a], H. Sakuraoka [b] , N. Miyazato [c], H. Ooka [d], T. Sato [b],
A. Horio [c], K. Owada [d] and T. Aoi [c]

National Institute of Technology (KOSEN), Gunma College, Maebashi, Japan
[a] Department of Natural Science
[b] Department of Humanities
[c] Department of Civil Engineering
[d] Department of Chemistry and Material Science

*miyako@gunma-ct.ac.jp

Abstract

In recent years, the understanding for biological diversity and environment is required from engineering students of all disciplines. There is a pond (wetland) called Shokanji-numa with an area of 7,000 m^2 on campus of Nationai Institute of Technology (KOSEN), Gunma College, whose biodiversity had been reported by our previous research on wild birds, plants and some microorganisms. We developed high school-level biology classes focused on biological diversity and college-level classes of environmental engineering for sustainable society called "Satoyama-Satoike" class based on "Satoyama Initiative (COP10, 2010)". Previous research on the diversity of this wetland revealed that more than 90 species of wild birds are observed and some of the species breed on the pond. The study also clarified that the wetland occupied by reed or *Phragmites australis* is a good model of wetland succession. Worksheets for counting of avian species and higher plants around the pond were prepared and used in the basic biology classes. These tools helped students understand the biological diversity and succession of the flora.
In the courses for upper grade students, environmental assessment and "Satoyama-Satoike" activities were practiced as follows. Environmental assessment was carried out by continuous counting of wild birds and plants. In "Satoyama-Satoike" class, reed cutting activity was practiced to preserve the wetland. The effect of the bottom mud of the pond to stimulate growth of plants was evaluated using *Brassica rapa* var. *perviridis*, and the possible utilization of the dredged mud was demonstrated. By using the unique wetland on our campus as an educational tool, we have developed basic biology classes focused on biodiversity and its succession, as well as "Satoyama-Satoike classes" for college-level students to understand sustainable management of environment.

Keywords: *biodiversity, wetland, Satoyama, wild bird, sustainability*

Introduction

Shokanji-numa is a small wetland with an area of 7,000 m^2 on campus of NIT (KOSEN), Gunma College, which is located in the center of Japan. This pond was originally constructed as a buffer pond of Maebashi Airport, and has been utilized as a reservoir for the surrounding paddy fields.

Figure 1 Shokanji pond on campus of National Institute of Technology (KOSEN), Gunma College, (after renovation in 2012).

Miyakoshi has been conducting research on the diversity of this pond as well as its surrounding environment for 13 years and reported more than 90 species of wild birds on this small wetland. Several heron species and common kingfishers (*Alcedo atthis*) are residents of the wetland, while several kinds of ducks migrate from Siberia to stay over the winter, and some species including little grebe (*Tachybaptus ruficollis*), black-crowned night heron (*Nycticorax nycticorax*) and common moorhen (*Gallinula chloropus*) breed in the reeds every summer. And occasionally, goshawks (*Accipiter gentilis*) come in search of prey (Miyakoshi. S. 2010, 2016). Diversities of plants, fish, and mammals have also been reported. Weasels, badgers and some species of bats have been observed so far.

We started to hold bird-watching parties open to the local community twice a year. A total of more than 700 people have participated in the parties during the last decade (Figure 2).

Figure 2 Wild bird information board, moohen family, kingfisher, goshalk, and bird-watching party open to the community .

Based on the results of the biodiversity research, we started our educational program, i.e., high school-level biology classes focused on biological diversity and college-level classes of environmental engineering for sustainable society which we named “Satoyama-Satoike” class based on “Satoyama Initiative (COP10, 2010)“ (Berglund B. E. (2014)). The term “satoike“, literally “village“ (“sato“) and “‘pond“ (“ike“), was introduced to denote ponds adjacent to the village as the wetland version of “satoyama“ (literally “village hill“ (“yama“). In the “Satoyama-Satoike” class, reed cutting was practiced to preserve the wetland.

Materials and Methods

(1) Educational tools for evaluation of biodiversity

Based on the results of our continuous research, we created a worksheet, a dedicated check list, for observation of birds at Shokanji pond. Binoculars were lent to participants, if needed, and field telescopes were also used to observe the details and habits of birds. Birds were identified consulting the information panel and field guides, and the appropriate cells on the check list were marked. Date, time, weather and other conditions were also recorded as shown in Table 1.

Table 1. Worksheet: Original check list for wild birds on campus

鳥合わせリスト　　観察地 ： 正観寺沼(群馬県東西湖)(高崎市中尾町)
日 時 ： 2017年 3月 12日 9 ： 00 ～ 11 ： 15
観察者 ： 吉越俊一, 遠川千佳夫,　　(ほか 48名)
天候・気温など ： 快晴　　特記事項 ：

No.	種 名	観察記録		No.	種 名	観察記録	
1	キジ	○		26	アマツバメ		
2	オシドリ			27	ヒメアマツバメ		
3	オカヨシガモ			28	タゲリ		
4	ヨシガモ			29	コチドリ		
5	ヒドリガモ			30	イソシギ		
6	マガモ	○		31	ヨアジサシ		
7	カルガモ	○		32	トビ	○	
8	ハシビロガモ			33	ハイタカ		
9	オナガガモ			34	オオタカ		
10	コガモ	○		35	ノスリ	○	
11	カイツブリ	○		36	クロウ		
12	キジバト	○		37	カワセミ	◎	
13	アオバト			38	コゲラ	○	
14	カワウ			39	アオゲラ		
15	ゴイサギ			40	チョウゲンボウ		
16	アマサギ			41	ハヤブサ		
17	アオサギ	○		42	コウライゲイス		
18	ダイサギ	○		43	モズ	○	
19	チュウサギ			44	オナガ		
20	コサギ			45	ハシボソガラス	○	
21	クイナ			46	ハシブトガラス	○	
22	バン	○		47	シジュウカラ	○	
23	オオバン	○		48	ヒバリ		
24	ツツドリ			49	ツバメ		
25	カッコウ			50	イワツバメ		

No.	種 名	観察記録		No.	種 名	観察記録	
51	ヒヨドリ	○		76	シメ	○	
52	ウグイス	○		77	イカル		
53	エナガ			78	ホオジロ	◎	
54	エゾムシクイ			79	カシラダカ	○	
55	センダイムシクイ			80	アオジ		
56	メジロ	○		81	オオジュリン		
57	オオヨシキリ			82	コジュケイ		
58	ムクドリ	○		83	ドバト	○	
59	クロツグミ			84	ワカケホンセイインコ		
60	シロハラ			85	ガビチョウ		
61	ツグミ			86	カオジロガビチョウ		
62	ルリビタキ			87	雑種ガモ		
63	ジョウビタキ			88			
64	エゾビタキ			89			
65	コサメビタキ			90			
66	キビタキ			91			
67	オオルリ			92			
68	スズメ	○		93			
69	キセキレイ			94			
70	ハクセキレイ	○		95			
71	セグロセキレイ	○		96			
72	ビンズイ			97			
73	アトリ	◎		98			
74	カワラヒワ	○		99			
75	ベニマシコ	○		100	観察種合計	31	+1

The syllabus of “biology” for the high school level education includes succession of flora. As a practical example of wetland vegetation succession, series of aerial view of the wetland were shown to the students.

Six trail cameras with infrared vision were set up to monitor nocturnal animals around the pond (Figure 5). These cameras automatically take pictures when sensing motion.

(2) Evaluation of plant growth promoting effect of mud

The effect of the bottom mud to promote plant growth was evaluated using Komatsuna (*Brassica rapa* var. *perviridis*) grown in pots.

(3) Survey of nocturnal animals using an automatic camera

In order to investigate nocturnal animals, trail cameras equipped with infrared sensors and capable of automatic shooting (VEAMA, 2.0 megapixel) were installed at four locations around the pond.

Results and Discussion

(1) Symposium on "Satoyama Initiative"

Prior to the development and application of educational courses, we organized the Symposium on "SATOYAMA" in 2009 based on the results of our research conducted on campus until then. Mr. Yasuhiro Ono, an executive producer of NHK (Japan Broadcasting Corporation) who had been engaged in many TV programs on nature, was invited as a keynote speaker. He gave a lecture on "Satoyama-ism" and people's sustained efforts in relation to nature in their vicinity. After the keynote speech, lectures by three professors of NIT (KOSEN) Gunma College, a poster session, and a panel discussion, it became clear that participants deepened their understanding on biological diversity and "Satoyama Initiative" (Figure 3 and 4).

Figure 3 Symposium on "SATOYAMA" (2009).

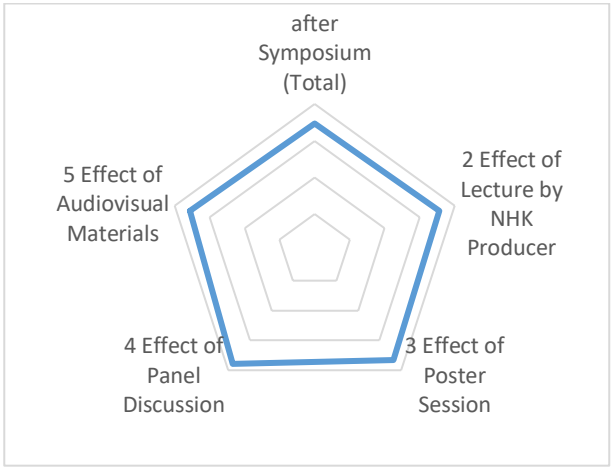


Figure 4 Overall effect of the Symposium on promoting understanding on "Satoyama Initiative"

In addition, COP10 was held in Nagoya, Japan, the following year. This conference helped to promote the interest and understanding on environmental issues especially on "Satoyama Initiative".

(2) Consolidation of understanding of biodiversity

Questionnaire survey after the Symposium on "SATOYAMA" results showed that more than a half of the students were "impressed to know that so many kinds of living species inhabit this environment near-by" and some of the students understood the role of reed bush and water front as breeding grounds for some wild bird species, thus contributing to the pond's wide biodiversity.

Figure 5 Succession of the wetland from 1969 to 2018.

Some of the students answered, "our biology textbook describes the succession process of wetlands, but it was only after the observation on campus that I understood the real waterfront species and changes of the flora."

Continuous observations revealed that great egrets (*Ardea alba*) gather to form a roost at sunset from late August to September. At peak, around 100 great egrets get together and spend all night (Figure 6).

Figure 6 Great egrets returning at sunset to roost on the pond.

Trail cameras and visual observation captured some species of mammals including Japanese weasel (*Mustela itatsi*), Japanese badger (*Meles anakuma*), racoon dog (*Nyctereutes procyonoides*) and an alien species, common racoon (*Procyon lotor*). Some pictures were taken by students with smartphone. The biological class seemed to improve interests of students for living things.

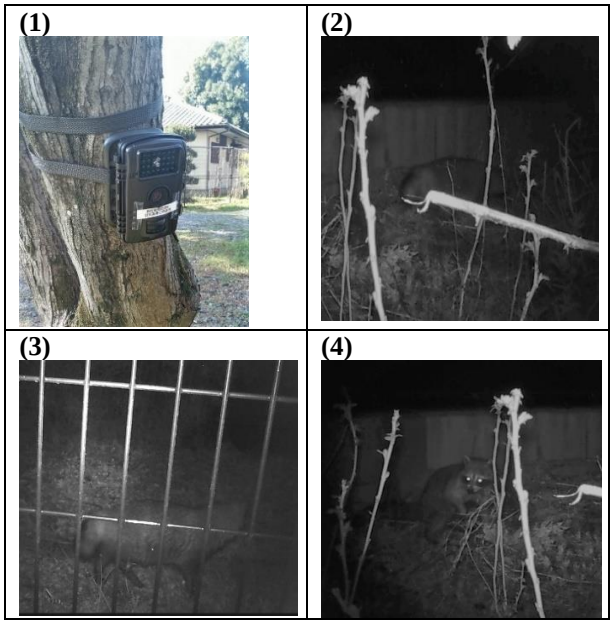


Figure 7 A trail camera (1) and photographs of nocturnal animals around the pond; Japanese badger (2), racoon dog (3) and common racoon (4) .

(2) Satoyama-Satoike Activities

The college-level class which started in April 2017 and were concerned with environmental engineering for sustainable society were called "Satoyama-Satoike" classes based on "Satoyama Initiative (COP10, 2010)".

At the bigining of the class, a workshop was held in which the students learned to recognize common species of spring wildflowers, of which some are toxic. Then several three or five-membered groups went out for collecting fresh plant samples on campus for about half an hour. After collecting samples, they got together and identified the species to know whether these plants were edible or poisonous. Finally, all groups helped making the collected plant samples into Tempura (deep fried dish), and enjoyed tasting the fresh spring harvests (Figure 8).

Figure 8 Workshop of Satoyama-Satoike activities.

As the second part of Satoyama-Satoike activities, reed cutting was carried out in February or March, during which time the effect of the cutting on the environment is minimum. Participants understood that this helps slower the wetland succession, and sustain the environment (Figure 9).

Figure 9 Reed cutting workshop in the wetland

(3) Possible Application of Educational Programs

As a model of environmental impact assessment

Before the Satoyama-Satoike activities were initiated, continuous surveillance of wild birds had been carried out. Annual and monthly changes in the number of wild bird species observed in the wetland are shown in Figure 10.

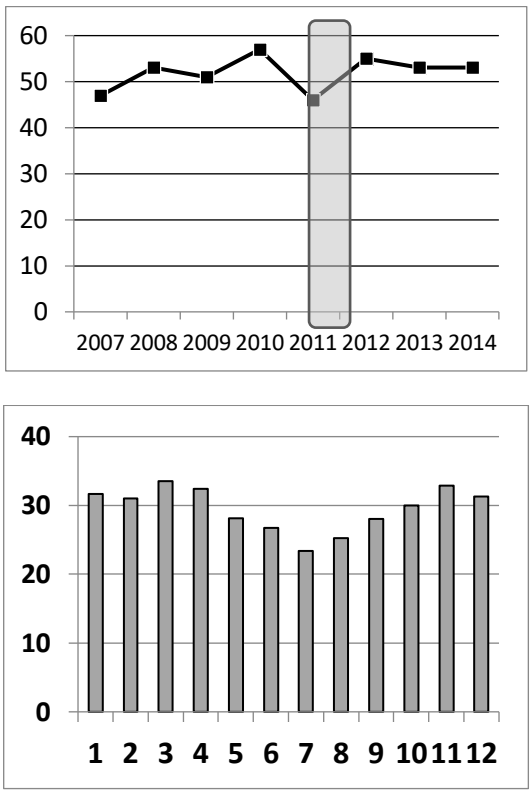


Figure 10 Annual and monthly changes in the number of wild bird species on the wetland

When we compared monthly aggregation, the number of species in winter was higher than in summer, because of larger numbers of migratory birds in winter. In annual basis, the number of species has remained stable around 50, except that it temporarily decreased in the latter half of 2011, during which time the pond was dredged and the surrounding environment was renovated. The result shows that the renovation affected the habitat of wild birds temporarily, but its impact was minimum and the environment recovered soon. From these results, the possibility of applying the continuous surveillance as a means of environmental impact assessment was proposed.

In addition, during our recent activities and biology classes, Japanese honeybees (*Apis cerana japonica*) were observed to nest in a cavity of a willow tree just beside the pond (Figure 11). Possibility of providing a practical educational program on the topic of beekeeping using Japanese honey bees was proposed.

Figure 11 Japanese honeybees nesting on the base of a willow tree.

As a model of recycling and sustainable society

Aoi has developed a novel bottom mud dredging technology for conserving ecosystem and utilizing dehydrated soil (Figure 12). The method was originally developed on this pond and has been applied to many fields in Japan.

In the present program, the effect of the bottom-mud, a by-product of dredging, to promote growth of Komatsuna was evaluated (Figure 13).

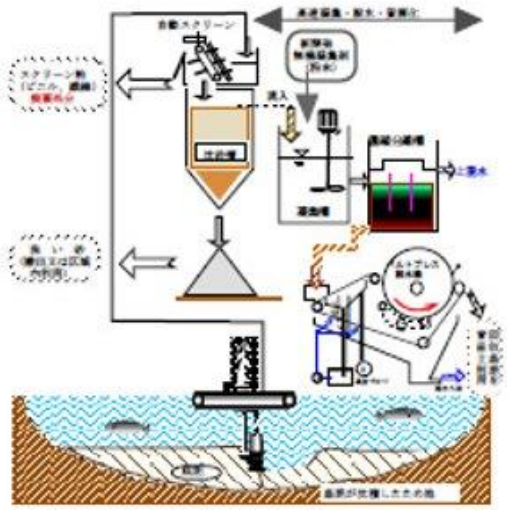


Figure 12 Bottom mud dredging technology for conserving ecosystem and utilizing dehydrated soil (T. Aoi, 2015)

Figure 13 Promoting effects of bottom mud on the growth of Komatsuna (*Brassica rapa* var. *perviridis)* with (lower) and without (upper) the botton mud

The vegetative growth of Komatsuna in the pod (lower) with the bottom mud was promoted in comparison with negative control. The utilization of the bottom mud in horticulture shows the possibility of this wetland as a sustainable field from the point of view of Satoyama-Saoike Initiative.

Conclusions

Using a small wetland on campus as a field of practical education, we have developed a couple of educational programs.

One is the high school-level biology class focused on biological diversity, using wild bird worksheets, trail camera and other tools.

The other one is the college-level environmental engineering class with "Satoyama-Satoike" activities based on "Satoyama Initiative (COP10, 2010)".

Prior to the educational programs, the Symposium on "SATOYAMA" helped deepen the understanding on biological diversity and "Satoyama Initiative".

Possible application models of "Satoyama-Satoike" activities to the environmental impact assesment and recycling of resources were demonstrated.

These programs are expected to help train engineers so that they may contribute to the realization of sustainable societies.

Acknowledgements

We thank the Wild Bird Society, Gunma, for its cooperation in bird watching activities, and the staffs of KOSEN for their efforts in maintaining Shokanji Pond.

We are grateful to City of Takasaki and National Institute of Technology for their financial supports for the dredging of the pond and renovation of the surrounding environment.

References

Aoi, T. (2015). Newly developed bottom-mud dredging technology for conserving ecosystem and utilizing dehydrated soil. Jiban Kogakkaishi (Journal of Japanese Geotechnical Society), 63, 685-686

Berglund B. E. (2014). Traditional farming landscapes for sustainable living in Scandinavia and Japan: Global revival through the Satoyama Initiative. *AMBIO*, 43, 559-578.

Miyakoshi, S. (2010). Wild birds on Shokanji Pond (Lake Saiko, Gunma National College of Technology) Biodiversity and its potential as a field for environmental studies. *The Gunma-Kohsen Review*, 28, 1-6.

Miyakoshi, S. (2016). Wild Birds on Shokanji Pond (Lake Saiko, National Institute of Technology, Gunma College) (Part 2) Effects of the construction work for the environmental preservation on the biodiversity of the pond. *The Gunma-Kohsen Review*, 34, 1-7.

AN INTERNATIONAL GRADUATE-SCHOOL-LEVEL COLLABORATIVE PROGRAM IN NIT AKASHI ON CUTTING EDGE RESEARCH AND PROJECT DEVELOPMENTS

H. Nakanishi[*,a,b], S. M. Aspera [a], R. L. Arevalo [a,c], H. Kasai [a,d]

[a] National Institute of Technology, Akashi College, Hyogo, Japan
[b] Institute of Industrial Science, University of Tokyo, Tokyo, Japan
[c] University of San Carlos, Cebu, Philippines
[d] Osaka University, Osaka, Japan

*nakanishi@akashi.ac.jp

Abstract

The National Institute of Technology (KOSEN) in Japan is a two stepped education program: the main associate degree course, a five-year engineering education course starting from 15 years old; and the advanced course, a two-year higher education course in engineering after the main associate degree course. KOSEN has been responding to a strong demand from the industrial sector to foster engineers who can sustain the high Japanese economic growth. Today, interrelationship between science and technology is becoming stronger and their distinct boundary is becoming unclear. This accelerates technological advancement. On the other hand, the eager and fresh minds of the graduate students of the universities, under the supervision of their Professors, could contribute to relevant and promising research activities. Therefore, it may have an advantage to sustain their high-level research and education. KOSEN has no graduate-school-level system. To cope with this, we tried to construct a sustainable KOSEN research-education program in harmony with university research-learning environment, which we call "Sandwich Program".

In this program, started circa 2017, we fostered excellent graduate students from foreign universities who have mastered the fundamentals in their major field and are nominated by their supervising Professors as Sandwich Program students. The Sandwich Program students will study in our laboratory for one or two years where they can enjoy the Japanese research environment. The duration of their study in our college is sandwiched within their university education. After which, they will go back to their own home universities to finalize their researches under their supervisors for the completion of their doctorates. The presence of foreign Sandwich Program students can provide an aura of global education environment to our college. To date, we had two students from Institut Teknologi Bandung (ITB) in Indonesia and two students from De La Salle University (DLSU) in Philippines under the Sandwich Program. The first student-recipient of the program already obtained a master's degree in ITB and is currently a under a doctoral program in Osaka University, Japan.

In this paper, we introduce the evidences of our sandwich program, and discuss its advantage, outstanding issues and its future.

Keywords: *International collaborate education, Sustainable, Rapid technological advancement, Research-oriented learning,*

Introduction

The unique structure of the National Institute of Technology (KOSEN) of Japan curricula set it apart from other technological school in other countries, particularly in the neighboring Asian countries. The structured form of its 5-year courses, that starts from senior high school to an associate degree in technology (which could further be continued to advance course), exposes students at an early stage to an enriched experience in field of technology. The aim of KOSEN is to provide students with knowledge to carry industrial skills, developments, and innovation (National Institute of Technology (KOSEN)–Views, n.d.). However, with the rapid advancement in technology and increasing demand for globalization, coping up with the world standards for internationalization poses additional expectations for future graduates of KOSEN. They are furthermore expected to be/have: (1) trained as highly practical and creative engineers in a wide range of fields, (2) trained global engineers with experience in international exchanges, (3) contributed to the local community and technological innovation of the local industry, and (4) prospective human resources that can contribute to the revitalization of the local industry (National Institute of Technology (KOSEN)–Views, n.d.). These additional expectations further ensure that KOSEN produces future

engineers that could sustain Japan's advanced and rapid economic growth. These also necessitate for KOSEN to have programs that exposes students to: (1) a variety of fields other than their own, (2) advanced studies particularly in research, and (3) the relevance of internationalization and globalization. Students who are exposed to a variety of fields other than their own can develop to be future innovators. The innovator's ability to integrate different concepts/ideas feeds the creativity of an individual to realize new and advanced concepts/ideas/methods. Future innovators contribute greatly to scientific and technological advancements. On the other hand, being exposed to advanced studies, particularly in research, present students with pressing relevant scientific and technological issues. These issues are expected to be what they will face in the future. Future innovative leaders should realize at an early stage what will be relevant in the future and focuses on developing that. And lastly, the future engineer's ability to integrate his/her own skills in a global platform is important to the growth of Japan's economic advancement. In this sense, being globally literate is important to globalization. One definition of global education, as expressed by Peters (2009), is "teaching and learning with global perspective by (1) able to recognize interdependencies and interconnection of issues, regions, people, places, systems, and times; (2) infusing global issues into traditional subject areas; and (3) working towards active, responsible global citizenship and building a more peaceful, just, and sustainable world." The National Institute of Technology, Akashi College (NITAC) realizes the need to support its students with activities that promote globalization and cooperative learning as exemplified by different programs that promote global literacy and interactive tasks, e.g. Co+work, Tobitate Projects (Hirashi, Herbert, Kajimura and Fujiwara, 2018), Hands-on international workshop (Higashino 2018), etc.

