ENABLING DEVELOPMENT OF INNOVATION COMPETENCES BY MULTIDISCIPLINARY LEARNING ENVIRONMENTS

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Abstract

All sectors of the economy emphasise the importance of innovations. Businesses and organizations are continuously looking for innovative employees. Consequently, how to educate innovative graduates is a crucial question for educators. The aim of this paper is to discuss how to develop students’ innovation competences by applying a multidisciplinary learning environment. In this paper we first describe a learning approach called innovation pedagogy, which aims to educate innovative graduates. In order to participate in innovative activities in working life, it requires that graduates must have not only the study field specific competences but also the innovation competences. This paper also presents the results of the research done on defining innovation competences, which are a prerequisite for innovative knowledge. Based on the research results innovation competences can be presented in form of five dimension: critical thinking, creativity, initiative, teamwork and networking. Each of these dimensions is measured via items which together form the final score of a person. After describing innovation pedagogy and defining innovation competences, we present one example of how to build an innovative multidisciplinary environment in higher education where both approaches are present. The presented example gives ideas how to develop students’ innovation competences through social learning in a diverse surrounding. However, the implementation of a multidisciplinary approach and training students' innovation competences has many challenges and it can meet strong opposition especially by the faculty members but also by the students. In our paper, we discuss how we handled the implementation and present our view on the results to which it has led to.

Keywords: Innovation pedagogy, competence, learning outcome, multidisciplinary learning

Introduction

Innovations are a topic handled all over in modern society. When aiming to create added value the companies are increasingly basing their earnings logic on innovations. There are several definitions on innovation and the topic itself is constantly evolving. Today we understand something different by innovation than some five years ago. In ISPIM 2018 Innovation conference the innovation was defined simply as something novel and valuable. Verganti (2016) makes a notion that today we are more facing the problem of defining a meaningful direction when considering innovation rather than being worried about the amount of ideas when looking for solutions to problems which are difficult to solve in the field of a single discipline. It is known that new solutions based on innovations are best born at the boundaries of different knowledge domains. (Kairisto-Mertanen & Mertanen, 2007; Kairisto-Mertanen et al., 2010; 2011; Konst 2017.)

World is changing at a speed never seen before. The companies and other working life organizations are facing the need to adapt themselves to the changing customer requirements, to the changing ways of conducting work and to the changing conditions in the whole environment. All this calls for capability to change old ways of doing things. The universities are supposed to educate the future labour force. They should be at the top of the development and capable of meeting new requirements. However, at universities, we still tend to educate students with traditional methods meant originally for a stable world, emphasizing the learning of explicit knowledge.

The aim of this paper is to discuss how to develop student’s innovation competences by applying multidisciplinary learning environments. We also give one concrete example of innovative learning method where innovation competences have been set as learning outcomes for first year engineer students. The paper does not only focuses to present the method and connect it to the development of student’s innovation competences, but also to reflect our experiences as educators concerning implementing a new and innovative learning method in the faculty.
Methods better suited for a constantly changing world focus on activating students in learning and include unofficial and exceptional situations. It is a crucial step for any nation to be able to educate future generations so that they are equipped with the tools and understanding needed in the present and future world. It is also a crucial step for any university to be able to adapt their studies to these needs and continue to develop new approaches to meet them. (Kairisto-Mertanen, 2017.)

Innovation pedagogy is the new learning approach with an aim to educate graduates who in addition to a study field specific competences also gain competences called innovation competences, which help them to be active in different innovation processes and ultimately create innovations (Kairisto-Mertanen et al., 2012; Kettunen et al., 2013). The innovation competences include the 21st century skills defined by OECD but they have been defined so that also the innovation aspect has been taken into account.

It is important to understand what we mean by innovation as it can be defined in many ways. According to Rogers (2003) it is an idea, practice or object that is considered new. In innovation pedagogy, we use the definition of Finland’s national innovation strategy (Innovation Strategy 2008), where an innovation is understood as a competitive advantage based on knowledge. According to this definition, innovation can also be understood as a process that can be already existing but new in the circumstances where it is being applied (Lehto et al., 2011; Kairisto-Mertanen et al., 2010).

To make sure that the defined aims will be met we have defined several cornerstones, which should be present in the learning environment. Some of these cornerstones such as multidisciplinary education or RDI activations embedded in learning, require a strategic decision made by the university but some of them, such as activating learning and teaching methods or versatile and development-oriented assessment, can be made at the faculty level or even at the individual teacher level. The different cornerstones are presented in figure 1.