In line with the KOSEN's initiative to inculcate to its students the relevance of globalization, cooperative learning, and being updated with recent state-of-the-art concepts/methods/techniques in science and technology, NITAC introduced the *Sandwich Program*. The Sandwich program aims at providing NITAC students with an experience of a university-like research-learning environment, and at the same time strengthen global collaboration with partner universities with activities that contributes to the advancement of science and technology and intercultural exchanges. In this program, graduate students from different partner universities will be given a chance to conduct their research at NITAC under the supervision of a and NITAC Professor. The progress of the Sandwich Program students will be monitored by his/her supervising Professor in his/her home country and by his/her host Professor in NITAC. Details of the program, its first few student participants, the activities, and some perspective about the program and comments to the possible next phase of the program will be discussed in the succeeding sections.

Methods

The structure of KOSEN and introduction of the Sandwich Program. The structure of the educational system of Japan is depicted in Fig. 1. This figure shows the branching paths taken by students after Junior high school. Basically, majority of the students goes to the usual path of entering the regular high school program and about 1% of the graduating junior high school students are accepted to the KOSEN program. The low acceptance rate at KOSEN makes its students an elite group. At a young age of 15 years old, the students enter the associate degree program for 5 year, where after which, they can already join Japan's workforce. However, students can opt to continue for another 2 years of advance course, which is equivalent to a university bachelor's degree. The degree is conferred by the National Institution for Academic Degrees and Quality Enhancement of Higher Education (NIAD-QE). Just like any bachelor student who graduates from a university or university of technology, KOSEN graduates of the advance course are also eligible to enter a master's course program.

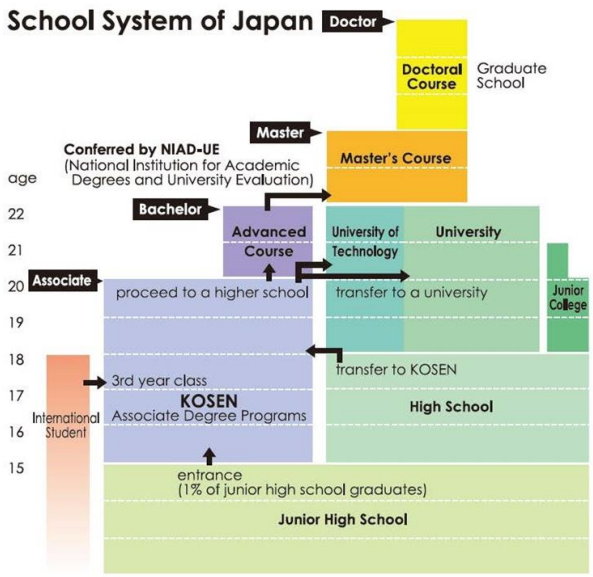


Figure 1. The Japan School System. Illustration of the Japanese school system. There are two paths taken after completion of the Junior High School program: (1) the regular path to High School (right side), and (2) by going through the KOSEN program (left side). Allowable transfers in between programs are also depicted by arrows. (National Institute of Technology (KOSEN)-Education System, n.d.)

To keep students up-to-date with the recent advances in science and technology, and to equip them with the necessary experience and knowledge in research, particularly for advance course students, NITAC, through the Global Education Center (GEC), introduced a university-like research-oriented program called *Sandwich Program*. The idea of the Sandwich Program

is to expose students in a university-like environment where scientific discussions on latest pressing topics in science and technology research are active. This also provides a means to encourage students to conduct research in their own field and integrate new ideas they obtained from active discussions of researches from different fields.

Generally, university graduate students are at a stage where they are encouraged and trained to do independent research. Under the guidance of their supervising Professors, they conduct their own investigation and experimentation to answer posing problem, issues, or generate new idea. Therefore, their fresh and eager mind is a good venue for discussions on underlaying information and concepts related to a topic, in this case science and technology, and appropriate techniques and methods to solve the problem. Recently, Japanese universities have been proceeding to integrate the undergraduate education and graduate one. If KOSEN students are exposed to these kinds of educations, it could unconsciously instill a mindset that puts high reverence to research. And it could contribute the sustainable fresh research and education system in KOSEN.

Globalization is one important realization that KOSEN finds relevant for student to be aware of. As a contribution to this cause, the Sandwich Program prioritized to recruit international students under a university graduate course offered by partner universities of NITAC as initial students of the program. The call for student candidates were sent to different Professors from other countries with whom NITAC Professors have current research collaborative activities. This will somehow strengthen the current ties with the partner universities and assure continuity of the current collaborative projects. The program started around 2017 with about 5 students that completed the program to date. These students, are under a graduate school program of their host universities with the following graduate courses:

- Master of Science in Engineering Physics
- Doctor of Engineering in Engineering Physics
- Doctor of Philosophy in Physics
- Doctor of Philosophy in Quantum Engineering Design
- Doctor of Philosophy in Chemistry

Students of the first batch of the Sandwich Program. The first batch of students accepted to the Sandwich Program were chosen from several candidates nominated by their supervisors. They were chosen based on their research proposal, educational background, related research activities, relevant basic scientific knowledge on theories and method of the field, and previous research background. They should also be under a graduate school program of their host university and completed most of their academic courses. And furthermore, they should be highly regarded by their supervising Professor. The university affiliation of the students under the program and the inclusive dates of their stay in the program is depicted in Table 1. The first batch of Sandwich Program students were under the supervision of Professor Hiroshi Nakanishi of NITAC. Nakanishi laboratory (Fig. 2) of NITAC conducts theoretical research on condensed matter physics and trains researchers who are responsible for the development of next-generation materials (Nakanishi Laboratory, n.d.). As depicted in Table 1, there are two students from the Institute of Technology in Bandung Indonesia, 2 students from De La Salle University in the Philippines, and 1 student from Osaka University. The Nakanishi Laboratory has strong collaborative ties with the laboratories and supervising Professors of the students. The students of the first batch of the Sandwich Program are doing computational material design, which is the expertise Prof. Hiroshi Nakanishi of NITAC. Each student stayed at NITAC for around 1 year as seen the inclusive dates in the program. The number of year spent doing research in NITAC is determined by their study plan in their respective host universities and the progress of their research at NITAC, as evaluated by the host professor in NITAC and their supervising professor in their home university. After evaluation of a completed study here at NITAC, they will return to their host university to complete their graduation requirements. The results of their research in NITAC can also be submitted for publication at high impact journals and can be used as a requirement to satisfy graduation.

Figure 2. Nakanishi Laboratory. The first batch of the Sandwich Program students were under the supervision of Prof. Hiroshi Nakanishi, which is a theoretical condensed matter laboratory.

Table 1. Students of the first batch of the Sandwich Program. The graduate student participants of the Sandwich Program are indicated by student number. Correspondingly, their home institution and the inclusive dates they are in the program are also included in the table.

Student No.	Home University	Inclusive dates in the Program
Student 1	Institute of Technology Bandung, Indonesia	2017.1.16 — 2017.12.28
Student 2	Institute of Technology Bandung, Indonesia	2017.7.31 — 2018.7.31
Student 3	De La Salle University, Philippines	2017.3.3 — 2018.3.31
Student 4	Osaka University, Japan	2016.10.24 — 2019.9.30
Student 5	De La Salle University, Philippines	2019.4.1 — 2019.12.24

Table 2. Conferences and workshops attended and presented by Sandwich Program students. A part of the activities of the Sandwich Program Students is to present the results of their research through discussions in workshops inside and outside NITAC. The details of the conference/workshop and presentation title of the Sandwich program student is presented in this table.

Conference Name	Title of Presentation
The 72nd Annual Meeting of the Physical Society of Japan 2017, Osaka University, Suita Campus, March 17-20, 2017	First principles study of CO adsorption on $Pd_3Au(110)$-(1x2) missing row reconstruction surface
The Japan Society of Applied Physics, Kansai Branch, First Lecture 2017 "Frontiers of Materials Design and Green Devices", Egret Himeji, Himeji, May 26, 2017	HCHO dissociation to HCO+H on (111) surfaces of Pt and Rh
The Physical Society of Japan, Autumn Meeting 2017, Iwate University, September 21-24, 2017	Ethylene Decomposition on Different Transition Metal Catalyst
National Institute of Technology 3rd Block Advanced Course Research Forum, Nagoya International Center, Nagoya, March 2, 2018	Catalysis for Fruit Preservation: Ethylene Decomposition on Transition Metal Catalysts (Oral presentation award)
National Institute of Technology 3rd Block Advanced Course Research Forum, Nagoya International Center, Nagoya, March 2, 2018	A first-principles study of the antioxidant activity of dimer resveratrol: Predicting the radical scavenging site
1st SMA International Workshop on Materials Design and Processes: Research Trends Towards Low Catalyst Loading, National Institute of Technology, Akashi College, July 6, 2018	First Principles Study of Oxygen Atom Adsorption Induced Surface Segregation and its Impact on Oxygen Reduction Reaction on $Pt_{ML}/Pd(111)$
1st SMA International Workshop on Materials Design and Processes: Research Trends Towards Low Catalyst Loading, National Institute of Technology, Akashi College, July 6, 2018	Hydroperoxyl Radical-Scavenging Activity of Melinjo Resveratrol: A First Principles Study
2nd SMA International Workshop on Materials Design and Processes: Computational Materials Design for Energy Utilization, National Institute of Technology, Akashi College, October 5, 2018	First Principles Study of Oxygen Atom Adsorption Induced Surface Segregation and its Impact on Oxygen Reduction Reaction on $Pt_{ML}/Pd(111)$
3rd SMA International Workshop on Materials Design and Processes: Carbon-based Materials Design for Technological Application, National Institute of Technology, Akashi College, March 26, 2019	Surface composition of Pt-Pd/Pd(111) alloys in the presence of O and OH during the oxygen reduction reaction

Activities of the Sandwich Program students. Aside from doing research activities for the completion of their research problems, other activities of the students under the Sandwich Program includes: (1) promotion of research discussion within or outside the laboratory they belong, (2) dissemination of information from the obtained results of their research, (3) cultural immersion with the students and faculty-community of NITAC, and (4) presentation of results through joining conferences/workshops and a concluding (final) presentation of their research results in NITAC.

Regular discussions on students' research progress were conducted. The regular discussions were under the guidance of their host professor in NITAC, in coordination with their supervising professor in their home universities. Apart from this, some students under the Sandwich Program were able to present a part of their research in conferences and workshops inside and outside of NITAC. The conference/workshop names and the title of the paper presentation from the Sandwich Program students are listed in Table 2. These presentations, either oral or poster presentation, provides a venue for the Sandwich Program students to discuss their respective researches and its results to the community. This allows for exchange of ideas and issues that are relevant to the scientific and technological community. The Sandwich Program Students are also required to give an oral concluding presentation about the research they conducted at NITAC (Fig. 3). After the conclusion of their final presentation, students of the Sandwich Program who successfully completed their research will be awarded with a certificate of completion (Fig. 3).

Figure 3. Final Presentation and Awarding of Certificates. A final requirement for students under the Sandwich Program is having a concluding (final) presentation of their research results at NITAC. After the satisfying the requirements of the Sandwich Program, they will be awarded a certificate of completion.

Results and Discussion

The conceptualization of the Sandwich Program was designed to benefit both parties: the Sandwich Program students and NITAC students, and the partner university (Professors) and NITAC (Professors). The mutual benefit was for the advancement of science and technology, and at the same time promotion of globalization.

All students under the Sandwich Program completed their studies as exemplified by their concluding presentations and the open discussions that followed. The presentation title of each student in the concluding presentation is listed in Table 3. The concluding presentation is open to all faculties and students of NITAC. This is a venue where students and faculties of NITAC can further discuss with Sandwich Program students the details of their research presentation. For all 5 concluding presentations, only a limited number of NITAC students attended the presentation. This could be improved by more activities that promote interaction between NITAC students and the Sandwich Program students. Prior connotation on the complexity of the topic, language barrier, and minimal exposure to them (Sandwich Program students) could be some possible reasons. Nevertheless, these activities somehow instill relevance of research to NITAC students as observed some of the research presentation of NITAC students presented in the NITAC festival. The detailed manuscript of the scientific results from the Sandwich Program students is being compiled to be published as "NITAC Sandwich Program 2019 Final Report" whose proposed cover page is shown in Fig. 4. The certificates that the Sandwich Program students obtained and the research that they accomplished in NITAC can be used for the completion of their graduate degree in their own home university. To date, after Sandwich program, the Student 1 earned his master's degree at his home university, ITB, and continued his PhD degree at Osaka University. Student 2 became a lecturer in a University of Technology similar to her home university and is expected to finish her PhD degree soon. Student 3 is also a lecturer at a Technological University in his country, the Philippines, he is soon to graduate from PhD. Student 4 earned his PhD and is now a Specially Appointed Assistant Professor at NITAC. And Student 5 went back to his previous position as an Associate Professor in the Philippines and is a final defense away from obtaining his PhD. After coming back to their home country, several academic requirements are still needed to be met. These probably are some of the factors that lengthens the initial study plan they had. An improved coordination with the supervising professor in their home country regarding the student's study plan could probably overcome this problem, which could be improved in the future.

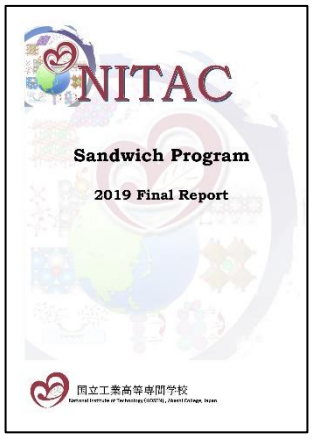


Figure 4. Proposed Sandwich Program 2019 Final Report cover. The compilation of the scientific results of students under the Sandwich Program is compiled and published as Sandwich Program 2019 Final Report. In preparation

The presence of the Sandwich Program students is assumed to contribute to the awareness of the current scientific and technological research trend and promote globalization through cultural immersion of NITAC students. The presence of the international-nature of the Sandwich Program graduate students creates an aura of a university-like environment in NITAC. The activities of the Sandwich Program students are typical of graduate students engaged in research-related activities. Students of NITAC are aware of that and thus gain an overview of the typical activities of a graduate student. Apart from that, Sandwich Program students also participated in student-related activities of NITAC, e.g. NITAC festival, sports-related activities, and sometimes they join in activities involving other international exchange students. These venues are good for cultural exchange and practice of communication skills between Sandwich Program students and NITAC students. With these benefits gain through interaction between Sandwich Program students and NITAC students, we hope that activities related to these kinds of program will be well promoted and well participated in the future. Collaborative projects between Sandwich Program students and NITAC students, on a minor part, could also be good way to promote stronger impact of the program.

Table 3. Concluding presentation title of the Sandwich Program students. The graduate student participants of the Sandwich Program are indicated by student number. Correspondingly, the title of the concluding presentation is indicated in the cell across it.

Student No.	Title of Study
Student 1	First principle study of hydrazine N-N and N-H bond cleaving on Ni (111) and (211) surface in presence of co-adsorbed OH
Student 2	Dimer structure effects on the peroxyl radical-scavenging activity of melinjo (*Gnetum gnemon* L.) resveratrol: A first principles study
Student 3	Industrial Functionalities of Transition Metals in Fruit Preservation Catalysis and Molecular Switch Devices
Student 4	Surface compositions of Pt-Pd/Pd(111) alloys in the presence of O and OH during oxygen reduction reaction: A First-Principles (Chanteramolee et. al, 2019)
Student 5	First principles study of oxygen evolution reaction on Ru and Ru-Ir alloy surfaces

Conclusions

The National Institute of Technology (KOSEN) is a uniquely structure educational system of Japan that trains students at an early age as promising engineers to cope up with the rapid technological advancement of the country. In line with this, the National Institute of Technology, Akashi College (NITAC) introduced the *Sandwich Program*. The Sandwich Program is a sustainable KOSEN research-education program in harmony with university research-learning environment. In this program, highly talented graduate students from different international partner universities can conduct research in a Japanese research environment of NITAC. After the duration of their research study NITAC, they will go back to their home universities to obtain a graduate degree. This program creates an aura of global education in a university-like environment in NITAC. There were 5 international students in the first batch of the Sandwich Program who successfully completed their research study.

The Sandwich Program, through the research-nature of its activities, contributes to the advancement of science and technology in NITAC, and at the same time promotes globalization between Sandwich Program students and NITAC students. It also strengthens the relationship between the partner universities through the collaborative research activities. The success of the first batch of the Sandwich Program merits continuation of succeeding similar activities. The impact of the Sandwich Program students' research activities on NITAC students could be strengthened with continuous interaction. With this, we hope that future collaborative activities such as these will be supported.

Acknowledgements

This work is supported in part by JST ACCEL grant number JPMJAC1501 "Creation of the Functional Materials on the Basis of the Inter-Element-Fusion Strategy and their Innovative Applications", MEXT Grant-in-Aid for Scientific Research (16K04876), and JST CREST Innovative Catalysts and Creation Technologies for the Utilization of Diverse Natural Carbon Resources: In-situ atomic characterization of catalytic reactions for the development of Innovative Catalysts (No. 17942262). Some of the numerical calculations presented here were done using the computer facilities at the following institutes: High Energy Accelerator Research Organization (KEK), Institute for Solid State Physics (ISSP, University of Tokyo), Yukawa Institute for Theoretical Physics (YITP, Kyoto University), and the National Institute for Fusion Science (NIFS). The Global Education Center (GEC) of the National Institute of Technology, Akashi College for their support.

References

Chantaramolee, B., Aspera, S.M., Arevalo, R.L., Arguelles, E.F., Kishida, R., Padama, A.A.B., Kasai, H. and Nakanishi, H. (2019). Surface composition of Pt-Pd/Pd(111) alloys in the presence of O and OH during oxygen reduction reaction: A first-principles study. *Journal of the Physical Society of Japan*, 88, 044802. https://doi.org/10.7566/JPSJ.88.044802

Higashino, A.P., (2018), Culture as tool for internationalization: Hands-on international workshop. *Proceedings of ISATE 2018*, Retrieved from https://www.kosen-k.go.jp/about/global/isate/

Hiraishi, T., Herbert, J.C., Kajimura, Y., and Fujiwa, S., (2018), Developing competencies through Co+Work and Tobitate Projects. *Proceedings of ISATE 2018*, Retrieved from https://www.kosen-k.go.jp/about/global/isate/

Nakanishi Laboratory. (n.d.). Nano-design Lab, Nakanishi Laboratory National Institute of Technology, Akashi College [Blog post]. Retrieved May 29, 2020 from http://www.akashi.ac.jp/~nakanishi/index.html

National Institute of Technology (KOSEN)-Education System. (n.d.). Educational System. Retrieved May 28, 2020 from https://www.kosen-k.go.jp/english/what/educationsystem/educationsystem

National Institute of Technology (KOSEN)-Views. (n.d.). Increasing expectation for KOSEN (College of Technology) [Blog post]. Retrieved May 28, 2020 from https://www.kosen-k.go.jp/english/what/features/views.html

Peters, L, (2009). *Global Education: Using Technology to Bring the World to Your Students.* Washington D.C., USA: International Society for Technology in Education.

Human Resource Development of IoT Engineers for Disaster Prevention and Mitigation Based on Remote Island Engineering

H. Fukuda*[a], T. Ito[b], T. Masuzaki[c], T. Tabusa[c], M. Tada[d] and K. Kuzume[c]

[a] NIT, Yuge College/ Electronic Mechanical Engineering Department,
[b]NIT,Yuge College/ General Education Department
[c] NIT, Yuge College/ Information Science and Technology Department
[d]NIT,Yuge College/ Maritime Technology Department, Kamijima Town, Japan
*fukuda@yuge.ac.jp

Abstract

In recent years, "Problem Based Learning (PBL)" has attracted our attention as an educational method for developing "human power" such as autonomy, activity, cooperation and creativity. Unlike conventional classroom lectures, students take on the challenge of acquiring knowledge on their own, and teachers become their supporters. In PBL, it is important to present the "what is the problem" task, and the motivation of the students is greatly influenced by the task tackled.

Yuge Island, where our college is located, has problems peculiar to remote islands due to population decline, aging and decline of birth-rate. However, Yuge Island is also a unique island where our students, teachers and staff occupy about 20% of the town's population. In the neighbourhood, our college is the only higher education institution and is expected to play an important role in solving the problems of remote islands.

In this research, we utilize the engineering and human resources of our college to solve problems from an engineering perspective in cooperation with the local community and our college. We defined such engineering as "remote island engineering". From the perspectives of education, energy, disaster prevention, mitigation and environmental conservation, we carried out several projects for developing human resources using the PBL education method. These could contribute to the "safety and security" of the island based on remote island engineering. At the start of the projects, a new organization was established to facilitate cooperation between our college and residents of the community and to evaluate the implemented projects. This organization, composed of staff from Kamijima Town and faculty from our college, played a very important role in realizing the PDCA (Plan Do Check Action) cycle for the project. We implemented the following four kinds of programs:

1) IoT application technology program
2) Environmental and energy technology program
3) Disaster prevention and mitigation education
4) programs
5) ICT education support program

In our projects, we applied IoT or ICT, which are important technologies, required for engineers in all fields, and tried to solve the problems together with local residents. Most participating students tried to work and learn actively with people of the local community of Yuge Island. According to the survey, they were very pleased with their activities and had many positive opinions. It was confirmed that the PDCA cycle system could be built to promote the next project, and our approach was very effective at implementing the PBL teaching method.

Keywords: *PBL, remote island engineering, disaster prevention, mitigation, ICT, IoT*

1. Introduction

In recent years, in order to cope with rapid change, complexity and globalization in society, in addition to certain specialized knowledge, education that fosters "human power" including autonomy, activity, cooperation and creativity is required. PBL is attracting our attention as a method for promoting this education. Unlike conventional classroom lectures, students take on the challenge of acquiring knowledge on their own, and teachers become their supporters. As a result, PBL is considered to be an excellent class technique that effectively improves "problem solving ability", "self-learning ability", "analytic ability", "teamwork ability", "communication ability", etc. (Ichitubo et.al (2016)). However, in PBL, it is important to present the "what is the problem" task for participating students, and their motivation is greatly influenced by the task set in the field.

Yuge Island, where our college was established, was located in the centre of the Seto Inland Sea and had various problems due to population decline, aging and decline of birth-rate. However, Yuge Island was also a unique island where our students, teachers and staff occupied about 20% of the town's population. In the neighborhood, our college was the only higher education institution and therefore, it was expected to play an important role in solving the problems of remote islands.

So far, our college had tried to solve the above problems in the fields of disaster prevention, mitigation, education and welfare, utilizing the knowledge and technology of our students and faculty members to

collaborate with the local community, as part of PBL education (K. Ise (2019) and T. Ito, S. Ishida (2019)). We defined such engineering as “remote island engineering”. From another perspective, "PBL education based on remote island engineering", in which students and faculty members entered the area on a daily basis like amoeba and worked with local residents to solve problems, was a great opportunity to discover problems in PBL. Also, in the process of problem solving in the PBL lesson, students could experience that "our activities were actually useful in society", so it could be expected that the motivation of participating students could be further enhanced.

In this research, we focused on development of human resources that could contribute in the fields of disaster prevention, mitigation and education on remote islands with an approach based on "remote island engineering". First, we established new organizations to facilitate the cooperation between our college and the residents of the community and to evaluate the implemented projects. These organizations, which were composed of staff from Kamishima Town and faculty staff from our college, played a very important role in realizing a PDCA cycle for the project. Next we implemented the following four kinds of programs:

1) IoT application technology program
2) Environmental and energy technology program
3) Disaster prevention and mitigation education programs
4) ICT education support program

In Section 2, we outline the organization for implementing PBL education based on remote island engineering. Section 3 is devoted to introducing five projects and evaluating their effectiveness from a questionnaire and discussing the results of each project. Section 4 describes conclusions and future work.

2. Organization for implementing projects based on remote island engineering

In order to promote projects based on remote island engineering, it was necessary to establish an external organization that played the role of connecting the on-campus organization and the local community to carry out the projects. Therefore, one or two faculty members were selected from the Department of Maritime Technology, Department of Electronic Mechanical Engineering, Department of Information Engineering and Department of General Education as an internal organization, and a leader for each project was appointed from among them. In addition, there were administrative staff on campus who were in charge of public relations and coordination with external organizations. We requested the cooperation of the Kamijima Town Office as an external organization from where our school was located, and the division managers of education, industry and crisis management in the office participated as members. (See Figure 1)

At the first meeting, about 10 members from both our college and Kamijima Town Office attended. At the meeting, the problems and needs that Kamijima Town currently had were explained in each field by each division manager of the town office, and the faculty members of our college discussed whether or not to cooperate with them. As a result of the discussion, several kinds of projects were nominated. For each actual project, the project staff individually made an implementation plan and took charge of all tasks, such as recruitment of students wishing to participate, requesting cooperation from the local community and evaluation after implementation. Each implemented project was evaluated by two committees, the "Kamijima Town Liaison Council" and the "Management Advisory Committee." The "Kamijima Town Liaison Council" was composed of Kamijima Town and our college faculty staff, and the "Management Advisory Committee" was composed of our college president, the Mayor of Kamijima Town, a university professor, the president of the chamber of commerce, a junior high school principal and the alumni president. The evaluation was based mainly on the results of questionnaires on things such as the satisfaction and impressions of community, staff and students who had participated in the projects, and also identified new needs through the projects. The evaluation results would be reflected in the projects implementation in the following year.

3. Project based remote island engineering

In this section, we introduce five projects based on “remote island engineering” using the PBL method and discuss their effectiveness on education and development of human resources.

3.1 IoT Hands-on Seminar

An IoT hands-on seminar was held for the purpose of applying IoT technology to disaster prevention and mitigation. At the seminar, a lecturer was invited from

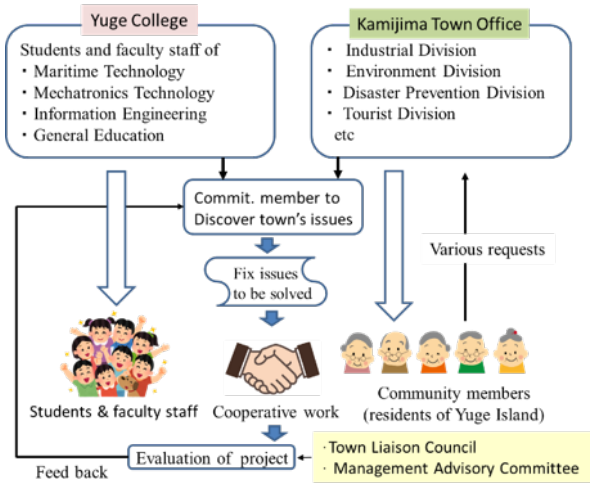


Figure 1. Organization for implementing project based on remote island engineering.

Figure 2. IoT hands-on Seminar

Sakura Internet Co., Ltd., and the participants conducted temperature measurement training using the IoT board for about 3 hours (See in Figure 2). At the seminar, 39 students and 4 faculty members with basic knowledge of embedded technology and the Web participated and took a lecture on how to use IoT utilizing cloud technology. When we conducted a questionnaire on the future applications of IoT technology to participants, the following ideas were gathered.

1) Confirmation of safety of grandparents
2) Environment monitoring during disasters such as landslides and high tides over the island
3) Support for people with disabilities

3.2 Environmental and energy technology education program

On remote islands, due to aging, it is very difficult for residents to maintain their lifelines in the event of a disaster. The project was to provide students with an opportunity to investigate the possibility of utilizing combustible waste drifting along the coast of remote islands as fuel for emergency power generation in the event of a disaster and to think about environmental problems in the Seto Inland Sea. As a concrete activity, we conducted coastal cleaning on remote islands and investigated stranded waste. Furthermore, we designed and manufactured a Stirling engine that could use combustible waste as fuel and considered the possibility of using it as a generator in the event of a disaster.

3.2.1 Environmental education program

First-year students of our college volunteered to clean up the shore at Takai Kamijima, Kamijima Town, as part of the “Regional Revitalization Exercise”. Takai Kamijima was located about 20 minutes away using the school's training ship, Hamakaze, and was a remote island with about 20 residents. Our students collected about 100kg of waste plastic, 10kg of bottles and cans and a large amount of oversized garbage for about one hour, together with residents of the island. 80% of participating students began to have interest in environmental issues. (Figures 3, 4)

3.2.2 Energy education program in the event of disaster

Figure 3. Picture of clean up ashore.

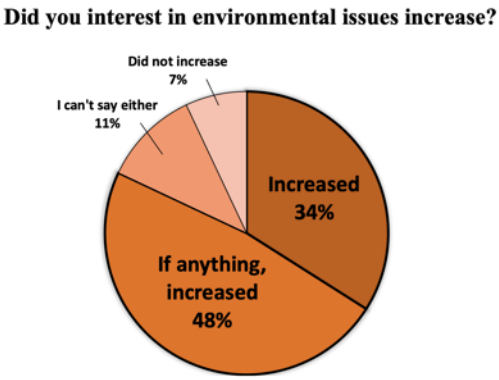


Figure 4. Questionnaire survey results.

In the event of a disaster, securing energy such as electricity and gas is an important issue for several days until the rescue team arrives at the evacuation centre. A rocket stove is an efficient and hot burning portable stove using wood fuel. It can be made easily from a pail and L-shaped metal tube. Therefore, it was used in the Great East Japan Earthquake and caught our attention. Then, we made a small eco-stove as a teaching aid for environmental and disaster prevention education. We had lectured using it with elementary and junior high school students and residents of Kamijima Town (T. Ito, Y. Ito, S. Iwasaki, H. Ichimori, H.Okano, K. Tada, J.Yano, (2019)). The Stirling engine was an external combustion engine that could convert the volume change of air in a cylinder by heating and cooling to kinetic energy. Since the structure of the Stirling engine was very simple, it could be utilized in various fields. The Electricity Business Law was amended in 2014 and regulation of Stirling engine power generation of less than 10kW was deregulated. Therefore, medium-scale Stirling engine power generation was researched and developed. This section outlines how we tried to generate electricity by combining a Stirling engine with a rocket stove using flammable garbage and bamboo etc. as fuel, so that we could secure power at each evacuation site during a disaster. First, we compared the PM2.5 concentration of different fuels using a compact PM2.5 measuring sensor. We made a rocket stove using a pail, metal chimney and perlite (see Figure 5). The compact PM2.5 measuring sensor used was jointly developed by Nagoya University and Panasonic (see Figure 6), (Y. Matsumi1, T. Nakayama (2016)). We burned firewood, bamboo, split chopsticks, pine cones and driftwood as fuel using the rocket stove and measured the concentration of PM2.5.

When chopsticks were used, fast and stable combustion was possible.

Figure 5. The rocket stove used in the experiment.

Figure 6. The compact PM2.5 measuring sensor.

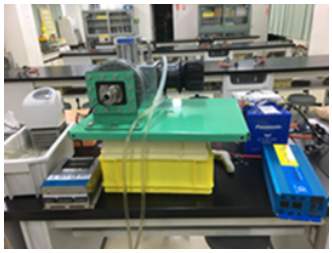


Figure 7. Stirling engine for power generator.

Figure 8. Picture of disaster prevention training workshop.

When switched to firewood, the burning area was reduced for burning in case of disaster. We are now comparing the power generation efficiency depending upon kind of fuel and improving the equipment, and constructing systems for power generation and lower PM2.5 emissions. For firewood and chopsticks, the concentration of PM2.5 was less than 10μg /m^3, with no significant difference between them. When bamboo was used, the flame became stronger than firewood, but the concentration of PM2.5 was slightly higher than firewood and chopsticks at 20μg /m^3 or less. Driftwood has high moisture content, but it was able to burn. When driftwood was used, the concentration of PM2.5 was higher than firewood and chopsticks at 20-30μg /m^3. On the other hand, when pine cones were used, intense burning was observed, and the concentration of PM2.5 was lower than that of chopsticks and firewood. By combining bamboo and driftwood with pine cones and chopsticks, stable combustion was possible with a relatively low concentration of PM2.5, and they could be sufficiently used in evacuation sites. After design of the outline of the Stirling engine generator, it was manufactured by ADMIEXCO Engine Design Co., Ltd. (see Figure 7). It had a maximum speed of 1200 rpm and a power output of 300W. First, the generator did not work due to the low thermal power of the rocket stove. Later, the generator could run by surrounding the combustion section with heat-resistant bricks. However, it needed to be improved to operate the cooling part and transport controlled using IoT. The embedded IoT system was being developed by grade 5 as a graduation thesis. With this system, some parameters such as the temperature and concentration of PM2.5 of the Stirling engine could be monitored on the Internet in real time.

3.3 Disaster prevention training workshop for student leaders

An instructor was invited from the Kamijima Town Crisis Management Office to hold a "Disaster Leader Training Workshop". The purpose of this workshop was to foster students' disaster prevention leaders who could actively respond to evacuation of lives in the event of a disaster and to foster human resources that could contribute to the community and society. A total of 27 students participated in this workshop, the breakdown of which was student association officers, dormitory association officers and club activity leaders.

First of all, the instructor explained about "Disaster Prevention Measures in Kamijima Town" and the damage situation in Kamijima Town from the previous year's heavy rain disaster in western Japan and how to deal with it. Next, the students were divided into small groups and conducted the following training (See Figure 8). Most participating students were satisfied with the contents of this seminar.

1) Assembling a simple tent
2) Assembling a cardboard bed
3) Assembling a simple toilet

The students who participated in the workshop were a little confused and nervous at first, but they seemed to get used to it quickly and cooperated with each other to assemble. After the review, the instructor said with expectation to students, "In Kamijima Town, where there are many elderly people, the cooperation of young people is more and more necessary, so in the event of a disaster, please cooperate with the community." That was the second time this workshop had been held. In the future, we would not only raise awareness but develop practical disaster prevention leaders who are useful to society at large. Participants came to the following conclusion: In the event of a disaster, I definitely want to cooperate with the construction of evacuation centers. I would like to

develop an evacuation center management system for supporting the lives of evacuees by cloud computing using IoT.

3.4 A revival project of campus wells

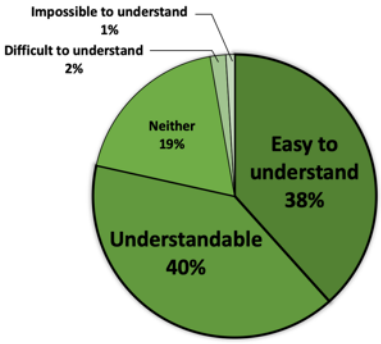
Many lifelines were also damaged by the heavy rain disaster in western Japan in July 2018. For a long time, Kamijima Town had been supplied with tap water from the Hiroshima Prefectural Enterprise Bureau, but the Nuta River was flooded and the water intake damaged, and about 3,300 homes cut off for 11 days. In response to the damage, Yuge College provided support to local residents using groundwater, but could not use it as drinking water because the quality of the groundwater was not tested. For this reason, drinking water was supplied by the local government. Therefore, in this project, we researched the design and installation of water intake equipment, water intake capacity and its applicability to drinking water in order to secure water from wells that are not currently used in the college as domestic water in the event of a disaster. As a result of the research, it was confirmed that wells could supply 50 m^3 of groundwater per day. In preparation for a power outage in the event of a disaster, we installed a solar cell panel and built a system that allowed real-time monitoring of water storage and transparency by IoT. We are currently discussing with Kamijima Town about "Effective use of wells during disasters" (See in Figure 9).

3.5 ICT education support program for junior high school students by our college staff and students.

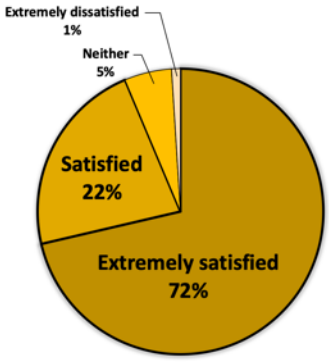
In recent years, social interest in programming education has increased significantly. In Japan programming education became compulsory at elementary schools from 2020, so the number of private schools and events where students can learn programming, especially in urban areas, is increasing rapidly. However, there are few opportunities to learn programming in islands. As a result, the gap in programming learning opportunities between urban areas and islands is widening. Therefore, since 2018, staff and students of the Department of Information Engineering and the Department of Electromechanical

Figure 9. Revival of campus well for supply during disaster.

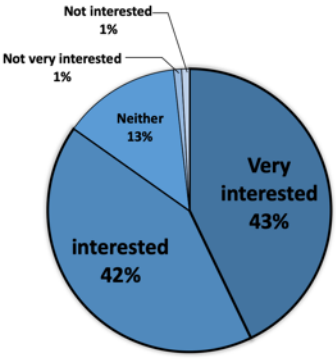
Figure 10. Picture of robot programming contest.



(a) Understanding



(b) Satisfaction



(c) Interest in programs and robots

Figure 11. Answers for questionnaire about programming support education.

Engineering of our college have been supporting programming education using robots in junior high

schools. In 2019, approximately 100 third-year students from four junior high schools were supported in 2 to 6 hours of programming education. First, the mechanisms of measurement and control and the information processing procedure and program were explained. Next, students were divided into pairs and practiced programming using robots (mbot, makeblock) (Figure 10). The robot was controlled by a program using a visual programming language called Scratch. The robot had an ultrasonic sensor, light sensor, infrared sensor, microcomputer, motor, LED and buzzer. Therefore, by controlling the sensors and motors by programming, the robot could run, avoid obstacles and illuminate the LEDs. Finally, students were challenged by assignments devised by our students. Figures 11 (a)-(c) show the results of the questionnaire after the programming education support. As for the degree of understanding of the support education, 78% answered that they could "easily understand" and "understandable". As for the degree of satisfaction, 94% answered "Extremely satisfied" and "satisfied". 85% of the respondents answered "very interested" and "interested" to the question, "Are they interested in programming or robots?"

In 2019, we held a robot programming contest at our college for junior high school students who were supported by us with programming education. A total of 16 junior high school students participated, consisting of six teams. The contest was about competing for the number of missions completed within a 60-minute time limit, and our students were involved in its operation. The junior high school students who participated said they had fun programming and obtained a sense of accomplishment when they cleared the tasks. They were eager to study more about computers. These results suggested that this support education had the effect of closing the gap in programming learning opportunities and increasing interest in programming and robots.

4. Conclusions and future work

In this research, we proposed novel engineering defined as "remote island engineering". It aimed to solve various problems that the local island had, utilizing together both the human resources of our college and the local community. In the first attempt, we planned four kinds of programs and implemented five projects with Kamijima Town Office. We evaluated the usefulness of our projects by questionnaire survey. Most participating students tried to work and learn actively with people of the local community on Yuge Island. According to the survey, they were very satisfied with their activity and had a lot of positive opinions. Therefore, it seemed that our attempts were very well suited to the challenges of PBL. In addition, the results of each project were evaluated by external organizations, the Town Liaison Council and the Management Advisory Committee. As a result, our projects received high praise and a PDCA cycle system to promote the next projects based on remote island engineering was established.

In the future, we plant to continue to develop PBL in which we discover and solve local issues through local activities. This time, projects' themes were mainly selected by faculty members, and some were carried out as graduation research. The next step is to help students discover problems and do everything from planning to assessment. We had opportunities to have several meetings with Kamijima Town, such as with the Town Liaison Council and the Management Advisory Committee, to share the problems to be solved. It was an added benefit to be able to construct a foundation for consultation and communication with each other. In the future, we will carry out collaborative research closely with Kamijima Town to solve local issues discovered by students based on this foundation.

Acknowledgements

This research was partially supported by 2019 Chuden Education Promotion Grant (College of Technology) and KOSEN4.0 Grant of National Institute Technology.

References

T. Ito, Y. Ito, S. Iwasaki, H. Ichimori, H. Okano, K. Tada, J Yano, (2019). Teaching Materials of Rocket Stoves for Environmental Education and Investigation of Educational Effect. *Journal of Japanese Society for Engineering Education vol.67 (4) p86-90.*

Y. Matsumi1, T. Nakayama, (2016). Development of a compact, simple and precise PM2.5 sensor and its applications. *Japan Geoscience Union Meeting 2016. A-AS12.*

T. Ito, S. Ishida, (2019). Activity of scientific experiment club based on remote island engineering. *The 13th International Symposium on Advances in Technology Education 2019(ISATE2019), p564-568.*

K. Ise, (2019). Isolated Island Engineering Helps Students Develop. *Journal of Japanese Society for Engineering Education vol.67 (4) p33-3490.*

Efforts at Education and Student Guidance with a Focus on Comprehensibility and Diligently in KOSEN

Mitsuhiro Saito*[a]

[a] Department of Civil and Environmental Engineering,
National Institute of Technology, Fukushima College, Iwaki city, Japan

*E-Mail : mitsuhiro@fukushima-nct.ac.jp

Abstract

This paper presents a method to help junior high school students and their parents better understand the civil engineering curriculum and see the attraction of entering the field. The method gets students more interested the specialized field and allows them to regularly check their understanding.

Due to the declining birth rate in Japan, it has become more difficult to attract candidates for many specialized fields. The fact that students must choose their academic specialization (and thus their future career path) at the age of 15 makes recruiting students even more challenging. To better attract candidates to our program and to retain these students after enrollment, we have made changes in our recruiting efforts and in our teaching approaches.

To improve recruiting, we redesigned our recruiting materials with a focus on comprehensibility and diligently, and regularly present these materials at college briefings and open campus events. In these revised materials, we outline what students can learn in the program and where they can apply this training in the future. We have recast the graduates of our program as "Machi no Oishasan", which emphasizes the social and environmental mission of engineers working in this field. As a result of these change, the number of candidates applying to the department has recovered a little in the following year.

To better educate students after enrollment, I have developed a new feedback mechanism called the "Catch Ball Sheet", with which students can review lesson content and ask questions freely. This feedback sheet allows the instructor to check student understanding as well as to better understand each student's personality and life situation. The use of this sheet has been effective for both students and teachers to reinforce lesson contents and to communicate with each other. Because there is a need for comprehensibility and diligently as well as the attitude to get candidates, teachers are required to maintain a consistent attitude toward students as "Machi no Oishasan".

Keywords: *education method, student guidance, public relations, examination student acquisition, civil engineering, KOSEN (National Institute of Technology)*

Introduction

Japan is currently experiencing a seriously declining birth rate, shrinking the pool of potential students for all academic and training programs. This is especially the case in technology education, where young people must choose their specialization and their future career path at the age of 15. In such a situation, the field of civil engineering is at a disadvantage, since it evokes images of dangerous, dirty, and hard work, making it difficult to attract students to this specialized field. Once enrolled, students are expected to master substantial knowledge and skills in the field, which presents an additional challenge to attracting engineering candidates.

The purpose of this paper is to present new methods to help junior high school students and their parents better understand the civil engineering curriculum, as well as the attraction and benefits of entering the field. And I want to show how to teach in a way that makes students more interested the specialized field and how to check their understanding.

1.Present circumstances and problems facing higher education institutions

1-1. Decrease in young population and influence to number of applicant for admission

The decrease in the youth population is a common problem in Japan. In Iwaki city, which has a population of about 350,000, the youth population aged 0 to 14 decreased from 46,776 in 2010 to 42,404 in 2015, a drop of 4,372 people. Under such circumstances, the number of applicants for admission to Fukushima College has decreased over this time. In particular, enrollment in the civil engineering department has been declining in recent years. In 2019 the number of applicants identifying civil engineering as their first choice department for the entrance examination fell below the admission capacity: only 13 applicants selected civil engineering as their first choice out of a capacity of 20, an application ratio of 0.7. Looking at each department, electrical engineering had

46 applicants with an application ratio of 2.3. But the application ratios of other departments were closer to one, including mechanical engineering (1.0), chemistry and biochemical engineering (1.0) and business communication (1.1). The 2019 application ratio of around 0.7 in civil engineering shocked department staff and suggested that action was urgently needed in the department.

1-2. Current situation of KOSEN civil engineering departments

To consider ways to improve this result, I surveyed current entrance examinations done in KOSEN (National Institute of Technology) colleges that have a civil engineering department. Nationwide there are 25 KOSEN institutions that have a civil engineering department. Four of these colleges consist of a single department and a multiple course system. In other words, the entrance examination is conducted for the entire college, and students are then assigned to a specialized course after admission. This approach can attract applicants to a KOSEN regardless of whether the department is popular or not, so it is expected that a higher application ratio can be attained.

Table 1 summarize published entrance examination data from 2018 and 2019. The 2019 average application ratios were 2.7 for all those taking the entrance exam and 1.4 among candidates selected for admission at the three KOSEN that consist of a single department/multiple course system. In particular, the application ratio based on those taking the entrance examination is high. On the other hand, looking at the data from the 16 KOSEN where the recruitment is conducted by individual departments, the average application ratios were 2.1 for all students taking the entrance examination and 1.8 for selected candidates. In fact, application ratios differ by each KOSEN, with the highest ratio among selected candidates in 2019 being 3.8 and for all those taking the entrance examination being 4.1. On the other hand, the applicant ratio for two KOSEN, including the Fukushima KOSEN, has fallen below 1.0. In the same way, considering those KOSEN where the recruitment is conducted by individual departments in 2018, the average application ratios were 1.8 for both selected candidates and all those taking the entrance examination. As a whole, it turns out that application ratios, while somewhat variable, have decreased every year. Possible influences include the ratios of the previous year and those of a highly-ranked school in the same region. There are many regions where a large number of candidates apply for both KOSEN and advanced schools and where a large number of examinees decline KOSEN after passing. Thus the situation is different by region.

Table 1. The application ratio of entrance examination

	2018		2019	
	Selected	Examination	Selected	Examination
A single department/multiple (3 colleges)	1.2	2.1	1.4	2.7
Civil engineering department (16 colleges)	1.8	1.8	1.8	2.1

2. Efforts and achievements to attract candidates

2-1. Creating brochures and catchphrases

To attract candidates for civil engineering programs, we primarily developed new materials that introduced the department with a focus on comprehensibility and diligence at college briefings and open campuses. In the introductory material, we first explain that the department of civil and environmental engineering is where students acquire the engineering skills to create more livable cities for everyone's benefit while considering the environment, and to do so requires a substantial body of knowledge. Then we explain the need for students to have a broad general education background. In this section, we mention why we require courses in subjects from elementary and junior high school, such as language, mathematics, science, society, and English. Table 2 lists the main general education requirements and the rationale for students to study them. For example, language is necessary to share our thoughts and ideas and gather necessary information, and mathematics is necessary to understand various phenomena occurring around us. We then present more specialized subjects which build upon this foundation.

Further we mention to prospective students that it is necessary to acquire specialized knowledge from other disciplines, as shown in Table 3. For example, knowledge of the "Internet of Things" (IoT) has recently become important in many applied fields including civil engineering; likewise many types of construction machines and mechanical tools are used at actual construction sites. So, to effectively use these tools, it is necessary for the civil engineer to have specialized knowledge about machinery, electricity, information technology, and other related fields.