Figure 1. The outcomes, competences and cornerstones of innovation pedagogy (Keinänen & Kairisto-Mertanen, 2018; Kairisto-Mertanen 2017.)

The cornerstones are essential requirements for the everyday application of innovation pedagogy. They are designed to guarantee that the desired learning outcomes will be produced during the learning process as they are enabled in the learning environments.

There are altogether nine cornerstones which are: multidisciplinarity, working life orientation, integration between studies and RDI activities, versatile and development-oriented assessment, activating learning and teaching methods, flexible curricula, entrepreneurship, internationalization, and renewing teacher roles.

The innovation process calls for different types of knowledge to be available and to be used. This requires that the learning environments also are multidisciplinary. Working life orientation and integration between studies and RDI activities are needed to ensure that learning takes place in authentic learning environments where real-life situations are brought to be handled in the learning situations in format of assignments and projects stemming from the working life. This way it becomes possible to emphasize that the task of education is also to develop, renew and question the models of operation in working life. People with different talents and competences interact in the learning environment which in addition to a physical space is also a virtual and social space.

The learning and teaching methods have been shown to be the most important cornerstone regarding the development of student’s innovation competences (Keinänen & Kairisto-Mertanen, 2018). Their aim is to activate the students in actively constructing knowledge and meaning from the situations they meet. One of the key elements is also the flexibility of the curriculum, which enables students to take various alternative learning paths. It means that the curriculum can be adapted during the study years to meet the needs and motivation of each individual learner. Adopting entrepreneurial attitude is needed in working life regardless of the tasks or study field. It includes also the ability to manage innovations and have the courage to seize the opportunity in the situations encountered. The world is becoming increasingly global and new graduates are facing the situation of a multicultural working environment instantly when entering working life. This requires that the students develop both their language skills and cultural understanding needed when entering working life and encountering the global working environment. Teachers and faculty members in general are the key people to make the innovation pedagogy approach work so they have to be ready and willing to constantly reflect and question their ways of conducting teaching.

Innovation competences as objects for learning

In innovation pedagogy, innovation competences are the targeted learning outcomes. Learning outcomes are statements used to describe what a learner is expected to know, understand and do at the end of a period of learning. These statements describe what is achieved and assessed at the end of the course. Guidelines for learning outcomes highlight that they should be clearly observable and measurable (Buss, 2008; Harden, 2002). Competence is a holistic concept, which describes a
person’s ability to manage in a specific context (Mulder, 2012). According to Marin-Garcia, Pérez- Penalver and Watts (2013), competences, capacities and skills can be considered the three categories of complexity in contextualized know-how. A competence is formed by a set of capacities and these, in turn, are formed by several skills, all of which are required for a more complex professional performance.

The work of defining innovation competences and creating a tool to assess them has been done in several EU funded projects in a network of universities (e.g., Keinänen, Ursin & Nissinen, 2018). The results presented here are a result of a project called FINCODA (Framework For Innovation Competencies Development And Assessment), which was finished at the end of year 2017. The project partners included a significant number of universities and innovation-intensive companies from five countries, which were working together to develop a tool to measure innovation competences (Butter & van Beest, 2017; Marin-Garcia et al., 2016; Perez-Penalver et al., 2018).

The FINCODA Model of Innovation Competence, presented in Figure 2, is based on five equally important dimensions: Creativity, Critical Thinking, Initiative, Teamwork and Networking. Definitions of the five dimensions are:

- **Creativity:** ability to think beyond existing ideas, rules, patterns or relationships. To generate or adapt meaningful alternatives, ideas, products, methods or services regardless of possible practicality and future added value.
- **Critical thinking:** ability to analyse and evaluate advantages and disadvantages and estimate the risks involved for a purpose.
- **Initiative:** ability to influence/make decisions that foster positive changes. To influence creative people and those who have to implement the ideas.
- **Teamwork:** ability to work effectively with others in a group.
- **Networking:** ability to involve external/outside stakeholders outside the team. (Marin-Garcia et al., 2016; Perez-Penalver et al., 2018.)

If we want that students will learn innovation competences already during their studies, we must also embed these competence objectives in curriculum and take them into account in course designing. Consequently, we can develop learning environments, which mirror and simulate innovation processes.

Several studies also support these objectives. For example, Kivunja (2014) states that the key to teaching creativity and innovation skills lies in designing quality learning environments in which learners can solve real-life problems, and be inquisitive and open-minded. Instead, Vila et al. (2012) show that working together on solutions to new problems supports the acquisition of innovation capabilities in higher education students. Moreover, Keinänen and Butter (2018) and Keinänen and Oksanen (2017) have found that specific pedagogical practices in university-company cooperation develop students’ learning of innovation competences. Furthermore, it has been shown that an innovative curriculum improves students’ innovative performance (Hu et al., 2016).