In this way, the civil engineer is a special engineer who employs knowledge and skills from multiple fields, and is expected to solve problems in our society through the creation and maintenance of a wide variety of infrastructures. Our objective is to convey these attractions of the civil engineering field to junior high school students. Here, we strive to avoid difficult expressions as much as possible, and we tried to

Table 2. The rationale of learning general education

Main subjects	Why this knowledge and ability are needed?
Language	To share our thoughts and ideas and gather necessary information
Mathematics	To understand various phenomena occurring around us
Science	To understand phenomena and environmental around us
Society	To understand current state of society and economy
English	To work global challenges with people from all over the world

Table3. The rationale of learning other specialized field

Specialized field	Why this knowledge and ability are needed?
Machinery, Electricity, Information	To use the latest technology
Power, Physics	To understand the energy that supports living
Biology, Chemistry	To understand the environment
English / Communication	To contribute to global environmental conservation and to be active in the world

Figure1. The title call on the front page of brochure

introduce and explain this specialized field in a way that is appealing and easy to understand. To support this approach, we adopted the term "Machi no Oishasan", i.e., someone who solves social (Machi) problems through studying manufacturing and town development. We encourage students to think of themselves as future "Machi no Oishasan" instead of a "civil engineer." Therefore, we selected "You are Machi(Social) no Oishasan" as a catchphrase for our recruiting, and raised it as the title on the front page of our brochure.

Our recruiting materials also introduce descriptions of student life and extracurricular activities, and details on specialized sub-fields, with any comment on another page. On the final page, we list the major career paths followed by graduates over the past three years, and introduce some of the graduate Machi no Oishasan who are active in various regions, along with their comments on their selected fields. In this way, we present what the candidates will learn and where they can be active in the future. In particular, we reinforce the idea of the engineer as "Machi no Oishasan", and emphasize that this course of study will be enjoyable because students will be exposed to a variety of subjects.

2-2. Efforts to acquire applicants and its results

We have adopted this approach at new student recruiting events, such as the college briefing, where we introduce the field of civil engineering and explain how civil engineering departments train students for the field. To start conversations with prospective students, we use our catchphrase "You are Machi no Oishasan". These recruitment efforts have continued at trial enrollments and other opportunities in 2019.

We have carried out questionnaire surveys at trial enrollment every year. In this survey, we have asked students which departments they favor after trial enrollment. Survey results are shown in Figure 2. Looking at the result of 2019 compared to 2018, the percentage of responses that approved of civil and environmental engineering programs increased. In particular, the positive response by students' guardians increased from 17.6% in 2018 to 23.9% in 2019, which was the highest percentage among the five target departments.

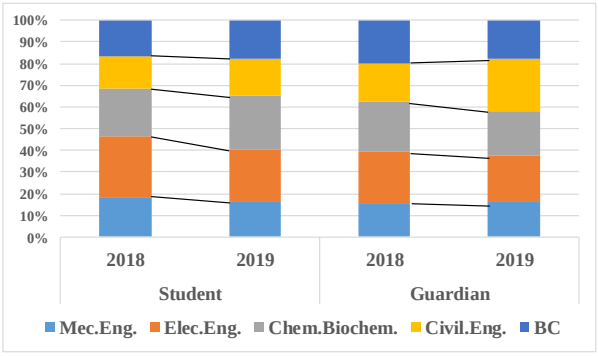


Figure 2. Evaluation for department in trial enrollments

Table4. Answer about impressive things

Respondent	Answer contents
Student	The contents of the Department were good (I was interested. Students were fine. Town model was good)
	I could see the friendship between students
	I was convinced of the word "Machi no Oishasan"
Guardian	The presentation seemed most enjoyable (I felt like the participating students were having fun)
	The atmosphere of the Department was good
	The female student was fine
	The explanation of a wide variety of job of "Machi no Oishasan" was good

Some of the comments and impressions offered by survey participants are given in Table 4. The phrase "Machi no Oishasan" had a notable impact on both students and guardians. And the explanation of the wide variety of jobs open to civil engineering graduates appeared to be very convincing. Survey respondents also noted student's cheerfulness and the positive atmosphere within the department. These impressions were formed through daily lessons, experiments, and training that teach students to design cities and work in cooperation with groups of people, which are characteristics work in civil and environmental engineering.

To attract program candidates, it is necessary to clearly convey these characteristics to junior high school students and their guardians. In particular, the students around 15 years old who may be attracted to programs at KOSEN are often interested in manufacturing technology for robots, automobiles, and the like. In such a situation, in order to get applicants interested in fields dealing with civil engineering and the environment, it is necessary to devise programs that incorporate these interests along with new discoveries. Also, it is necessary to introduce these specialized fields to students who may be undecided about their interests and future course of study. In that sense, the expression "Machi no Oishasan" was effective in getting those students to consider the civil engineering field.

As a result of a series of efforts to attract candidates including trial enrollment, the number of candidates recovered a little in 2020. The number of applications for selected candidates increased from 28 to 41, and the application ratio increased from 1.4 to 2.1. The number of applications for the entrance examination increased from 13 to 45, and here the ratio increased from 0.7 to 2.3. The number of applications for entrance examination for civil and environmental engineering was second only to that of the electrical engineering department.

Furthermore, looking at the results of the questionnaire survey conducted after enrollment (number of respondents was 203), the most common reasons of "The opportunity to get interested in Fukushima KOSEN" were "Recommendations from family and relatives" (number of answers was 116), followed by "experience-based enrollment" (number of answers 99) and "college briefings" (number of answers 65). From these results, it appears that these new recruiting efforts, including the creation of a brochure for attracting applicants in FY2019, were very effective.

Our experience suggests that efforts to attract program candidates during college briefings and trial enrollments are important and necessary. Further, the nature and advantages of the civil engineering training program must be diligently explained to prospective students in a comprehensible fashion.

3. Educating students carefully with comprehensibility and diligently

3-1. Consideration of program lessons

Once enrolled in a program, students must be educated carefully and comprehensibly. In particular, as a position to teach a specialized field, it is important to have interest and understanding in the field they learn for the first time. With that in mind, we must develop and refine sustainable lessons.

In general, there are two methods for checking a student's understanding of lesson contents: 1) talk to students at key points in the lesson and check that they were able to understand the material; and 2) have students complete a check test, and confirm the learning achievement from the results. Each of these methods present advantages and disadvantages. Method 1) has the advantage that it leads to an interactive lesson format and students can concentrate on the lesson without getting tired of it. But it is not easy to check the understanding of each student in a class of about 40. When using method 2), in preparing for the test, students may only work to memorize specific answers, so it is difficult to properly judge students' understanding of the full content of the lesson. There is a clear need for a method that allows instructors to efficiently check the level of understanding of each student about class content.

Based on the author's teaching experience, the following are typical characteristics of students as they work to grasp each classroom lesson.

(1) During lesson time, there are not many students who are likely to respond honestly when they are asked if they have understood the material being presented. In particular, there are some students who pretend to have understood. They evidently care about what their fellow students think of them, and do not say "I do not understand" since they believe that it is embarrassing to say so.

(2) During a lesson, students are willing to work hard on solving calculation problems, but are less interested in listening silently and taking notes during lecture.

(3) Although there are not many students who respond honestly when I ask if they have understood the teaching content, many students submit questions and comments when they are asked to do so on paper.

(4) Students tend to be more worried about exam scores than whether they understand the essence of the lesson content. They are very concerned about exam scores and evaluation scores.

(5) The lesson period is typically 100 to 120 minutes in length, which most students feel is too long, so more effective lesson implementation and utilization of each class hour are required.

(6) Because the results of regular examinations account for a large portion of their final grades, students tend to focus on getting high exam scores rather than working on regular lessons. It is necessary to establish the significance of completing the lessons, and instructors should consider emphasizing the daily lesson results in students' final grades.

3-2. Development of the Catch Ball Sheet

Based on the above, after considering the problems of both teaching methods and students' attitudes toward lessons, I developed a set of teaching materials called the "Catch Ball Sheet". Through the use of the "Catch Ball Sheet", students can review lesson content and ask questions freely. And similarly, teachers can check student comprehension and gain a better understanding of each student's personality. I have used this sheet at every lesson except experiment and practice time.

Figure 3 shows the format of a sheet.

(1) The paper size is A3 sheet and uses both sides.

(2) This A3 sheet is divided into 8 sections, providing space for 15 lessons of a half term using both sides.

(3) The feedback for each lesson consists of two items: "B1: Point of lesson" and "B2: Questions and impressions of the lesson". The sheet provides 13 lines and 5 lines, respectively, for student responses to these items.

I have been used this sheet as follows.

(1) Students complete the sheet during the last 10 minutes of a lesson.

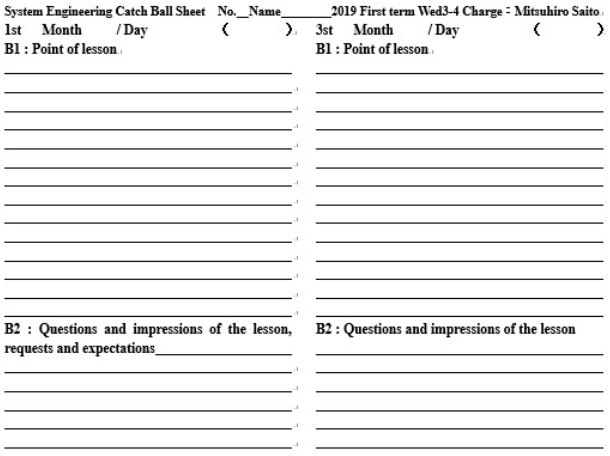

System Engineering Catch Ball Sheet No.__Name_____2019 First term Wed3-4 Charge：Mitsuhiro Saito
1st Month /Day ( ) 3st Month /Day ( )
B1 : Point of lesson B1 : Point of lesson
B2 : Questions and impressions of the lesson, requests and expectations B2 : Questions and impressions of the lesson

Figure 3. The format of the Catch Ball Sheet

(2) I collect the sheets after completion, check contents, and evaluate student feedback.

(3) In the next lesson, students complete a new sheet in a similar fashion. At that time, they check the previous evaluation and my responses.

By repeating this process, it is possible to carry out 15 lessons for a half term on both sides of an A3 sized paper. I named this sheet the "Catch Ball Sheet" to emphasize the interaction between the student and the teacher each time.

Utilizing this catch ball sheet has revealed the following problems which appear to be characteristics of many students.

(1) Some students say, "I can't write," "I'm not good at summarizing the point," and/or "I'm not good at writing."

(2) Some students write something but cannot fill the given space, and leave one-third or nearly half as white space.

(3) Some students complete the sheet by copying from the beginning of the notebook, so the given space is filled up by the middle of the lesson and does not address all the lesson contents.

(4) Some students' writing has many typos or misspellings, and does not form sentences that can be read by others.

On the other hand, some students have the following abilities.

(5) They can summarize the contents of the lesson, and organize and summarize the points well.

(6) Some students are good at writing and can write well in their own words.

3-3. Practical Use of Catch Ball Sheet

The Catch Ball Sheet has been used in my classes to collect student feedback for 15 years. Below are listed some specifics of how the feedback sheet has been used in the classroom.

(1) I evaluate each submitted sheet on a five point scale (corresponding to letter grades from A to E) based on whether on not the student could summarise the main point of the day's lesson, and whether they could express themselves and write the result in their own words. Then the evaluation is treated as the score for each task and is reflect in the final grade.

(2) For the student who could not get an A grade, I write comments on the sheet like "Check about○○!" or "○○ is an important point of the lesson, too!" In this way, I explain to the student he additional points of the lesson they may have missed.

(3) For misspellings and Kanji mistakes, I make corrections to the text and call attention to the errors.

(4) For the student who correctly summarizes the points of the lesson, I provide comments of praise and include symbols such as a flower circle.

(5) Further, for students who can not only summarize points, but also provide their own explanation, I write comments of praise with a circle and a flower circle. I also offer strong praise for students who can summarize the lesson content in a way that would be impossible to write without closely listening to the lecture. Evaluations and comments are written with red pen, to contrast with the students' black pencil.

On the other hand, the sheet includes the space labeled "B2 : Questions and impressions of the lesson". This space is not evaluated; in it, students can provide open feedback about their experience of the lesson, such as pointing out portions they found hard to understand and/or contained unknown words, requests to modify the teaching methods, improvement of blackboard writing and teaching materials, and so on. Since the comments in this space are excluded from evaluation, I encourage the students to write whatever they want. Further, this is the exchange that is "Catch Ball" between myself and the student only; it emphasizes that the student's feedback is off the record and it is possible to write freely.

4. Effect of Catch Ball Sheet

4-1. Improvement of Teaching Methods

Through the use of this catch ball sheet, it has been possible to review the lesson every time for teachers, enabling improved teaching methods as follows.

(1) The instructor can determine the degree of students' understanding of the lesson, and this knowledge can be used to improve the next lesson. In particular, if many students did not understand what the most important point in the lesson, or if they generally understood the lesson without getting the main point, I can re-emphasize and explain it in the next lesson, by creating additional materials and so on.

(2) The instructor receives constant feedback on the speed of lesson progress and the legibility of black board writing, which can lead to lesson improvement.

(3) As an instructor, I am aware of the main points for every lesson, so I emphasize these points while covering a wide range of topics, thereby deepening students' understanding.

These effects of using the catch ball sheet appear in the responses to questionnaires about the lesson evaluation. In the questionnaire, there are questions about lesson methods, such as, "Are the explanations and materials easy to understand?", "Are there areas that need improvement?". In recent years, there have been no suggested improvements in response to such questions. This suggests that the lesson content and delivery has improved based on student feedback, while confirming the student's understanding of the material. In this way, the development and practical use of the catch ball sheet have achieved their purposes.

4-2. Effectiveness in Student Guidance

The positive effects of using the catch ball sheet have appeared not only in improving teaching methods but also in better student guidance.

(1) Because the sheet will be evaluated, students tend to work hard to complete it. And because they know that the feedback sheet must be completed at the end of each

lesson, many students diligently take notes listen intently during class time.

(2) Each year several new students arrive in my classes with very undeveloped writing skills. Through the practice of completing the catch ball sheet, many gradually improved their writing and have been able to achieve an A grade by around the end of the tenth lesson.

(3) The sheets capture descriptions of student and instructor from the first lesson onwards, so through looking back on them, both the students and the instructor can confirm their growth with each other. In particular, I have found that the corrections of students' errors and the praise given to good work both serve to increase a student's motivation to do well in the class, helping to create an attitude to work hard for an A grade the next time.

(4) By pointing out student behaviors I may have noticed during a lesson, I can make them aware of being constantly watched and correct their attitude if needed.

(5) Student feedback has included comments by female students comments about poor physical condition, it became possible to realize the need for consideration for students. In the past, when there were students lying down on the desk, I thought that they were sleeping, so I alerted immediately. But I have aware of the effects of poor physical condition, I was able to ask about the presence of poor physical condition and take appropriate measures.

(6) By being better able to grasp the situation of each student, it is possible to provide individual guidance both within and outside of the class, including assisting with career guidance.

In this way, while speaking and teaching in front of the whole class, the instructor can effectively speak and teach individually, making it possible to give guidance to all students and building mutual trust. In fact, the communication enabled by the catch ball sheet has become a regular topic among students, and it has become a standing conversation when passing in the corridor, thus leading to improved overall communication between students and teachers.

5. Future tasks for further utilization

5-1. Current Problems

There remain some challenges to its effective use, and there are several potential areas for improvement.

(1) Because the sheet is assumed to be completed at the end of each lesson, if the lesson does not proceed as expected, in some cases, the lesson progresses make quickly or the explanation ends simply.

(2) In the same way, the end time of class may be slightly late, leaving insufficient time to complete the sheet.

(3) The feedback sheets from a class of 40 students require about 1 hour or more to check each sheet and write comments. So while this method works well, it is time consuming. In particular, because the students who wrote the sheet remember the lesson content, and it will be a topic of discussion when we next meet, it is important for the instructor to check the submitted sheet the same day.

Overcoming these problems is necessary to continue our efforts in the future.

5-2. For Further Practical Use

The process of summarizing the contents of the lesson and organizing the main points from their own viewpoint and in their own words within a limited time (about 10 minutes) demands a considerable effort by students, and often requires advanced abilities to respond. So it seems like completing the sheet represents hard work for students. But going beyond the burden and dissatisfaction of these students, it is necessary to improve teaching effectiveness, a significant task for the future.

In recent years, it has been pointed out that the number of students cannot write well or organize ideas or concepts. Under such circumstances, the use of the catch ball sheet can help to train those skills. The author has witnessed students gradually acquiring the needed skills through writing the sheet 15 times in half a year. And those skills can be used in various fields. For example, the importance of being able to complete entry sheets in job hunting is increasing; the ability to complete the sheet has begun to function as a primary exam, rather than just a part of the submission process in recent years. It requires a certain amount of description, such as 400 or 800 words for a given question. I have heard from students that their experience in completing the catch ball sheet was helpful in those cases. In this way, the practical use of the catch ball sheet offers advantages in many areas.

6. Conclusion

These my efforts is not necessarily desirable. There will be pros and cons of implementing this feedback into the KOSEN system. The daily work of KOSEN includes research, education, student guidance, regional contributions, and so on, and the demands on the technical training system are increasing. Moreover, interacting on paper using handwriting methods may be outdated in an era when educational materials that utilize electronic devices are becoming mainstream. But the written feedback sheet approach has been shown to have positive educational effects and to be effective in providing guidance to students.

In particular, in an educational system where many students focus only on the success or failure of their answers or test scores, I suggest that it is import to improve students' ability to summarize complex ideas and write clearly, thereby not only improving their academic prospects, but also helping to foster a richer human experience. And above all, these efforts have led to building trust between teacher and students. So my goal is to improve implementation of the method and continue efforts at overcoming challenges and continually improving. It can be said that there is a need for comprehensibility and diligently as well as the effort to get candidates.

DEVELOPMENT of a PROBLEM-BASED-LEARNING PROGRAM in ENGLISH to FOSTER STUDEDNTS' THINKING ABILITY AND COOPERATIVE SKILLS

Y. Ominato[a], Y. Tsuchida[a], M. Omori[a], N. Fukuda[a], S. Urabe[a], K. Ichimura[a], N. Maharjan[b]

[a] National Institute of Technology, Nagaoka College/Division of General Education (English), Niigata, Japan
[b] National Institute of Technology, Nagaoka College/Department of Civil Engineering, Niigata, Japan

*ominato@nagaoka-ct.ac.jp

Abstract

National Institute of Technology, Nagaoka College (NITNC) has reorganized some English courses with the aim of improving students' thinking ability and cooperative skills, which are both necessary to work as an engineer in a diverse international society. In addition to learning critical thinking and logical thinking methods, we designed new courses for students to learn problem-solving skills based on the design thinking method, using English, and started teaching them in 2020. In this paper, we will introduce the basic design of these courses, and discuss the educational effectiveness based on student evaluations of the six-month trial and self-evaluation questionnaires regarding their thinking ability, cooperative skills, creativity, and their English skills. Before preparing our course design, we visited Singapore Polytechnic, which provided us with the module of thinking methods used there in all first-year compulsory courses. They gave us great suggestions to consider the general course framework, the assessment policy of students' achievement and the procedure for teaching. We set four main categories in our course framework: 1) Critical Thinking, 2) Logical Thinking, 3) Design Thinking and 4) English Language. The courses consist of 15 x 90-minute lessons or 30 x 50-minute lessons, and they are designed to help students improve their thinking through the following steps: topic explanation, individual thinking / work, group discussion, and presentation to share their ideas in class. This year, class topics incorporated two SDGs, with students addressing the issues of safe urban environments and marine plastic waste utilizing the five steps of Design Thinking: Empathize, Define, Ideate, Prototype and Test. After the six-month trial, we surveyed students about the classes. Unfortunately, due to COVID-19, the first half of 2020 classes were taught offering online and on-demand lectures. Despite this complex situation, more than half of the students responded favourably to the class. In particular, the number of favourable responses to the effective use of teaching materials increased from the previous year. The combination of English language learning with thinking skills is an innovative and challenging approach. Working in a group to solve problems while using English is a necessary experience for future engineers.

Keywords: *English language ability, critical and design thinking, problem-based learning, SDGs*

Introduction and Background

National Institute of Technology, Nagaoka College (NITNC) has worked on numerous international projects to foster future engineers including sending out students overseas to join exchange programs such as the Sakura Science Exchange Program, TOBITATE! Young Ambassador Program, International Internship Programs to Thailand, Malaysia, France, and Finland, as well as international students from overseas institutes in special programs of NITNC from Malaysia, Singapore, Thailand, Finland, and France. Moreover, NITNC students always have opportunities to exchange ideas with international students on campus since there are usually more than twenty international students officially enrolled in our college. This globalized learning environment in NITNC requires the students to develop not only their engineering knowledge and skills, but also more positive and fundamental skills such as the ability to think, cooperate, create, and use English.

Before starting the problem-based learning program in our English classes, four different types of English classes were offered to the students. Each class focused on reading (90 minutes x 30 weeks), grammar (90 minutes x 30 weeks), communication (50 minutes x 30 weeks), and extensive reading (50 minutes x 30 weeks) for the first-year students to the third-year students. For the fourth-year students, we offered an English Practice class which focused on preparation for the TOEIC® Test (90 minutes x 30 weeks) and an elective English Communication class (90 minutes x 30 weeks). For the fifth-year student, several elective classes were offered

so that students could choose one of them from a variety of topics such as technical English, preparation for the TOEIC Test, English presentation, and preparation for university transfer examinations. From 2020, we have changed the Communication Classes for the first-year students to the third-year students and the English Practice Classes for the fourth-year students to new Essential Thinking Classes. In 2020, these classes have started for the first-year students and the fourth-year students. In 2021, the second-year students were added, and the third-year students will be added in 2022. Therefore, the first-year students in 2020 will be the first students who will get four years of Essential Thinking Training through this English class program. Before and after the year of 2020, two different types of questionnaires were given to our students. In this study, these new English classes will be introduced, and the result of the questionnaires will be discussed.

Literature Review

Ping, Chow, & Teoh (2011) mention that there are a variety of definitions of design thinking, however, they cited Brown's (2008) design thinking definition as a useful starting point as follows: "Design thinking can be described as a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity." The definition which NITNC adopted and shared with all the teaching staff in this project is as follows. "Design thinking is a non-linear, iterative process which seeks to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. The method consists of 5 phases—Empathize, Define, Ideate, Prototype and Test – it is most useful to tackle problems that are ill-defined or unknown." (Interaction Design Foundation, n.d.).

Hasso-Plattner-Institute of Design at Stanford University (the d.school) provides five phases of design thinking: Emphasize, Define, Ideate, Prototype, and Test. Also, Ping *et al.* (2011) introduced their simplified design thinking flow, which are Emphasize, Ideation, and Prototype. NITNC added an "Interview and Research" phase to the d.school's five phases so that younger students would be better able to understand the human-centered design process with less or enough preparation.

The framework of design thinking has been applied not only to business and product design, but also to various professional fields such as education. Lor (2017) examined various settings of literature using design thinking in educational field and pointed out that design thinking is advantageous for those who are teaching 21st century skills in schools. He has reviewed a total of 64 studies published from 2005 to 2016 regarding design thinking and categorized those studies into three different categories: (1) curriculum design, (2) teaching-learning approach, and (3) teacher training and support. Therefore, this study is focused on the second category.

Materials, Methods, and Pedagogy

Even though there was a plan to start our first trial on teaching these newly designed classes from April 2020, we had to start our classes online due to the COVID-19 pandemic. Generally, in Japan, the school year starts from April and ends in March, and in NITNC, an academic year is divided into two semesters, the first semester (from April to September) and the second semester (from October to March). Due to the huge influence of COVID-19, just like other universities and colleges in the world, our school did not have any other choice but to offer on-demand lectures online in the first semester. NITNC students downloaded all the document files and video files they needed to study and worked on their assignments independently. However, these online course materials were evaluated quite positively by our students (Refer to "Educational Program to Develop Global Engineers based on Nagaoka CO-CORE Vision," written by Y. Tsuchida *et al*. in the same volume for more details about their analysis and overview of this project.) In July 2020, we were able to gradually resume our face-to-face lectures on campus. Finally in the second semester we started full face-to-face lectures in NITNC.

<What We Teach>

In our newly designed English class called essential thinking class (English IC: English Communication class for the first-year students), the students need to come up with solutions for two different obstacles in a semester (15 weeks). There are basically ten groups of four or five people, and they discuss issues and cooperate with one another to create and present one solution. Generally, two teachers are assigned to teach one class. One is a newly hired teacher in this global engineering project who is a non-Japanese teacher and the other is a full-time Japanese faculty member of the English department.

INTERVIEW & RESEARCH: Some topics were selected from 17 SDGs' and then simplified to a level more suitable for the age of NIT students of 15 to 16 years old. For instance, the GOAL 11: Sustainable Cities and Communities was selected in the very first class of 2020. Instead of asking what those cities or communities would be, we prepared and asked the students to think about the following question. "In your house or neighbourhood, there must be some unsafe or dangerous spots. Talk to your family members or neighbours and identify one such spot and suggest a solution." Since design thinking is a human-centered method, they needed to start by collecting information from family members (users). Students needed to ask detailed questions to determine what their family and neighbours' experience had been, where, when, how it had happened, and so forth.

EMPATHIZE: In the following week, students were ready to share the results of their interviews. We usually utilize big poster-size Post-Its® to share ideas in groups. They were asked to write as many ideas as possible on stickies and place them on the Post-It®. At this stage, they were asked to find out what the real problems were. After choosing one problem in each group, they were

asked to think about the "user's surprising recognition of reality." For example, if a group said the problem was that people who walk while using a cell phone bump into other people, students needed to realize and discover the user's assumption while doing so. Students learn that users believe that they would never bump into anyone on the road. Through providing various examples, students will find out user's surprising recognition of reality in their groups.

DEFINE: After analysing the problem and figuring out what the surprising recognition of reality was, they needed to write a problem statement. This is one of the hardest steps in the design thinking process, because students need to analyse all the data collected and notice what others have failed to notice including the users. Then finally, students need to identify what the real problem is.

IDEATE: Students need to come up with ideas to solve the defined problem. In this step, they do not have to come up with a perfect idea, but they need rather as many ideas as they can. With other members in the same group, they need to brainstorm and come up with a creative idea. Usually, we have them draw a graph placing existing ideas in the middle and have them consider whether the solution is inexpensive and practical.

PROTOTYPE: This is a hands-on activity stage of the design thinking which engineering students love. We prepare many kinds of materials to create prototypes in our classroom such as markers, stickies, papers of different colors, origami, scissors, utility knives, scoth tapes, glue, paper clips, rubber band, cardboard, and so forth. They will be given a limited amount of time to create a prototype, because in most cases a prototype does not have to be in a perfect form. Students need to keep in mind that their users will experience their ideas with their prototypes, and if necessary, they will rearrange the prototype and fix their ideas to fit into their users' demand.

TEST: In this step, a group will be divided into two; one group makes a presentation about their prototypes and the other join the other groups to listen to their presentations and to experience their prototypes and provide feedback. Their presentations or explanations should be very brief because it is essential to get some feedback from the users such as inspiring points and points that need improving.

In addition to the design thinking materials, logical thinking and critical thinking training and activities are introduced in this course so that students can understand what is expected in a "thinking" class. Moreover, most of the interactions taking place in this class are in English, including teachers' directions, their questions to students, worksheets, and all the slides the teachers show.

<Organization>

All the teachers who teach this essential thinking classes are required to use English, even though they all understand the students' mother tongue, Japanese. In 2019, two additional teachers were hired for this project. The qualifications for this position were obtaining Ph.D. degree in engineering and the ability to teach in English. Several candidates came forward and we were able to hire two of them. One was from Nepal and the other was from Sri Lanka. Furthermore, there are six teachers in our English department, and every teacher taught at least one or more essential teaching class together with newly hired teacher. Thus, it was conducted by team teaching (TT) with one foreign teacher and one Japanese teacher.

<Questionnaire>

Participants of this study are the 209 students who enrolled in the essential thinking (English IC) class in 2020. They took TOEIC Bridge® IP test both in October 2020 and in April 2021. The data of the students who took both tests was analysed. Data from students who had repeated a school year, who could not take the two exams, or who had incomplete response was excluded. In order to ascertain the effectiveness of this project, two different questionnaires were administered. One of them was administered using six attributes attached with TOEIC Bride® test, and the other one was distributed to the students on Microsoft Forms online at the end of the school year in February 2021. The first one asked the following questions with using four-point Likert scale: Do you think you have the following abilities? [Strongly Agree, Agree, Disagree, or Strongly Disagree]. The abilities we asked were, 1. Cooperativeness, 2. Creativity, 3. Thinking Ability, 4. English (Productive Skills [speaking & writing]), 5. English (Perceptive Skills [listening & reading]), and 6. Study Abroad Orientedness (Motivation for studying abroad). The questions in the second questionnaire were slightly different from the first one. It asked, "Have you improved the following skills through this English IC class?" The six items were exactly the same as the first questionnaire. The total of 189 students' date was analysed for the first questionnaire, and 183 students' data was analysed for the second questionnaire.

Results and Discussion

The Table 1 below shows the result of TOEIC Bridge® tests taken in October 2020 and April 2021. Since NITNC did not start the face-to-face classes from April 2020, they only had six months to take their TOEIC Bridge® test again.

Table 1. Students' mean score of TOEIC Bridge® Test score in 2020 and 2021 and two-sided *T*-test (*n*=189)

	2020	2021	*T*-Test
TOEIC Bridge Test Total	54.62	56.38	$^{**}p < .01$, $p = .002$
Listening	25.65	25.63	$p = .977$ *n.s.*
Reading	29.31	30.74	$^{**}p < .01$, $p = .000$

The culculation of the *T*-test showed that the students' improvement on TOEIC Bridge® score was statistically significant ($p< .01$), whereas their listening score did not show any impromement between 2020 and 2021. Although mean listening score dropped by .001 point, but the difference between 2020 and 2021 was not statistically significant ($p=.97$ *n.s.*). The mean reading score increased by 1.43 point, and this difference was statistically significant ($p< .01$).

The first questionnaire asked students whether they thought they had the following ability. Four-point Likert was given to the students (4:Strongly Agree, 3:Agree, 2:Disagree, 1:Strongly Disagree). The result was as follows in Table 2. Overall, very big differences in six months were not obsserved from this questionnair. Only two statistically significant differences were observed from this questionnaire, which were Cooperativeness ($p< .05$) and English Productive Skills ($p< .05$). It is noteworthy that the average point for English Productive Skills in April 2021 had increased from October 2020, and also cooperativeness had decreased.

Table 2. Students' mean response for the six different abilities and two-sided *T*-test (n=189)

	2020	2021	*T*-Test
Cooperativeness	2.97	2.86	*$p< .05$, $p= .030$
Creativity	2.66	2.61	$p=.372$ *n.s.*
Thinking Ability	2.83	2.76	$p=.249$ *n.s.*
English [Productive Skills: Speaking & Writing]	1.97	2.08	*$p< .05$, $p= .032$
English (Perceptive Skills: Listening & Reading)	2.25	2.25	$p=1$ *n.s.*
Study Aborad Orientedness	2.55	2.52	$p=.605$ *n.s.*

Yet, it is important to focus not only on the changes they made but also on the score itself. Cooperativeness shows a very high score for 2020 (2.97) and 2021 (2.86). The similar is also true for Creativity and Thinking Abilility. To the extent of this, the opposite is also true. The students are not feeling confident about their English Productive Skills (1.97 and 2.08).

In contrast to the result of the fisrt questionnaire, the result of the second questionnairre showed a very positive result. The students answered it only once at the end of the 2020 school year on Microsoft Forms, it is not something comparable. Therefore, we counted the number of the responses of strongly agree and agree as positive feedback and disagree and strongly disagree as negative feedback for their improvement of their six different skills. The primary question was weather they have improved the following skills through their English IC classes. Please look at Table 3 for all the results. More than 95% of the students felt that they had managed to improve their Cooperativeness, Creativity, Thinking Ability, and English Skills (both productive and perseptive skills) through this class. However, 37% of the students were not motivated to study abroad even after experiencing the new English IC class. Although this class is not arranged speciffically for persuading students to study overseas, sutdents have more opportunities to interact with teachers from other countries and discuss some international issues during classes.

Table 3. The number of students who believed that they have improved the six different skills through English IC in 2020 (n=183)

	Positive	Negative
Cooperativeness	180 [98%]	3 [2%]
Creativity	174 [95%]	9 [5%]
Thinking Ability	180 [98%]	3 [2%]
English [Productive Skills: Speaking & Writing]	175 [96%]	8 [4%]
English (Perceptive Skills: Listening & Reading)	172 [94%]	11 [6%]
Study Aborad Orientedness	115 [63%]	68 [37%]

Conclusions

It was and is quite a new challenge for all the NITNC teaching staff to prepare and teach new essential thinking classes in English, but in Japan it is urgent to foster global engineers who can apply their skills using English to their future jobs. From the results of the two questionnaires, it can be said that students are slightly confident about their cooperativeness, creativity, and thinking ability. Though we should always be careful about the drop in cooperativeness value. Having a group work may not be enough for the students to improve their cooperativeness.

It is also clear that students are concerned about their Enlgish skills, especially speaking and writing ability. It might be possible to say that this new essential thinking class program will enhance their opportunities to brush up their English abilities and other skills at the same time. Moreover, the direction to which their English production skills are developing is also standing for the effectiveness for this program.

This study has clealy some limitations. First, the interval between the 2020 and the 2021 tests and questionnaires is only six months, whereas it is usually one year. The result might have been different if they had

more time. It will be examined next year with new data. Second, this study did not assess students' abilities objectively. Hence, the result of this study is limited to how the students felt about their development, which might be different from what they really are. Third, NITNC students usually improve their English skills (TOEIC Bridge® scores) every year. Also they have other English classes and they might try other English learning materials on their own. Therefore, the reason for the increase in the TOEIC Bridge® score cannot be limited to this class alone.

Most importantly, it was a very nice opportunity for us to discuss a newly designed classes with all the full-time and part-time faculty members in English departments and newly hired teachers. We are sure that this team work is the key to bring about a successful project in the future.

Acknowledgements

This project is supported by Global Engineer Fostering Project promoted by National Institute of Technology Japan (KOSEN). I also would like to thank to Nayani Daranagama sensei, the former GE teacher in NITNC, for providing tremendous assists to start our new English classes, and to all the staff who supported us and showed great understanding for this project in Nagaoka Kosen.

References

Brown, T. (2008). Design Thinking. *Harvard Business Review*. June, 2008. Retrieved March, 15 from https://hbr.org/2008/06/design-thinking

Interaction Design Foundation (n.d.). *Design Thinking*. Retrieved March, 14 from https://www.interaction-design.org/literature/topics/design-thinking

Lor, R. (2017) *Design Thinking in Education: A Critical review of Literature*. Proceedings of the Asian Conference on Education and Psychology. Bangkok, Thailand. May 24026, 2017. 36-68.

Ping, C. P., Chow, P., & Teoh, C. (2011). *The Use of Design Thinking in C-D-I-O in Projects.* Proceedings of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, June 20-23, 2011. Retrieved March 12 from http://cdio.org/knowledge-library/documents/use-design-thinking-c-d-i-o-projects

ACCELERATING STEM EDUCATION THROUGH VIRTUAL EXCHANGE IN THE DIGITAL ERA

Eva L.Y. MAK[*,a], Jonathan K.F. LEE [^,b], Jimmy S.M. TANG[#,a], Johnny N.F. KWONG [≥,a]

[a] STEM Education Centre, Vocational Training Council, HKSAR, China
[b] International Development Office, Vocational Training Council, HKSAR, China

*evamak@vtc.edu.hk
^jkflee@vtc.edu.hk
[#]tangjimm@vtc.edu.hk
[≥]johnnykwong@vtc.edu.hk

Abstract

The pandemic has changed everyone's life and created the "new normal", in which it highlighted the importance of advanced digital infrastructure and the need for nurturing STEM talent with a global perspective in accelerating digital transformation and to solve global challenges in fostering smart city development. In times of digital transformation and emergence of smart technologies, innovation is a catalyst for smart city solutions and a robust STEM skilled workforce is needed to fuel continued economic growth, who have been required in fast-growing industries and soon to be dominate in the emerging digital workplace.

STEM education integrates diverse multidisciplinary knowledge to solve global challenges and project-based learning approach to embrace fundamental STEM disciplines, which relies on individuals possessing cross-disciplinary knowledge, problem-solving skills, creativity and foresight to the future. Given the commitment to nurturing future STEM talent with intercultural skills, and encouraging students to adapt changing contexts with the rise of new technologies, the STEM Education Centre (STEM Centre), Vocational Training Council (VTC) took a decisive action to host the International STEM Students' Forum (ISSF) 2020 in a blended mode, under the theme of "Innovation in STEM" – the first-ever digital STEM student forum in Hong Kong – where provided a borderless platform to engage students across the globe in STEM knowledge and cultural exchange amongst the new normal. Having received overwhelming positive responses, particularly on transforming student learning experience by new technology tools, it accelerated the VTC to introduce a Virtual Exchange (VE) strategy under the internationalisation in the Applied Education.

In this paper, it will provide an overview of the VE initiated by the VTC in Hong Kong with referencing the programme of Erasmus+ Virtual Exchange in Europe and the case study of the ISSF 2020. The paper will share the VE model developed by the VTC and its objectives to pioneer the educational VE with academic disciplines. It will also share the innovative approaches of transforming students' learning experience while deepening collaboration with overseas institutions. Moreover, it will cover what elements to consider in designing VE activities among the partnering academics.

Keywords: *Applied Education, Virtual Exchange, STEM Education, Innovation in STEM, Internationalisation*

Higher education institutions have been concerning with preparing their graduates to be global citizens who need to be equipped with knowledge, skills and intercultural awareness and competence in facing an ever-changing environment that are increasingly global, multicultural and even digital. Studying abroad has been one of the top desires and an effective approach to prepare students with an international mindset and their "capacity to critique the world they live, see problems and issues from a range of perspective" (Leask, 2015, p.17).

The pandemic has been an great impact into the heart of every education system across the globe and forced all educators to explore innovation to transform education systems and learning and teaching practices in preparing young generation with knowledge and skills for a better future, especially to the graduates from the Vocational Training Council who advocates an applied learning approach enabling students to apply specialised and theoretical knowledge and skills to solve real-life issues.

Virtual Exchange (VE) is not a new form of learning in education, which emerged more than a decade. The VE

refers as "application of online communication tools to bring together classes of learners in geographically distant locations with the aim of developing their foreign language skills, digital competence and intercultural competence through online collaborative tasks and project work (O'Dowd, 2017).

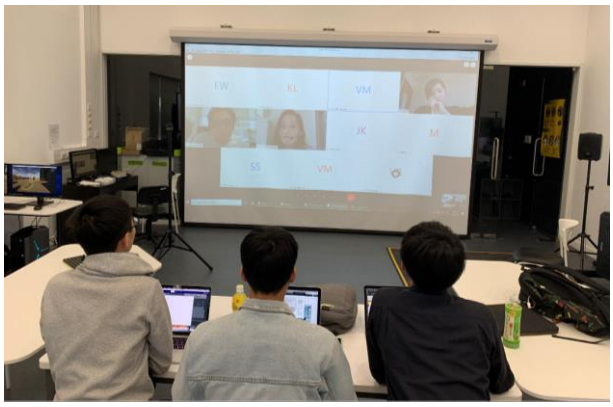
It has been highlighted as part of the higher education studies in the programme of Erasmus+ Virtual Exchange launched by the European Commission in 2018 while many higher education institutions are looking into Internationalisation at Home (IaH) was defined as "the purposeful integration of international and intercultural dimensions into the formal and informal curriculum for all students within domestic learning environment, according to Beelen and Jones (2015). In this article, we will present an overview of the VE model rolled out by the International Development Office (IDO) of the VTC and its objectives collaborating with academic disciplines.

Helm and O'Dowd (2020) argued that "Virtual Exchange should not be seen as being in competition with physical mobility". Physical student exchange should not be replaced by the VE. Instead, it would be part of the initial preparation for physical student exchange programmes and comprehensive integration of the blended student exchange initiatives, which would be a new practice in student exchange led by the pandemic. Students. It would offer inclusive international experience for students who are unable to study abroad or look for physical student exchange in the future, as well as part of their academic studies in their home institutions.

International STEM Students' Forum 2020 and Origins of Virtual Exchange at the VTC

STEM education has been highlighted as a curriculum emphasis and important in finding innovative solutions to our world's complex problems. The STEM Centre started hosting the International STEM Students' Forum (ISSF) since 2016 to promote STEM education with believe that project competitions and international exchange programme are the key elements and effective channel to promote STEM Education (LEE, 2016). While facing the global challenges of the pandemic, the STEM Centre made a decisive action to host the ISSF 2020 in a blended mode. The STEM Centre presented the spirit of innovation and connected with STEM and non-STEM students for promotion of STEM education by hosting the ISSF 2020, the first digital student forum in STEM education in Hong Kong with the support of the Education Bureau of the HKSAR Government. Themed "Innovation in STEM", the ISSF 2020 was successfully held with local and overseas participants from ten countries, including Australia, Finland, Japan, Russia, Singapore, the United Kingdom, etc., featuring (i) STEM Students' Chat with Entrepreneurs: Trends, Challenges and Opportunities for Start-ups, (ii) Panel Discussion with Industry Leaders: Skill Shifting for a Digital Future, (iii) STEM Student Project Presentation and (iv) STEM Graduates' Career Development Sharing.

The virtual forum provided an innovative approach to student learning experience via online collaborative projects with overseas partner institutions. With the four sub-themes in the session of the STEM Student Project Presentation, namely Smart City Development, IoT Applications, Green and Sustainable Development and Health Technology, STEM students from different countries in diverse cultural backgrounds connected through digital technologies and work together for their projects online in different groups. The project supervisors on each side collaborate to design the project aims and expected learning goals to be achieved together and project work allocation among local and overseas students. Taking an example on the joint student project between National Institute of Technology (Kumamoto College), Japan and Institute of Vocational Education (Tsing Yi), Hong Kong – Development of Auto-Parking System for 4-Wheel Vehicle, students employed two different approaches by comparing Improved Dynamic Window (I-DWA) and Reinforcement learning (RL) in Japan and Hong Kong respectively to address the same challenge. During the project preparation and discussion, the project supervisors supervised the students in project development collaboratively while the students continued collaborating and discussing on the project progress autonomous towards the completion of the project works and joint project presentation at the ISSF 2020 with a certain degree of supervision from the project supervisors. Prior to the ISSF 2020, the STEM Centre held a series of training and rehearsals with overseas student and speakers online.



IVE students, Hong Kong and NIT (Kumamoto College), Japan discussed the project presentation flow for the ISSF 2020 online with the supervision of project supervisors from both sides

At the ISSF 2020, the students shared their project outcomes and reflected their findings by adopting different approaches while establishing an intercultural dialogue among students from different parts of the world. Apart from offering students with international experience, it was an opportunity to equip students with the 21st century employment skills, including digital

competences, problem-solving skills, teamwork and most importantly, confidence in working in a diverse cultural environment and leading innovation in preparing them to be global citizens. Partnerships with overseas institutions were further strengthened with the positive responses from the local and overseas students and it also demonstrated their innovation spirit in the international arena.

VTC STEM graduates hosted a panel discussion in Hong Kong with overseas STEM graduates from Finland, Hong Kong and United Kingdom joining virtually to inspire young generation by exploring emerging careers and encourage female students pursuing STEM studies and careers at the ISSF 2020

Overview of the Virtual Exchange Model at the VTC

The pandemic created the largest disruption in education, especially in student exchange. The IDO anticipated that the number of physical student exchange would drop significantly in the coming years and a blended mode of student exchange would be emerged as a new practice in international learning contexts. According to the Digital Education Action Plan adopted by the European Commission, it involves eleven action items to support the use of technology and the development of digital competences in education, including 1) making better use of digital technology for teaching and learning, 2) developing digital competency and skills, and 3) improving education through better data analysis and foresight.

Since the new practice to the joint student project with overseas partner institutions, the VTC took up the VE as an innovation pathway to foster academic and cultural exchange for the VTC students in light of the current pandemic and travel restrictions. As such, the VE emerged as one of the effective and important educational tools connecting VTC students to the world for academic and cultural exchange via technology platforms under the guidance of the IDO and academic disciplines. With an aim of developing an innovative form of constructive communication and interaction without boundaries and geographical constraints, the VE model in the changing contexts of vocational education at the VTC is established as follows:

Objectives:

1. To engage students in a diverse culture environment and foster mutual understanding via student-to-student interaction in intercultural dialogue through technology-enabled communication under teacher facilitation with specific learning outcomes;
2. To strengthen partnerships and international collaborations.

Workflow:

1. To match school calendars among institutions to set the timeline;
2. To guide students to achieve learning goals in any forms of learning activities (e.g. case discussion or innovative educational projects or student activities);
3. To establish student groups with counterparts to pursue common goals (up to 10-15 students per group);
4. To use digital tools or skills for project development;
5. To supervise students continuing collaboration on project development; and
6. To do project presentation or demonstration by webinars or physical exchange.

The VE should make a valuable contribution to the internationalisation strategies at the institutional level and internationalise learning and teaching activities locally. Moving forward, there should be a need to review the impact of the VE in student learning, thus planning for upcoming physical student exchange programmes offering a comprehensive international learning experience to students from multiple disciplines at the VTC.

Support in Virtual Exchange Implementation

<u>Support to Teachers' Engagement</u>

In the VE Model, the students should be guided by the academic staff, in which it required to devote significant efforts in the design of the learning outcome from its VE activities or joint project aims with overseas partners. Technological infrastructure and academic recognition

should also consider in encouraging academic staff who play a vital role in the VE initiative.

Funding for the VE Initiative

On the other hand, the VE Funding provided by the VTC has been seen as an another approach to motivate academic staff to integrate the VE into more comprehensively in part of their curriculum design, which covers the accommodation expenses at the VTC Halls of Residence, if the students find themselves in difficulties looking for a place for small group discussion and project development with overseas students with a more stable network infrastructure, and other reasonable direct related expenses.

Conclusions

The VE is not an immediate solution in solving the education issues in the face of pandemic. Integrating VE into physical student exchange programmes should be emerged as a new form of student exchange programme. The impacts of the VE and the relationship between the VE and physical student exchange activities should further investigate among stakeholders. Senior management and academic staff, deemed as a driving force, heavily involve in developing the VE strategy collaboratively for diverse programmes with its features. Implementing without institutional commitment, VE would remain low-scale, dependent on individuals and influencing many students to experience internationalisation at home.

The VE should be a well-recognised activity in education institutions with developing an in-depth intercultural understanding among students across the world. The integrated approach of student exchange programmes should be highly promoted to nurture our young talent to be a new generation of globally and culturally aware citizens and give students a new window to the world at lower costs.

References

Leask, B. (2015). Internationalizing the Curriculum. Routledge.

O'Dowd, R. (2017). Virtual Exchange and Internationalising the Classroom.

Beelen, J., & Jones, E. (2015). Redefining internationalization at home. In A. Curaj, L. Matei, R. Pricopie, J. Salmi, & P. Scott (Eds.), *The European higher education area: Between critical reflections and future policies* (pp. 59-72). Springer International Publishing.

K. F. LEE & S. L. LIU (2016), Promotion of STEM Education in Vocational and Professional Education and Training (VPET).

Francesca Helm & Robert O'Dowd (2020). *Virtual Exchange and its role in Blended Mobility Initiatives*. Retrieved from https://www.unicollaboration.org/wp-content/uploads/2020/09/Position-paper-on-Blended-Mobility.pdf

Digital Education Action Plan (2021-2027), European Commission

NEW CHALLENGES FROM TEACHERS' PERSPECTIVES IN VOCATIONAL AND PROFESSIONAL EDUCATION AND TRAINING (VPET) DURING PANDEMIC

K.M. Chung

Vocational Training Council/Centre for Learning and Teaching, Senior Project Officer, Hong Kong

gloriac@vtc.edu.hk

Abstract

The outbreak of the Covid-19 pandemic has caused a suspension of classes in Hong Kong, and online teaching has been widely adopted as a major mode of delivery across different levels in the local education sector. Together with the unpredictable social situation, the swift change in teaching practices has caused the biggest challenges faced by teachers. As the largest vocational education and training provider in Hong Kong, the Vocational Training Council (VTC) provides a full range of pre-employment and in-service programmes to 200,000 students each year. Responsive actions are necessary and the mode of teaching has to be revealed timely. When the lockdown and work from home policy prevailed, VTC member institutions switched most of the classes online in early 2020. Some classes were resumed again in the 2nd semester in 2020 under strict safety measures, others were conducted online and the Council was in blended learning mode. For practical training/ laboratory/workshop sessions, class sizes were significantly reduced to maintain a safe social distance for face-to-face learning and teaching. For the theoretical sessions, classes were delivered online via Moodle and Microsoft Teams. As such, the Centre for Learning and Teaching (CLT), which supports VPET teachers to strike for excellence in learning and teaching practices, decided to collect feedback from teachers and CLT facilitators to investigate their needs and challenges for providing recommendation on enhancing the support and training services to VPET teachers. The data was collected via an online teacher survey, focus group interviews, and members' feedback from the learning committees; and CLT online facilitators' interviews from June to July 2020. By analyzing the data received, this paper will profile the phenomenon and challenges encountered by VPET teachers at the early stage of the COVID-19 pandemic, and propose remedial actions and suggestions to institutions, departments, support centers, and teachers for uplifting the VPET teachers' readiness to conduct online teaching and blended learning in the new normal.

Keywords: *online teaching, blended learning, teaching mode, VET, VPET*

Introduction

The covid-19 pandemics come of a sudden to Hong Kong in early 2020. Since then, society has to be lockdown including work from home policy, closure of restaurants and public facilities, school suspensions, etc. to keep social distancing. As the largest vocational education and training provider in Hong Kong, the Vocational Training Council (VTC) provides a full range of pre-employment and in-service programmes to 200,000 students each year. Responsive actions are necessary and the mode of teaching has to be revealed timely by government policy. VTC officially announced the suspension of face-to-face classes in February 2020. They are ranged from lecture, tutorial, practical lab, and hands-on workshop. The delivery of subject knowledge and skills can only be done via an online platform. VTC adopts Moodle as the official Learning Management System (LMS) and which is incorporated with Panopto, the Lecture Capture System for video/lecture recording. In the meantime, VTC launched Microsoft Teams, one of the crucial elements in Microsoft software, to all staff for live communication including meetings and live classes. The newly teaching mode was changed comprehensively to both teachers and students. Given this, the Centre for Learning and Teaching (CLT), which supports VPET teachers to strike for excellence in learning and teaching practices, decided to collect feedback from teachers and CLT facilitators to investigate their needs and challenges for providing recommendation on enhancing the support and training services to VPET teachers.

Methods

During the suspension of face-to-face classes, online teaching was widely used. To provide better support to teachers, CLT collected feedback from teachers and facilitators from June to July 2020 via the following methods: 1) online teacher survey, 2) focus group interviews, 3) learning committee's feedback in various member institutes; and 4) CLT online facilitators' interviews.

1. Online teacher survey

From November 2019 to May 2020, CLT provided six seminars/webinars in the areas of online teaching including e-pedagogy and IT skills in using Moodle and MS Teams aiming at responding to the switch of teaching mode. The frontline teachers are voluntarily enrolled in this training. As of June 2020, there was 1,394 VTC teaching staff who attended one of the following CLT training, and they were invited to fill out an online questionnaire to address their feedback on the training, as well as the support from CLT.

The online survey was conducted from 17 June 2020 to 8 July 2020, which lasted for three weeks. There were 95 responses with the response rate at 6.8%. The questionnaire is shown in Table 1:

1.	Are you comfortable to use Moodle, Microsoft Team and Panopto to do online teaching with students?
2.	Do you think that students accept online teaching using Moodle, Microsoft Team and Panopto?
3.	Do you agree that e-learning tools and platforms could help students with Special Education Needs (SEN) and Non-Chinese-Speaking students (NCS) enhance their learning motivation and efficiency?
4.	How often do you use the following online learning tools in AY2019-20?
5.	Please rate the teaching effectiveness of Moodle, Microsoft Team and Panopto. (1= the least effective; 5= the most effective)
6.	Please rate the effectiveness of Moodle quiz to assess students' ability. (1= the least effective; 5= the most effective)
7.	Have you ever used other e-learning tools other than Moodle, Microsoft Team and Panopto and you think that they are useful and would recommend them to others?
8.	Have you encountered any problems when you use online teaching?
9.	Have your students raised any problems when they attend the online lessons?
10.	How much extra time do you need to spend on e-learning lesson design, preparation and recording and communication with students online every week?
11.	Which item(s) take up much of your time when you prepare for your online lessons?
12.	Do you have any request(s) for CLT training course to better equip you for online learning and teaching in the future?
13.	Do you need any other assistance from VTC to better equip you for online learning and teaching in the future?

2. Focus Group Interviews

From the participants of the CLT training, four focus group interviews via Microsoft Teams were conducted in June 2020. 22 interviewees were being randomly selected, including frontline teaching staff and management staff, to share their online teaching experiences and training needs. They were from various disciplines including Applied Science, Business, Childcare, Elderly and Community Services, Design, Engineering, Hospitality, Information Technology, Languages, and Student Development.

Each focus group interview was hosted by CLT and lasted for around one hour. There were up to six attendees in each group. They were invited to share good practices and one burning issue during online teaching in the class suspension period at the warm-up session. It was followed by eight open-ended questions for them to free flow the views. The questions are shown in Table 2:

1.	Do you think there is sufficient support on online teaching? What kind of support and training do you need to facilitate effective online teaching?
2.	What essential skills do you think are required for delivering online lesson?
3.	What is the most difficult part of delivering online lesson?
4.	What kinds of resources do you need for planning an online lesson?
5.	Do you find it difficult to foster students' self-directed learning and reflection?
6.	How would you promote group interaction, collaboration and teamwork?
7.	What kinds of online assessment do you currently use?
8.	What kinds of challenge do you face when you conduct e-assessment?

3. Learning Committee's Feedback

Each campus in VTC has its local committee on learning and teaching to identify the educational development needs of staff and students in the operational unit and to make provisions and arrangements for them. In June 2020, qualitative feedback was collected from the various committees regarding online teaching.

4. CLT Online Facilitators' Interviews

During work from policy prevails, CLT has changed the mode of training to online via Panopto or MS Teams. All CLT facilitators were involved in online teaching and at first hand to experience the merits and demerits of online teaching. In July 2020, twelve face-to-face individual interviews with CLT colleagues, who facilitated online training from February 2020 to June 2020, were conducted to collect qualitative feedback from teachers' perspectives.

Results and Discussion

Data collected from the four above-mentioned channels were summarised as quantitative and qualitative findings.

Quantitative

The following data comes from the online teacher survey.

Readiness for online teaching

Most teachers (89.4%) are comfortable using Moodle and Microsoft Team while less than a quarter of them (22.3%) are comfortable using Panopto. Most students (81.9%) welcome using Moodle and Microsoft Team and nearly one-third (29.8%) welcome Panopto, reported by the teachers. As for the online learning tools and platforms, more than half (56.4%) of teachers agree that it can enhance the learning motivation and efficiency of Non-Chinese-Speaking students (NCS) while more than one-third (38.3%) agree that the same effect happens on Special Education Needs students (SEN).

The usage of Moodle, Microsoft Team and Panopto

The highest daily usage rate of an online teaching tool, from high to low, goes to Moodle (43.6%), Microsoft Team (23.4%), and Panopto (0%). About 65% of teachers heard of Panopto but never used it. A quarter of teachers (47.9%) agree that Moodle (23.4%) and Microsoft Team (24.5%) are effective. Only 4.3% of teachers agree that Panopto is effective, with 63.8% of them heard of Panopto but never used it.

The effectiveness of Moodle Quiz to assess students' knowledge and skills

More than one-third of teachers (35%) agree that Moodle Quiz can assess students' knowledge and skills but still, one-fifth (20.2%) of them heard of but never used it.

Problems encountered by teachers and students

Almost all of the teachers (80.9%) reflected that both teachers and students encountered problems when they do online teaching. One-third (31.9%) of them spent more than 15 hours weekly on preparation for online teaching. Most of the time spent on developing teaching materials (65.1%), recording video (59.6%), coordinating with students (56.4%), learning tools functions (36.2%), and giving instructions to students (35.1%).

Other comments

Teachers suggested the following online teaching tools for future use, such as Zoom, Google Meeting, Loom, Cisco Webex, WizIQ, Powerpoint narration, OBS video recording, Google classroom, Google doc, Google drive, Undemy, Zoho showtime, Kahoot, Nearpod, Padlet, Whatsapp business, Skype.

Qualitative

The following data comes from online teacher surveys, focus group interviews, learning committees' feedback, and CLT online facilitators' interview. It was compiled as areas of "support on using online teaching tools", "support on online delivery", "Online classroom management, effective communication, and efficient administration", "Instructional design for online lesson" and "Content selection and focuses".

Support on using online teaching tools

Moodle, as the official learning management system in VTC, serves the key platform for sharing teaching materials and students' assignments. Thus, teachers were keen on learning the practical tips and hands-on of various Moodle activities and functions. They would like to have Moodle practical workshop in small-class sized and from basic to advanced level, small video sessions with different quiz elements, workshop on "How to check students' view time on video", workshop on "How to receive assignments and send marked scripts and feedback", Veri-Guide Accuracy Issue, and Moodle plug-in functions.

Microsoft & Microsoft Teams, VTC provides license on the use of Microsoft including Office 365, one drive, and Teams. These online tools were very useful to facilitate online teaching. The Microsoft Teams were introduced to VTC teachers in 2019, it was a relatively new tool for teachers to use as an online communication tool for conducting live teaching. The e-manual and e-tutorials were provided to teachers, but still, more advanced and in-depth use of the tool was expected. Teachers want to learn how can Microsoft help online teaching and collaborative group work, how to integrate EdTech tools with Microsoft Teams, using a whiteboard, notes, PowerPoint, how to upload documents to Microsoft Teams and let students see it by students' account with limited functions, batch enrolling of students, how can they access Microsoft Teams via dial-in number, the privacy issues of Teams, such as how to stop students disturbing others via Teams and stop students video recording the lessons, and online attendance, like how to know if students physically attend video lessons and check their view time.

Support on online delivery

Most of the teachers concerned much about online teaching in terms of interaction and way of delivering content knowledge, such as how to interact with students online and encourage them to ask questions, skills, and techniques to make PowerPoint narration more attractive and interactive, skills of developing online video lessons, and video making & trimming, with questions embedded.

Online classroom management, effective communication, and efficient administration

The classroom management, logistics, and administration of the online lesson were one of the concerns by the teachers. The concerns could be classified into three sections, including before the lesson,

during the lesson, and after the lesson. Before the lesson, teachers want to learn how to enroll students on Microsoft Teams at a time, how to send Microsoft Teams hyperlink to students effectively, and how to remind students of the online lesson schedule. During the lesson, teachers want to know about online teaching skills, online classroom management, application of Microsoft Teams and Moodle with hands-on practice, how to engage & motivate students, encourage them to ask questions & give feedback, how to check students' learning progress? After the lesson, teachers want to learn how to remind students of assignment & project submission and to receive an assignment and give feedback online effectively.

Instructional design for online lesson

Regarding the instructional design, some teachers need supports on how to identify and select which teaching items are suitable for the online curriculum. Not all topics can be conducted online. The whole TLP should be revised completely. They concerned with the details of blended learning, such as what is blended learning, and how to make effective blended learning. Some would like to know about e-Pedagogy, delivery, and lesson plan of blended learning. Many of them are concerned with assignment elements, such as how to initiate an in-depth discussion, how to make role-play assignments, scenarios, and discipline-based designed workshops. Moreover, some would like to have good practice sharing and teaching materials samples.

Content selection and focuses

In the aspect of content selection for online teaching, teachers revealed that the digital gap among teaching staff is great especially on a small campus. Therefore, some basic courses on online tools have to be included. Some reflected that smooth delivery of lesson depends on the content nature. As such, teachers who teach soft and pedagogical skills have encountered the problems of initiating deep-thinking discussion, pedagogy application, teacher's feedback on students' instant responses in their online lessons as those teaching units make up a large proportion of their lessons. Students' engagement was unsatisfactory. Teachers need lots of time to wait for their response and sometimes we're forced to do "mono-talk". Although teachers have applied EdTech tools, some students left the Teams virtual chatrooms. Also, low participation leads to unsatisfactory peer support and learning and thus some intended learning outcomes (ILO) cannot be achieved. In addition, teachers who teach EdTech tools or informative theory feel better. In general, the time used on the document preparation before online lessons would be much more than face-to-face lessons since online lessons need concise and smooth delivery.

Good Practices

Nevertheless, several good practices were shared by the stakeholders in the interviews, such as reminding students of using desktops; putting PDF of detailed tool instructions in the chatbox for students' easier to follow; preparing words used for 'copy & paste' to save time; procedural videos of tools to avoid internet breakdown; using infographic, table and chart to accommodate massive information; presentation & convincing skills, good intonation, decent appearance, and eye-catchy PowerPoint. In sum, they reflected that theory, factual information, a procedural demonstration can be put online in the modes of videos, while pre-tasks and post-tasks; hands-on, practical & application sessions; open-ended, deep-thinking discussions, and generic skills training were better to be conducted in face-to-face lessons.

Conclusions

The outbreak of covid-19 pandemics made things changing of a sudden forever. In the vocational and education professional and training sector, the mode of teaching was mandatorily converted to online and eventually to become a "New Normal". Frontline teachers, who had been familiar with face-to-face teaching, need to uplift their skills both the e-pedagogy and technology literacy in shifting to online teaching. In the early stages of switching to online teaching, CLT collected the feedback from frontline teachers via various channels, including survey, focus group interviews, feedback from regular meetings and individual meetings to review the impact and more importantly, to understand the needs of teachers to adapt in an online teaching environment. With the quantitative and qualitative findings from the above-mentioned methodology, teachers were positive in facing new challenges and tried their utmost effort in adapting the new mode of teaching. Nevertheless, it is concluded that more supports were essential from member institutions, supporting units, and campuses, to facilitate online teaching in VTC. The readiness on hardware, software, and staff capability could be enhanced through the purchase of equipment and licenses, and also the provision of new training. The recommendations to various stakeholders would be further illustrated below.

Support from Member Institutions. Equipping on hardware and technology infastruture would assure the quality of online delivery in techincal aspects. From the insititional level, we could purchase some latest computers and devices, Edtech Tools' licenses, and copyright-free images and videos for both teachers and students, to offer them sufficient resources and easy accessibility. More measurements could be done, such as replace the old laptops with new ones, use of iPad or Mac computer to assist or program the online teaching, providing licenses of Zoom, Adobe, Kahoot, Mentimeter, etc., and offer a bank of images and videos which are copyright-free. Moreover, quiet locations for teachers to record videos and conduct online lessons could also be provided.

Support from Supporting Units. As an in-house training provider, CLT could conduct face-to-face workshops on

three levels: Basic, Intermediate, and Advanced with theme-based content description, such as Moodle, Microsoft Teams, Panopto, PowerPoint Narration, and Video trimming, in small class size (20 at most) with sufficient practice time. To cater to diverse needs, the use of Moodle, Microsoft Teams, and Panopto could be delivered via bite-size videos for viewing at any time and anywhere. In a training programme, theory, factual information and procedural demonstration can be delivered via online mode; while practical & application sessions; hands-on practice, and generic skills could be delivered in face-to-face mode. Furthermore, some training topics were identified to be delivered online including but not limited to new Edtech tools (explaining pros and cons, and its key functions), good practice sharings from all disciplines, the concept of blended learning, including pedagogy, delivery, instructional design and lesson plan and topics selection for online teaching, classroom management, and effective online communication, including students' engagement and attention, teacher-student interaction, student-student discussion and instant feedback from students; and efficient administration including students' enrollment in Microsoft Teams, student's attendance checking, marking and receiving assignment online, reminders for students to check online lesson schedule and submission of project & assignment. As IT supporting units, the technical issues, such as slow video uploading speed of Moodle and Panopto, a platform with large storage space for teachers to upload VAR videos in One-drive, the traffic to Moodle platform for Moodle Quiz for common modules, and access right to Teams/Moodle by students could be tackled. Other supports including an accessible hotline by various channels, online technical support, and Q&A session on using Microsoft Teams, Moodle & Panopto as references on the official webpage could be provided.

Support from Campus. As a local campus, students' online learning habits and attitudes (mindset, self-directed learning, time management, self-checking) could be addressed and better catered for. Physically, all classrooms could be equipped with online learning hardware, e.g. webcam, Bluetooth connection to a computer for the microphone, or other devices, e.g. drawing pad. These measurements could facilitate the smooth operation of online lessons.

With the collaboration of various stakeholders and experiences gained at the early stage of shifting to online teaching mode, it is expected that both teachers and students could better adapt to the new normal of learning and teaching, and also benefit from the blended learning mode and environment.

Acknowledgments

We thank Dr. Albert Cheuk, Dr. Kitty Wong, and Ms. Elita Lam for supporting us to conduct this research. We thank the chairpersons of various learning committees for collecting feedback from teachers. We thank Ms. Chantel Fan for collecting and compiling the data.

References

Berge, Z. L. (1998). Barriers to online teaching in post-secondary institutions: Can policy changes fix it. *Online Journal of Distance Learning Administration*, 1(2), 2.

Bigatel, P. M., Ragan, L. C., Kennan, S., May, J., & Redmond, B. F. (2012). The identification of competencies for online teaching success. *Journal of Asynchronous Learning Networks*, *16*(1), 59-77.

Callo, E. C., & Yazon, A. D. (2020). Exploring the factors influencing the readiness of faculty and students on online teaching and learning as an alternative delivery mode for the new normal. *Universal Journal of Educational Research*, *8*(8), 3509-3518.

Covington, D., Petherbridge, D., & Warren, S. E. (2005). Best practices: A triangulated support approach in transitioning faculty to online teaching. *Online Journal of Distance Learning Administration*, *8*(1).

Downing, J. J., & Dyment, J. E. (2013). Teacher educators' readiness, preparation, and perceptions of preparing preservice teachers in a fully online environment: An exploratory study. *The teacher educator*, *48*(2), 96-109.

Mahmood, S. (2021). Instructional strategies for online teaching in COVID-19 pandemic. *Human Behavior and Emerging Technologies*, *3*(1), 199-203.

Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open*, *1*, 100012.

Orr, R., Williams, M. R., & Pennington, K. (2009). Institutional efforts to support faculty in online teaching. *Innovative Higher Education*, *34*(4), 257-268.

Palloff, R. M., & Pratt, K. (2013). *Lessons from the virtual classroom: The realities of online teaching*. John Wiley & Sons.

Scherer, R., Howard, S. K., Tondeur, J., & Siddiq, F. (2021). Profiling teachers' readiness for online teaching and learning in higher education: Who's ready?. *Computers in Human Behavior*, *118*, 106675.

Young, S. (2006). Student views of effective online teaching in higher education. *The American Journal of Distance Education*, *20*(2), 65-77.

THE IMPACT OF KOSEN VOLUNTEERS ON CHILDREN'S STEM EDUCATION

Kaori Tsukazaki[*,a], Takeshi Shintoku[b] and Takaaki Fukuzoe [c]

[a] National Institute of Technology, KOSEN, Academic Affairs Section, Tokyo, Japan
[b] National Institute of Technology (KOSEN), Kagoshima College, Department of Information Technology, Kagoshima, Japan
[c] National Institute of Technology (KOSEN), Kagoshima College, Department of Electric Control Engineering, Kagoshima, Japan

*tsukazaki@kosen-k.go.jp

Abstract

The purpose of this paper is to introduce female college student volunteers' significant impact on children's STEM education over a four-year period. Female student volunteers of a national college of technology (KOSEN) in Japan have been teaching ICT skills to children for four years in order to foster interest in STEM and introduce them to female role models in this field through workshops. This is because the number of female students in STEM, especially engineering, is extremely low in Japan compared with other countries, as *UNESCO Science Report* (2015) points out, for example. The female college student volunteers of the national college of technology (KOSEN) decided to impact girls in younger generations to change this situation. They have visited local elementary and junior high schools with computers and robots to teach programming since 2017. As a result of their efforts, they influenced both local children and children's STEM education to some extent. In this short paper, we will look at some examples of their impact. First, this project was so innovative that it was introduced in *the White Paper on Gender Equality 2019* published by the Japanese government (2019). Second, the good reputation that the KOSEN student volunteers had built up makes it possible to receive support from industry and the board of education in the local government when they hold workshops in elementary and junior high schools. Third, judging from the feedback of the participants in a workshop, the college student volunteers were successful in teaching ICT skills to junior high school students in an enjoyable way. As a result of working for four years, this project was introduced in a supplementary resource book for teaching social studies to junior high school students as an example of realising gender equality (2021). Lastly, but most importantly, the college students seemingly contributed to increasing the number of new female students who entered the college.

From these results, we may be able to conclude that this project received a good evaluation from the participants and the society. However, this is an on-going project and the college student volunteers will keep working until the number of female students in their college increases up to more than 30 %.

Keywords: *gender equality, STEM education, programming robots, volunteering, children*

Introduction

As *UNESCO Science Report* (2015, p. 86) points out, 'Japan still has the lowest proportion of female researchers of any member of the Organisation for Economic Co-operation and Development (OECD)'. On the other hand, 'In Asia, Malaysia, the Philippines and Thailand have all achieved gender parity'. The report also states that in Japan, the percentage of female researchers in engineering and technology was only at 5.3 %, which was lower than any other field in 2013; natural sciences (12.6 %), medical sciences (30.8 %), agricultural sciences (21.5 %), and social sciences and humanities (31.9 %) (p.87).

Furthermore, the number of female students who major in engineering in higher education is also low compared with other fields in higher education in Japan. In 2018, the percentage of female undergraduate students in engineering was only at 15% (p. 4) (T*he White Paper on Gender Equality 2019*). As for the national college of technology (KOSEN) to which the student volunteers belong, the percentage of female students who have entered the college year on year has been around 10 %. In this way, the female college student volunteers decided to impact girls in younger generations to change this situation. The purpose of this paper is to introduce some of their achievements over a four-year period.

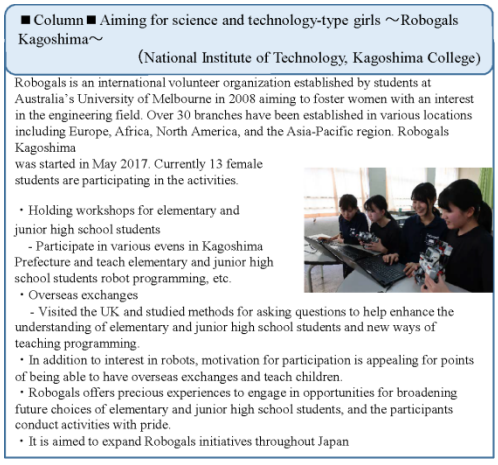
Some Achievements of Female College Student Volunteers in Four Years

1. *The White Paper on Gender Equality 2019*

Figure 1 is an excerpt from *the White Paper on Gender Equality 2019* published by Gender Equality Bureau of the Cabinet Office in the Japanese government in June in 2019 (p. 9). This volume features enriched education and learning which enables diverse choices (p. 2). Our project of teaching ICT skills to children was introduced in a column page in the section which introduces 'initiatives to enable diverse career choices' (p. 9).

This is because the project was evaluated as one of the most leading and innovative projects to balance the gender gap in the STEM area in higher education in Japan. The national college of technology (KOSEN) was one of the three institutions in higher education in the column pages of this governmental document. The college volunteers teach ICT skills to children with the use of a robot, whereas the other two institutions provide recurrent education for women on business or health sciences in their graduate schools (p. 14).

This project can be a good model of how we foster interest in STEM in children and introduce them to female role models. These are some of the key factors of influencing children in choosing their path in the STEM area, as the White Paper points out (p. 9).


■Column■Aiming for science and technology-type girls ～Robogals Kagoshima～

(National Institute of Technology, Kagoshima College)

Robogals is an international volunteer organization established by students at Australia's University of Melbourne in 2008 aiming to foster women with an interest in the engineering field. Over 30 branches have been established in various locations including Europe, Africa, North America, and the Asia-Pacific region. Robogals Kagoshima was started in May 2017. Currently 13 female students are participating in the activities.

・Holding workshops for elementary and junior high school students
- Participate in various evens in Kagoshima Prefecture and teach elementary and junior high school students robot programming, etc.

・Overseas exchanges
- Visited the UK and studied methods for asking questions to help enhance the understanding of elementary and junior high school students and new ways of teaching programming.

・In addition to interest in robots, motivation for participation is appealing for points of being able to have overseas exchanges and teach children.

・Robogals offers precious experiences to engage in opportunities for broadening future choices of elementary and junior high school students, and the participants conduct activities with pride.

・It is aimed to expand Robogals initiatives throughout Japan

Figure 1. A Column Page in *the White Paper on Gender Equality 2019*

2. The Collaboration with the Local Board of Education and Industry

This project has had a reputation in providing interesting workshops for children, which led to financial support from leaders in industry who appreciated the importance of educating female students to be engineers. Moreover, they were provided opportunities to visit their factories to experience some of the latest technologies in Japan to empower themselves.

Furthermore, it is a great honour that one of the leaders decided to work with us to foster interest in STEM in children. His company offered us robots which can speak as programmed, VRs, and a game app in which you can experience the latest technology of facial recognition. In addition, a team of engineers from the company help student volunteers set up the tools every time they hold a workshop.

It should be also added that the student volunteers started to work with the board of education in the local government. Since the Japanese government decided to teach computing skills from the early stages of compulsory education, the local board of education wanted the female college students to be mentors for children in ICT education which was supposed to begin at all elementary schools in 2020. This is because schools lacked resources such as computers and robots and teachers did not have necessary skills in teaching ICT skills to children.

In this way, the local board of education highly appreciated the college student volunteers' efforts to hold STEM workshops for children. As a result, the local board of education contacted every single school in some areas in order to analyse its needs of our STEM workshops, which made it easier for the students to organise their workshops and enabled them to visit the exact school whose pupils wanted to participate in their workshops.

Figure 2 depicts the collaboration among the college student volunteers, the local board of education and industry. Working together enabled us to teach ICT skills to children efficiently. Furthermore, it should be noted that more junior high school students from the areas where the college volunteers had workshops applied to their national college of technology (KOSEN) the next year.

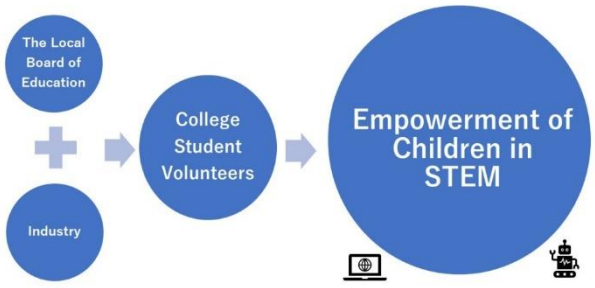


Figure 2. Three Organisations Work Together to Empower Children in STEM

3. Feedback from the Participants

Here is feedback from 39 participants who attended one of the workshops in 2019 that we collaborated with industry and the board of education. This workshop was held at a junior high school in October in 2019.

Their feedback was analysed based on the method which Olmedo-Torre et al. (p. 294, 2018) used in their qualitative research on gender equality in STEM (Table 1).

Table 1 shows phrases which were found repeatedly in their comments. Judging from their comments, it seems that the workshop held by the college student volunteers was a success in teaching ICT skills in an enjoyable way.

For example, most participants mentioned that it was interesting to programme a robot with the computer. However, for five students, it was difficult to programme a robot by adjusting the numbers on the computer, and so on. Four students programmed a robot for the first time. Three students were amazed how fantastic it was to programme a robot with the computer in the workshop. It can be interpreted from the two words 'fantastic' and 'interesting' that participants had positive attitudes towards the workshop. Moreover, two students would like to attend a programming workshop again. Finally, a student mentioned a teamwork in programming a robot, and another student said that the student learned much about programming.

However, it remains a challenge for future research to collect a certain amount of data to discuss the relationship between STEM experiences like this workshop and their motivation to choose a STEM path in more detail.

Table 1. Repeated Phrases in the Feedback

Phrases	Number
Programming was interesting.	29
It was difficult to programme a robot.	5
It was my first time to program a robot.	4
It was fantastic.	3
I want to attend this workshop again.	2
I worked in a team to control a robot.	1
I learned much about programming.	1

4. A Supplementary Resource Book for Social Studies Published in 2021

In addition to *the White Paper on Gender Equality 2019*, this project was introduced in a supplementary resource book for teaching social studies to junior high school students. This book was published in April in 2021. It referred to a newspaper article on the college volunteers and their workshop to teach programming to elementary school pupils in September in 2019.

This is a great opportunity for us to introduce our project to junior high school students as well as teachers who are working at junior high schools. The project was introduced in the section of gender equality in the book. It says, '*Robogals Kagoshima* is an international organisation of students to increase the number of female students in STEM. They hold workshops for children'. Under this, the terms 'gender' (socio-cultural viewpoints) and 'sex' (biological traits) are defined and some stereotypes concerning gender are explained; one of them is that men are better at learning STEM.

5. The Number of Female Students in Their College

Lastly, but most importantly, the college students seemingly contributed to increasing the number of new female students who entered the college. The number of female students who entered their college started to increase in 2019. Figure 3 shows the proportion of female students who entered the college from 2013 to 2021. Since they launched this project in May in 2017, they have been holding workshops for elementary school pupils and junior high school students. The percentage of female students who entered the college increased from 12 % to 19% in 2019. Although the percentage slightly decreased in 2020 and 2021, it is still higher than before; it was only around 10 % every year, as Figure 3 shows.

A possible reason is that as a result of being reported in local media reporting, the college volunteers became so famous that they impacted other junior high school students in addition to the ones who they met in the workshops. It should be noted that some of the participants in the workshops entered the college. In one case, this project impacted a female student who entered the college in 2019. Although she had had no opportunity to join a workshop before, a newspaper article on this project made her a student volunteer to teach programming a robot to children when she entered the college.

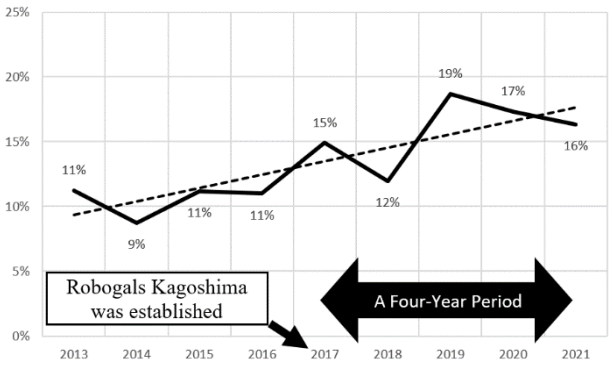


Figure 3. The Percentage of Female Students Who Entered a College of Technology (KOSEN)

Discussion

It is probable that the student volunteers will contribute more to STEM education for children. When they launched this project, it was necessary for them to take computers and robots to schools when they organised workshops. However, 'the GIGA School Initiative' by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan will promote the use of ICT at elementary schools and junior high schools in 2021 in the following way:

> Under the GIGA School Initiative, MEXT has been developing the ICT environment at schools, beginning with the preparation of one ICT terminal per student at the compulsary education stage with the aim of achieving optimal personalized learning for each child and cooperative learning among multiple children through enhancing education fully utilizing ICT. (p. 10)

In this way, MEXT considers 'ICT terminals such as smartphones, tablets, and PCs are must-have items in the same manner as pencils and notebook' (p. 10). It was fortunate that the unexpected covid-19 pandemic promoted this educational policy and that schools were ready to provide one device per child by the beginning of a new school year in 2021. It follows that it is important how to familialise children with their device. The college volunteers may be able to play this important role in their workshops and compensate for teachers' lack of skills in teaching ICT .

Conclusions

We had a look at what the student volunteers in a college of technology (KOSEN) in Japan had achieved over a four-year period. They seemingly contributed to increasing the number of new female students who entered the college. This project received a good evaluation judging from the following facts: (1) it was introduced in *the White Paper on Gender Equality 2019* by the Japanese government and a supplementary resource book for teaching social studuies to junior high school students in 2021; and (2) the student volunteers received support from industry and the board of education in the local government. However, this is an on-going project and they will keep working until the number of female students in their college increases up to more than 30 %. We would like to visit more schools and work with other colleges of technology (KOSEN) and industry so that we can reach as many girls in yourger generations as possible.

References

Tsukazaki, K., Shintoku, T., & Fukuzoe, T. (2019). Teaching ICT Skills to Children and the Empowerment of Female College Students in STEM in Japan, *IOP Conf. Series: Materials Science and Engineering* 551 (2019) 012036 doi :10.1088/1757-899X/551/1/012036
Online: https://iopscience.iop.org/article/10.1088/1757-899X/551/1/012036/pdf

UESCO Science Report Towards 2030 (2015).
Online: https://unesdoc.unesco.org/ark:/48223/pf0000235406

Gender Equality Bureau Cabinet Office (2019). T*he White Paper on Gender Equality 2019* Online: http://www.gender.go.jp/english_contents/about_danjo/whitepaper/pdf/ewp2019.pdf

Hamajima Shoten (2021). *Atarashii komin shiryoshu*, p. 49. [In Japanese]

Ministry of Education, Culture, Sports, Science and Technology (n. d.). Overview of the Ministry of Education, Culture, Sports, Science and Technology - Japan.
Online: https://www.mext.go.jp/en/content/20210325-mxt_kouhou02-200000029_1.pdf

Olmedo-Torre, N. et al. (2018). Do Female Motives for Enrolling Vary According to STEM Profile? *IEEE Transactions on Education*, Vol. 61, No. 4.
Online: https://ieeexplore-ieee-org.queens.ezp1.qub.ac.uk/document/8338160

Development and operation of Chinese language teaching materials for science students

Manabu Hatamura*

NIT,Ube College, Ube, Yamaguchi, Japan

*hatamura@ube-k.ac.jp

Abstract

This paper describes online Chinese language learning practice in cooperation with other technical colleges and overseas partner universities from August 24 to September 30, 2020. In this initiative, students watched the videos for class preparation in advance and learned the contents of the videos practically online from the students of the Applied Chinese Department of Wenzao Ursuline University of Languages(WZU) in Taiwan.

Since 2015, National Institute of Technology, Ube College has accepted students from the Department of Chinese Language and Literature of National United University(NUU) in Taiwan as Chinese language trainees every year. The trainees provide support to the teachers in charge of Chinese classes and conduct the classes themselves. However, in 2020, due to the pandemic caused by the coronavirus pandemic, we will no longer be able to accept Taiwanese interns. So, instead, we had students from WZU conduct one-on-one Chinese classes online.

As a result of the 26 classes given by WZU of Foreign Studies students for about one month, the Japanese students' ability to understand Chinese improved compared to previous years, especially in pronunciation. An evaluation questionnaire shows that the classes were significant for both students.

This paper will explain the process leading up to the implementation of the online class, class implementation, and the innovations in the class. Finally, this paper will discuss the points for reflection and future issues.

Keywords:*Chinese language,teaching materials,science students,overseas partner schools,cooperation*

1.Background to accepting Taiwanese educational trainees

National Institute of Technology, Ube College (NIT,Ube College) in Ube City of Yamaguchi Prefecture is one of Japan's first 12 technical colleges to be established. It has five departments: Mechanical Engineering, Electrical Engineering, Control and Information Engineering, Materials Science and Engineering, and Management Information Science. In the area of foreign language education, we are focusing on English.

In terms of foreign language education, Chinese is the second most important after English, and it is compulsory in four out of five classes in the fourth year. One Chinese class was also offered in the fifth year (from 2021, it will be optional with English classes, and about 80 students in two classes in the fourth year are taking Chinese).

A unique feature of the Chinese language classes at NIT,Ube College is that students from two Taiwanese partner schools are accepted as teaching trainees and participate in Chinese language classes for about a month from late June to late July every year. They are providing support to the school's faculty and also teaching the classes.

In 2015 and 2016, we accepted four students from the Department of Chinese Language and Literature at NUU. Since 2017, we have accepted four students: two from NUU and two from the Department of Applied Chinese Language at WZU.

A Taiwanese student teaching Chinese classes as a trainee teacher.

The acceptance of Chinese language education trainees from Taiwan is done in cooperation with other technical colleges. In 2015, four students were assigned to NIT,Ube College and two students to NIT, Anan College in Anan City of Tokushima Prefecture as Chinese language and literature trainees. NUU is one of the Taiwanese universities in which the NIT has a comprehensive exchange agreement (Five universities in Taiwan have a comprehensive agreement with the NIT. The other four are National Taipei University of Technology, Chung Chou University of Science and Technology, National Kaohsiung First University of Science and Technology, and Cheng Shiu University. In

addition, NIT each college can interact with NUU even if they do not have individual agreements with each other. Currently, NIT,Ube College is the only one that has an agreement with WZU.

NIT,Niihama College (in Niihama City, Ehime Prefecture) has been participating in this project since 2016, and NIT,Tsuyama College(in Tsuyama City of Okayama Prefecture) has been participating since 2017. In 2020, NIT,Hakodate College(in Hakodate City, Hokkaido) was also scheduled to participate in this project but has been canceled due to the coronavirus pandemic.

NIT,Ube College has accepted Chinese language and literature, science and technology, and business students from NUU in June and July every year since 2015. Students from NIT,Ube College also have been doing practical training related to the Chinese language and specialties at NUU during the long vacation in August and March. In terms of accepting students from WZU, we started accepting students from the Japanese language department in February 2016, and in 2017 we started accepting Chinese and English (foreign language pedagogy) education trainees until now.

In 2020, we had planned to accept interns from two Taiwanese partner schools as before, but we decided to stop sending and accepting students in April when the new school year in Japan begins. Therefore, they started working on the implementation of an online Chinese language program to replace them.

2.Preparation for Online Chinese

Every year, the school accepts 10 to 20 short-term international students from Singapore, South Korea, Malaysia, and other partner universities. These students come to our school for laboratory experiments, practical training, and research purposes. However, for the year 2020, the school decided to stop accepting all short-term students in April when the new semester started.

Immediately after the decision was made, we contacted Professor Lu Xiuman(盧秀滿) of the Department of Applied Chinese at WZU to see if it would be possible to offer Chinese language online classes. Professor Lu readily agreed, and we decided to proceed with preparations for implementation in August.

When we requested WZU to recruit participants, contrary to our expectation, 12 students participated in the class. Initially, we thought there would be about four students, and we requested NUU to recruit trainees as well. However, in the end, we decided to decline the request from them (the students from the NUU gave online Chinese lessons to the students of NIT,Niihama College and NIT,Tsuyama College).

The 12 students consisted of 9 third-year students, 1 fourth-year student, and 2 master's students. In addition to these 12 students, several other students were involved in this project as administrative staff. On NIT,Ube College side, there were 13 participants: four second-year students, five third-year students, three majors, and one faculty member.

As a result, we decided to implement the project in the following way.

(1) The implementation period was about one month, from late August to late September. The project colled Project Study will be conducted during the project learning period of NIT,Ube College. The Project Study will be described later.
(2) Online classes will be conducted using the Teams meeting system of Office365.
(3) The textbook will be "Chinese for Science" (Japan, Kobun Publishing, 2017).
(4) Twelve groups of 12 students from Japan and Taiwan will be formed as pairs, and online classes will be conducted one-to-one.
(5) Japanese students will watch a video for preparation before attending the online class.

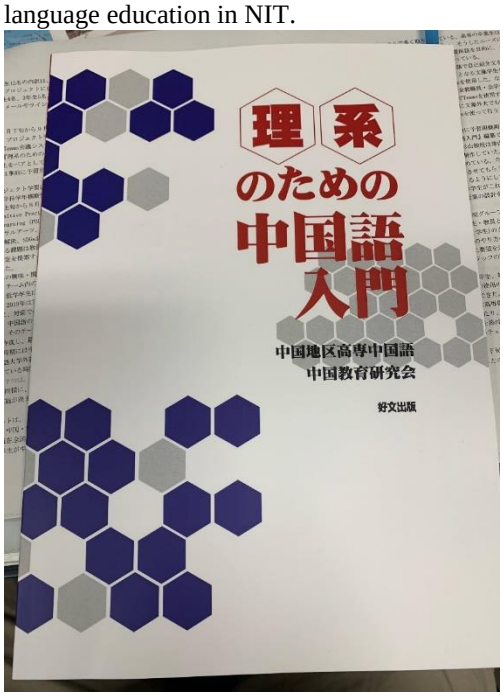
(1)First, we will explain project-based learning. Project-based learning is a cross-departmental PBL that NIT,Ube College has been conducting since 2019. It is a learning process to implement "Collaborative Practice for Enhancing Students' Basic Social Skills" in the latter half of the second semester (about one month from early July to early August) to strengthen students' competency. This is problem-based learning (PBL) course offered in the second grade through fourth years. The topics covered are diverse and include generic skills, liberal arts, extracurricular PBL, mechanical engineering, electrical engineering, control engineering, materials engineering, business administration, community problem solving, SDGs, and a combination of these fields.

In 2020, 29 themes were prepared, and were conducted online. Students selected themes based on their interests and worked in teams that transcended the boundaries of grade and department. The older students in the team are expected to lead the younger students based on their own experience, knowledge, and skills, while the younger students are expected to work with the guidance of the older students and their supervisors.

The students from NUU and WZU who visited the school for practical training in 2019 were assigned to teach face-to-face Chinese language classes.

Apart from learning Chinese, each of the Japanese students decided on their theme related to Taiwan and China, interviewed the trainees on that theme or researched on the Internet to prepare materials, and finally gave a presentation.
(2) The platform for the online class was Teams from Office365. Because the entire technical college is affiliated with Microsoft, so all faculty and students can use Office365. The students have been familiar with Teams through online classes since April, and we should be able to implement it without any problems in August. Fortunately, Office365 is also available at WZU, so we decided to use Teams for our first attempt at online Chinese.

(3)"Chinese for Science" (Kobun Publishing, 2017) is used as the textbook. This textbook was compiled by technical college teachers involved in Chinese language education in the Chugoku and Shikoku regions and is currently being used in six technical colleges nationwide. As the title says, "for science majors," the book aims to help science and engineering students learn Chinese. It contains many examples for sentences and columns on each topic, such as numbers, calculations, scientific terms, and element symbols. Graduates students of technical colleges often go on business trips and assignments to countries in the Greater China region as engineers in the future. The content of this paper is designed to meet such needs. In order to guarantee the quality of the Chinese language skills of technical college students, we are also conducting public relations activities to make this textbook become the standard textbook for Chinese language education in NIT.



"Chinese for Science" (Japan, Kobun Publishing, 2017).

(4)The first step for pairing the Japanese and Taiwanese students, Japanese students have to write a self-introduction in English and send it to Professor Lu.
(5)In order to take the online class, the Japanese students are required to watch a video for preparation beforehand. The videos were produced by Professor Akira Sugiyama of NIT, Tsuyama College, who played a central role in compiling the textbook "Introduction to Chinese for Science Students." Professor Sugiyama has produced class videos of all 14 sections from the textbook for the Chinese online classes at NIT, Tsuyama College. The videos are around 20 to 30 minutes and include explanations of grammatical matters and essential information for each lesson. With the permission of Professor Sugiyama, we decided to use this video as an introduction for the class this time. The video was uploaded to Teams on Office365 so that students could watch it at any time. The video was also uploaded to a team created by the WZU Institute of Foreign Languages so that WZU students could check the video and then create Power Point materials for the online class and design the actual class.

The above preparations and communication were carried out until just before the implementation of the project in late August, and the online class finally started on August 24.

3. During the implementation of the online Chinese classes

The following four things were done after the start of the online class.

(1) Managing the schedule of each pair
(2) Collecting the daily class questionnaires
(3) The students submit a weekly record sheet on weekends
(4) The students submit their schedule for the following week on the weekend.

Regarding (1),WZU students recorded each online class, we could check that the recording had started. Therefore, we checked whether the class was appropriately conducted by checking whether the recording was started at the time it was scheduled to be conducted. The recorded video is automatically uploaded to Teams after the class over to be checked. However, it is practically impossible to watch 13 pairs of 30-60 minute classes every day, so all pairs were checked to see if they were held and watched 2-3 pairs of video recordings of the classes every day.

Regarding(2), end of the online class each day, NIT,Ube College students were asked to submit a questionnaire for each class. The questionnaire consists of items related to the online environment, the instructor's teaching style, and the Japanese students' attitude toward the class. The questionnaire also related to whether the students could communicate with each other and their satisfaction with the class.

Dr. Lu from WZU acted as the contact person if the students had any enquiries or claims regarding the way of the classes. The enquiries could also be discussed directly with the instructors' students through online messaging application such as Microsoft Teams. Some of the claims were mentioned by the Japanese students in a questionnaire was that some instructors were teaching without showing their faces on the screen. In response to this matter, Dr. Lu informed all the Taiwanese students that the Japanese students requested the instructor to show their faces on the screen.

PJ学習アンケート200914　　中村愛華

	項目	1～5で回答
Ⅰ	動画の視聴環境	
①	相手の音声はよく聞き取れた。	1
②	相手の顔や資料はきちんと見えた。	1
Ⅱ	実習生の教え方	
③	教え方はわかりやすかった。	1
④	共有する資料はよくできていた。	1
Ⅲ	自分の学習態度	
⑤	事前に動画を見てきちんと予習した。	1
⑥	オンライン授業に積極的に関わった。	1
Ⅳ	その他	
⑦	英語でコミュニケーションが取れた。	3
⑧	今回のオンライン授業は満足だ。	1

1：非常に当てはまる
2：まあ当てはまる
3：どちらでもない
4：あまり当てはまらない
5：当てはまらない

■コメント・要望等
今日は、進行形と主述述語文、語気助詞の言い方用法を学んだ。進行形でも、言い方が4種類あったり、状態の継続で言い方あが変わったりと色々あると知った。今回難しかったと思ったのが、語気助詞だ。言い方が3つあり、文末に添えるのだけど、どれをどの文に入れるのかが難しかった。この語気助詞を入れると、会話にも気持ちが入ったり、日常生活で使えるので例文だけでも覚えようと思う。
<ミッション>
こんばんは、愛華！
私の名前はシンイーです。
私の家には、父、母、妹、祖父、祖母がいます。
私の誕生日は、11月14日です。
私は25歳です。
私の趣味は、本を読むことです。
よろしくお願いします。ありがとう！

Class Survey Form

Regarding (3) , the students were asked to write the contents and impressions of the class on a record sheet after each day's classes and submit a weekly summary after class on Friday. This is a record of learning, and it is related to evaluating the NIT,Ube College students' grades and checking attendance. Each class lasts for 90 minutes for 30 times in total. The 90 minutes included the time spent in the online class and the time spent on watching videos for prior learning and reviewing.

Finally regarding (4), at the end of each week, the students were asked to submit a schedule for the following week's online class. Basically, they were instructed to conduct online classes about the same time every day, but if they could not do so due to mutual business, they were asked to adjust the time in pairs. In addition, since the new semester started on September 14 at WZU and online classes could not be held during the day, most of the pairs had to hold their classes after school. The created schedule was uploaded to Teams so that students in Japan and Taiwan could check it. The time in the schedule is in Japanese time, and the time in Taiwan is one hour minus the time in Japan.

4. Rules and innovations for online Chinese classes

In order to encourage Japanese and Taiwanese students to actively engage in this project, two rules and two innovations were implemented. The two rules were (1) recording the online class and (2) showing up and participating face to face in the online class. The two innovations were (3) assigning task in the class and (4) role-playing the conversation at the end of the class. I will explain them in turn below.

(1)Recording of online classes

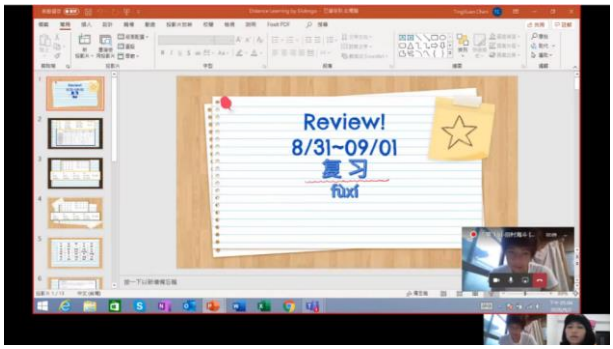
We made it mandatory to record online classes. The instructor, a WZU student, recorded all online classes. The recordings remain on Teams after the class to be viewed by the students or by the reporter.

The advantage of recording the class is that Japanese and Taiwanese students can look back later on the class content and teaching methods. Japanese students will be able to review the class by watching the recorded class video. The Taiwanese students can re-check the teaching methods and the level of Japanese students understanding by watching the videos. By recording the class, the students will be able to work on the class with a sense of urgency since they will be able to watch the video later.

(2)The policy of face-to-face communication

In the online class, the pair in a class which consists of the learners (the Japanese students) and instructors (the Taiwanese students) are required to show their faces during the class.

Showing up and participating face to face in the online class



Showing up and participating face to face in the online class

Sometimes after the class started, some Taiwanese students were not showing their faces during the online classes. They were only using Power Point materials and their voices in the explanation. The recorded video of the class shows that the Japanese students in that instructor's class seemed to have a darker expression compared to other classes. Moreover, their

pronunciation did not seem to have improved much. It seems that maybe the reason for this was that they were taking an online class without seeing the other person's face.

There may be a difference in the improvement of language skills between (i) taking a class with only the slides and the instructor's voice and (ii) taking a class with the instructor's face on the screen. In contrast, some Taiwanese instructors closed the Power Point screen when practicing pronunciation. They instructed the students on how to pronounce the words with their face enlarged on the screen. The Japanese student in this pair had better pronunciation than the other students. Therefore, there may be a difference in pronunciation improvement between practicing pronunciation while watching facial expressions and mouths movement compared to just listening to the audio. Compared to Japanese pronunciation, Chinese pronunciation requires the use of various parts of the mouth, from the lips to the back of the throat. However, it is not known if this can be visually understood to affect pronunciation improvement. In overall, the students' pronunciation was much better than in the previous years. While online classes were being held throughout the school, there was one school day per week, and I used that day to call the students to check their pronunciation and give them a simple oral test to confirm their understanding of the content. As a result, we confirmed that all students in the course could pronounce the words more accurately compared to the previous years. The main reason for this is that the students took one-on-one classes five days a week and concentrated on their studies. However, we also believe that the students who were too shy to speak out loud in face-to-face classes before could pronounce without hesitation in one-on-one online classes, so it may be the reason why their pronunciation improved.

(3) Assigning task in the class

From the second week of the class, a task was assigned to the Japanese students. They were instructed to complete the task during the class. The given task is simple such as greetings, reviews of the previous lesson, or something related to the content of the day's textbook. An example of an actual task is calling out the name of their Taiwanese partner in Chinese at the beginning and the end of the class. An example of a task instruction is as follows:

(i)At the beginning and end of the class, call out the partner's name in Chinese.
(ii)Write the questions you asked the Taiwanese instructors and their answers in Japanese and Chinese.
(iii)Use the Chinese words you have learned to introduce yourself.
(iv)Listen to your partner's self-introduction and write it down in Chinese.
(v)Note that in the online class, students are required to write down their answers in Chinese.

In online classes, students tend to be passive. However, as an initiative, the students must take an active and proactive role in the class by completing the given task.

Another purpose is to encourage communication among students. In a class, there are two sides, the instructors and the students, and both sides are students. Therefore, we assigned the above task to the Japanese students to allow them to interact with each other through the class.

The online class recording showed that two-way communication was relatively active during the activities related to the task.

(4) Creating conversation scenarios and role-playing

There were 26 lessons in total, all the contents of the textbook were completed in the first 20 lessons, and the remaining six lessons were group activities based on what was learned. The activity was to form a group of four people (two Japanese students and two Taiwanese students) and have a five-minute conversation in Chinese using the syntax and vocabulary learned in the class.

Concretely, the work proceeded as follows:

・Two pairs of students joined together to form a group that consists of four students, two Japanese and two Taiwanese.
・The two Japanese participants created a scenario (in Japanese) for the conversation. The conversation can be about anything, but the four students should participate equally in the scenario.
・This rule is to avoid having Taiwanese students speak more than Japanese students.
・The students must use syntax and vocabulary learned during the class in the conversation.
・The Japanese students can use Google Translate to translate it into Chinese if they do not understand the Chinese word. Then, the Taiwanese students will correct it.
・The point is to speak as if Taiwanese students are talking. They will practice once before the real role-play.
・Record the conversation on the last day of the class.
・They are required to submit the scenario's conversation after the role-play.

After watching the scenarios and videos, all groups were able to converse using the Chinese syntax they had learned in about five minutes. As for the speaking style, none of the students were able to reach the level of fluency, but thanks to the dedicated support of the Taiwanese students, all groups were able to have a conversation.

5. Impact of the classes

(1) Questionnaire results from Japanese students

After each class, the Japanese students were asked to fill out the questionnaire. As a result, we were able to confirm that all contents were highly evaluated.

The overall average rating for the teaching method of the instructor (a student from WZU) was 4.97 (out of 5), and the rating for the materials used in the online class was also high at 4.95.

As for the satisfaction level of the class, it was 4.83, which was a little lower than the other evaluation items, but this was not necessarily due only to the teaching methods of the Taiwanese students, as their own efforts and understanding were also included in the evaluation.

Other results of the survey on which language the online class commentaries showed that 8 out of 12 classes were all in English. The other two classes were all in Japanese (the same Taiwanese student was the instructor for two Japanese students), and the other two classes had the same ratio of Japanese and English.

Of the 12 Japanese students, three had studied Chinese before, and the rest were all new to the language. Therefore, the explanations given by the Taiwanese students in the class were either in Japanese or English. Since all the Taiwanese students in WZU can speak English and some of them can speak Japanese, the Japanese students were able to understand the explanations given by the Taiwanese students from WZU. Since the explanations were given in English, the students were able to study English while learning Chinese.

(2) Questionnaire results from Taiwanese students

After all the classes were over, a questionnaire for the students in WZU (7 out of 12 students responded) was conducted.

(i) The satisfaction level of teaching this online class was 4.14.

(ii) The effort to prepare materials was 4.86, and everyone worked very hard to prepare for the class.

(iii) "I would like to teach Chinese in online classes again if I have the chance" was 4.14, and most of the students hoped to teach online classes again next time.

When asked about their efforts in teaching, they said that they tried to keep students interested with various methods, such as by changing the structure of each Power Point presentation and used Quizlet (an online learning support application).

In the questionnaire, we asked for requests and issues regarding this project, and several students answered that information was not relayed well and they had to take urgent action. This needs to be addressed by the management staff so that the students can excel in their studies and practice smoothly.

6. Conclusion

Accepting Chinese language trainees is an excellent opportunity for students to learn Chinese directly from native speakers while they are on campus. It is possible to interact with the trainees not only in class but also after school and on weekends. The acceptance of short-term foreign students is a very good opportunity for Japanese students to improve their cross-cultural understanding.

Although we will not be able to accept students for educational training as we have done in the past years due to the pandemic caused by the new coronavirus, we will continue to conduct the program online. Last year, the content of the training was focused on Chinese language classes. However, this year, based on the reflections from last year, we would like to brush up the content to include elements that will deepen cross-cultural understanding and make preparations so that the training will be beneficial to students from both sides.

References

Manabu Hatamura. (2015). Exchange between Taiwan National United University and National Institute of Technology, Ube College. *Journal of the Japanese Association for Colleges of Technology (journal of JACT)*, Vol. 20, No. 4.

Manabu Hatamura. (2020).Short-term foreign student acceptance program to foster "global technical college students". *Journal of Japan Association for Abrasive Technology*, Vol.64, No. 7.

Yoshihiro Noda. (2021). An attempt of AL type class in Chinese and international understanding class. *National Institute of Technology, Niihama College. Bulletin*, No. 57.

Development of wildlife survey system by industry, academia, government, and residents

Yasuyuki Hirose[*,a]

[a] National Institute of Technology, Gifu College / Department of Civil Engineering, Associate professor, Motosu city, Japan

*E-Mail hirose@gifu-nct.ac.jp

Abstract

In recent years, the dangers of ecosystems disruption and the spread of pathogens by the wildlife have become a major social problem in Japan.

On 7 September 2018, a report was made by the pig farm in Gifu Prefecture that the number of dead pigs has increased. For the first time in 26 years since 1992, the occurrence of CSF (Classical Swain Fever) was confirmed in Japan. Then, by 7 May 2021, the positive cases of CSF from wild boars were confirmed in 24 prefectures. For wild boars, which are considered one of many routes of transmission of CSF, several measures such as confirmation of infection, installation of protective fences, and administration of oral vaccines to wild boars have been performed. However, there are still many unclear points about the ecology of wild boar.

Therefore, it is necessary to understand the ecology of wildlife in each region. The Gifu Prefectural government, Gifu Construction Research Center, and NIT, Gifu College have joint-developed the wildlife ecological information systems using WebGIS. By integrating information on sightings from residents, the habitat can be identified, and effective countermeasures can be considered. Developing educational tools about this issue has become a good practice for students to deepen their knowledge, facilitation, agreement formation, and technological suggestions. This program has been evaluated to have a significant impact on education about sustainability and engineering.

Keywords: *Collaborative education, Sustainability education, Engineer education, GIS*

Introduction

Since biodiversity is at stake in Japan, wildlife conservation has become an urgent and important issue. In recent years, the distribution of wild birds and animals such as wild deer and wild boar has expanded nationwide. The damages to ecosystems, the living environment of residents, agriculture, forestry, and fisheries have become more serious.

In addition, infectious diseases such as Bird-flu and CSF (Classical Swine Fever) have occurred in wild birds and animals. They have become infection routes for pathogens that causing serious damage. Therefore, there is an urgent need to promote efforts such as securing and training catchers, developing catching techniques, habitat management, damage control, and wide-area management.

On 7 September 2018, a pig farm in Gifu Prefecture reported an increased death of breeding pigs. A swift investigation was carried out, and the antigen particular to the CSF virus was confirmed on the next day. Hence, CSF patients since 1992 were identified. Further investigation based on Infection confirmation tests on wild boar groups revealed that CSF from dead wild boars is recovered within 10 km from the outbreak farm.

Fig.1 shows the infection status until 7 May 2021. At present, the positive cases of CSF have been confirmed at pig farms in 12 prefectures and wild boars in 24 prefectures [1].

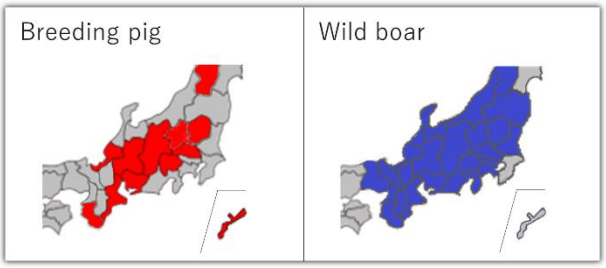


Fig.1 Infection status of CSF

For wild boars, which are considered one of the main infection routes of CSF, measures such as infection confirmation tests, installation of protective fences, and vaccination to wild animals have been executed. These measures are the first-ever attempt in Japan. However, there are many unclear points about wild boar ecology in individuals or groups, such as the range of movement and contact between individuals and groups. Therefore, a wildlife survey system has been developed in Gifu Prefecture to maps the status of infection based on confirmation tests, traps, food (vaccine administration), information on the location of sightings, etc., on the Web GIS.[2][3][4]

This research reports on the development, verification, and awareness of this system with student participation.

Overview of the Wildlife Survey System

Agricultural Administration Department of Gifu Prefectural Government (GPG), Construction Research Center of Gifu Prefecture (CRCR), and National Institute of Technology, Gifu College (NITGC) have cooperated and discussed how to develop a wild boar survey system.[2] The relationship between the three organizations is shown in Fig.2.

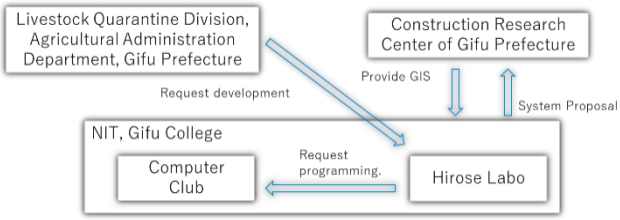


Fig.2 Management of Development Process

Regarding the system, (1) wild boar information, (2) trap information, and (3) vaccine information must be registered by the hunting association, government officials, consignment businesses, etc., as part of collective users. The information is shared according to each user, as shown in Table-1. Besides, there is a decision on the authority for viewing and editing.

Table.1 Access rights of classifications

Classification	Survey capture	Harmful capture	Municipalities	Vaccines
Captive boar	Editable	Editable	Editable	Display only
Trap	Editable	Editable	Editable	Display only
Vaccine	Hidden	Hidden	Display only	Editable

At the initial stage, there were more than 170 registered items reported by Gifu Prefecture.

As many users will use smartphones and tablets outdoors, there is a possibility of many input items that will burden the system and other users. Consequently, discussions between the three organizations are held, and the implementation of the items shown in Table.2 is decided.

Table.2 Stages of GIS

Captive boar	・Search and capture ・Gender・Body length・Body weight
Trap	・Installed traps ・Registered at installation / Update information upon removal
Vaccine	・Information on vaccines sprayed for wild boars ・Register when spraying / Update information upon collection ・Closed to all but vaccine vendors

Fig.3 shows the expected function of the wildlife survey system from the registered items.

(1) The hunter will register the information of the wild boar, whether captured or dead, in the Web GIS.

(2) From the initial information on wild boars obtained by Web GIS, traps are set at the places where they are likely to appear. Then, information in the system is updated.

(3) The vaccine company distributes the vaccine based on the registered capture and trap information based on the location where they are likely to appear. Then, the information in the system is updated again.

(4) Prefectural staff and researchers are then analyze the ecology of wild boars from all the information.

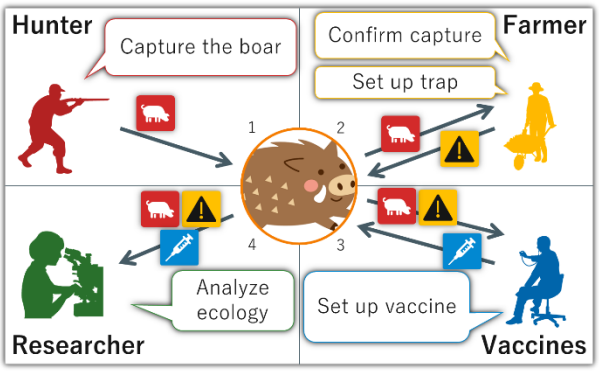


Fig.3 System overview

Development and verification of the system

"Prefecture integrated GIS Gifu" provided by CRCR is used as the base of GIS. The wildlife survey system is developed by Computer Club under the management of Hirose laboratory at NITGC in cooperation with CRCR and GPG.

After a demonstration version of the system was released, surveys based on meetings and questionnaires have been conducted. These surveys help evaluate whether the system was functioning properly, including its operability and readability.

A questionnaire survey conducted from January to March 2020 pointed out that the map display is slow, and there are problems with the screen behavior. Hence, further improvements were needed.

Focus group meetings were conducted from 9 June 2020 to 6 January 2021 for the persons in charge of GPG and CRCR regarding the current status of apps and systems. Their opinions are noted and considered for further improvement.

The system under development in 2020 is shown in Fig.4, Fig.5.

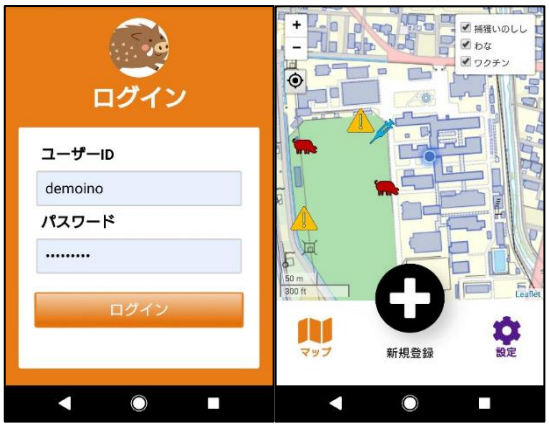


Fig.4 Login and System Screen (2020Ver.)

Fig.5 Data Input Screen (2020Ver.)

A subsequent questionnaire survey was also conducted. About 160 students participated, and all of them are 2nd, 3rd, 4th, and 5th grades of the Department of Civil Engineering, NITGC. Eighty-four responses were collected from the survey from 15 January to 31 January 2021, as shown in Fig.6.

This system has been evaluated to operate stably. It has significant future potential as the total of the evaluations of "Strongly agree" and "Agree" exceeded 80% for the question of "Useful for understanding the ecology." However, regarding the question "Would you like to use it?", the total of the evaluations of "Strongly agree" and "Agree" is just about 45%

Other opinions or requests received in the comment box of the questionnaire included favorable opinions such as "icons, maps, and markers are easy to understand.". However, there are also unfavorable opinions about the communication environment, such as "poor image quality" and "it takes time to log in.

The target of this questionnaire survey is the young people in the science field. Even though there is a bias that they might well be accustomed to electronic devices, the system is proven to have sufficient operability.

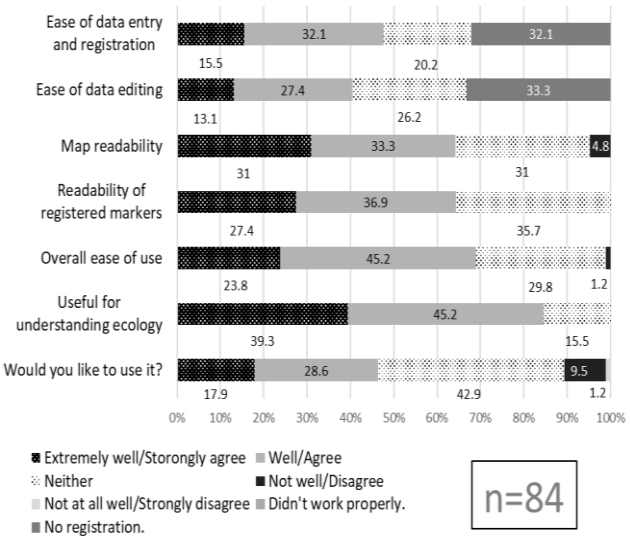


Fig.6 The NITGC students questionnaire result

Hearings of actual users' opinions were conducted from 9 June 2020 to 6 January 2021 with the cooperation of GPG and CRCR. The important opinions and requests for repairs regarding the system based on the hearing survey are shown below.

(1) The icons and layout are easy to understand.
(2) Several images can be registered at once.
(3) Information registered by self-confidence can be added and edited.
(4) Addition and change of several registration items according to the business.
(5) Addition a list up function to search by date, user, affiliation, etc.

The improved and upgraded system is shown in Fig. 7, Fig.8, Fig.9. This system is from the results of the surveys.

Fig.7 Login and System Screen (2021Ver.)

Fig.8 Data Input Screen (2021Ver.)

Fig.9 List up function Screen (2021Ver.)

Enlightenment activities

Students and teachers have organized awareness activities (Enlightenment activities) using the proposed educational tools. The following activities accomplish the disaster prevention education to the regional residents. Before the activities are carried out, there are several considerations. The considerations include the magnitude and duration of the event and the expected age range and number of visitors. This is to ensure the appropriate educational tools elaborated in the previous chapter are selected and prepared for the delivery class. (Fig.10)

Substantial activities in 2019-2021;

- Gifu city library "Gifu Media Cosmos," 12 January 2020. Participants 200
- Kitagata town Seiryu-Heiwa park, 1 September 2019. Participants 150
- Gifu city culture center "Gifu Science Festival," 16 October 2019. Participants 200
-

Fig.10 Various awareness activities

Students also actively collaborate in making radio programs and broadcasting with one of the radio programs on urban planning in the citizen media, "Teniteo Radio" [5]. They recorded a 15 minutes talk on Sunday, 14 April 2019, and 14 January 2021. (Fig.11) The radio program is repeatedly broadcast at 78.5 MHz of community FM [6] from Monday to Saturday, one week after the recording.

The contents of the talk are as follows;

- ・Characteristics of the educational system
- ・Risk of large-scale disasters
- ・Educational activities
- ・Thoughts through activities

Fig.11 Radio program recording

Conclusions

Students involved in the system development will participate every year in the "Forum on Information Technology" of the Information Processing Society of Japan. Currently, they have won the FIT Encouragement Award twice in 2019 and 2020.

In the development of educational tools, one of the proposals won the patent contest. The proposal was granted, and a patent was obtained.

The student group involved in the delivery class participates every year in "Project to solve regional problems by students" of "Gifu Network University Consortium" [7], composed of universities and colleges in Gifu prefecture.

Developing a wildlife surveying system becomes a good practice for the participated students for deeper knowledge, facilitation, agreement formation, and technology suggestion. Also, dialogue with other organizations becomes a good practice for practical skills, presentation, and communication. Therefore, this effort can be highly evaluated as education in collaboration, sustainability, and engineering. Lastly, considering the expansion of the educational program in the future, it is good to verify the educational effect of the participating students.

Acknowledgements

This research is funded by Gifu Prefectural Goverment, The OGAWA Science and Technology Foundation and the Association of Regional Alliances of NIT, Gifu College.

References

[1] Ministry of Agriculture, Forestry and Fisheries, about CSF, http://www.maff.go.jp/j/syouan/douei/csf/ (7.May.2021).

[2] Yasuyuki Hirose, Taskumi Niwa, Hiroyuki Enomoto and 6 others, Development of Gifu Prefecture Wildlife Research Information System, Information Processing Society of Japan, FIT 2019, C-034, 2019.9.

[3] Hiroyuki Enomoto, Taskumi Niwa, Yasuyuki Hirose and 3 others, Development and Verification of the Wildlife Research System in Gifu Prefecture, Information Processing Society of Japan, FIT 2020, CO-008, 2020.9.

[4] Hiroyuki Enomoto, Taskumi Niwa, Yasuyuki Hirose and 2 others, Wild boar Survey System Using Web GIS in Gifu Prefecture, Japan Society of Civil Engineers Chubu Branch, 2021.3.

[5] Citizen media group "Teniteo Radio", http://teniteo.net/ (7.May.2021)

[6] Community FM "FM WATCH 78.5MHz", https://www.fm-watch.jp/ (7.May.2021)

[7] Gifu Network University Consortium, Project to solve regional problems by students, http://www.gifu-uc.jp/daigakusei/chiiki_kadai/ (7.May.2021)