**Embedding a multidisciplinary approach and innovation competences in engineering education**

The learning method described in this paper is called project hatchery. It is one of the methods developed at Turku University of Applied Sciences to be used with first year students when introducing them to the new way of learning according to innovation pedagogy and its cornerstones. During the project hatchery study unit new students start developing their innovation competences, such as creativity, critical thinking, initiative, teamwork and networking competences, and acquire a new way of learning and engaging themselves.

Project hatchery is based on real-life assignments, peer counseling and working in cross disciplinary groups. There have been many implementations during the past 10 years through which we have gained experience of delivering it to first year students and this way engaging altogether 500 students in this novel way of working. It is a 5 credit study unit and lasts for one semester. The working groups, consisting of 12-15 students, are formed to include as many different students from different study programs as possible. Each of the groups has a second year student tutor responsible for helping the students to proceed with their work when starting with this totally novel approach of learning.

The assignments for the hatcheries are versatile, some of them include tasks given by external stakeholders like companies and other organizations, some of them are topics stemming from internal research and development projects in the university. This study unit offered to all first-year students is also the first experience with the intensive activating teaching and learning methods applied in the faculty. Interacting in team work with students having totally different approach and
networking with the world are basics of the learning environment.

The main objective of this study unit is to make students understand that in addition to their own study field competences their future employers will require that they during their studies have developed and adopted more general competences as well the innovation competences. Innovation competences are expected in all fields in businesses and organizations.

This study unit introduces a new way of learning and working when new students start their studies and by activating the students also encourage them to take responsibility of their learning. In the hatcheries the students are expected to start creating new ideas as they work with people who might have different agendas and ways of thinking. (Kairisto-Mertanen, 2017). They are expected to learn how to define the goals of work and ways how to reach the goals. One of the student tutor’s tasks is to lower the anxiety among project hatchery students when they face the challenge of not knowing exactly what they expected to do. The students are also expected to learn how to continue after something which could not be described as a success. During their first study semester they are allowed to make mistakes but they are expected to learn from them.

The work in the project hatchery groups starts by helping the students to identify themselves as members of the team. It continues by helping the team to assign roles to each team member. The group has to select the project leader, the secretary and assign other roles to the rest of the team members. The project hatchery group is also expected to elaborate on the assignment and find their own angle from which they want to approach the task. When doing this they start developing a capability to take responsibility for whatever they are doing. We also want them to develop an intrinsic approach and motivation to their work.

Studies in project hatchery are designed to contain weekly hours of contact work but also independent work which, as well as the working methods, the groups are free to choose. The study unit also contains a few compulsory tasks allocated to each group involved. Every group has to: 1) draw a project plan for their work, 2) design and prepare a poster reflecting what they are doing, 3) make a presentation and present their work in a creative way, and finally 4) write a final report on their activities and results. Moreover, every student has individual learning tasks, where s/he has to reflect own learning, experiences, goals and motivation.

Because ultimately the learning goals of the project hatchery are not connected with learning of the study field specific competences which are different for most participating students but to learn innovation competences which are equal regardless of the study field, it is very important to define and discuss the goals together with the participating students. Once they are set together it is equally important to reflect reached results constantly in order to make learning visible.

The project hatchery as an innovative learning environment supports students not only in helping them create and meet goals on the development of their innovation competences, but also helping them to find their preferred role in the continuously changing innovation teams present in today’s highly volatile organizations. Innovation requires not only creatives, but also critics, initiators, co-operators and networkers.

**Challenges and possibilities in multidisciplinary learning environments**

Although the project hatchery is a functional pedagogical practice nowadays, it has required lot of long-term and persistent development work. In this section we shortly reflect our experiences and observations related to changing pedagogical practices towards innovative learning. We also highlight some main elements, which are needed to make a change, and point out some key findings, which have changed in faculty during the development period.

There are many challenges when introducing a new way of learning in the faculty. According to our experience it is especially challenging when students from many different study programs are put together for the first time. However, since project hatcheries started, a clear difference could be observed in the atmosphere of the faculty. Students from different study programs started to hang around and work together when they were not forced to doing so. In addition, based on feedback, interviews and discussions with students, it seems that project hatchery concept has a significant role increasing communality of students in the faculty. Perhaps, a shared and common learning experience with new fellow-students in discomfort zone is a key factor enhancing a sense of solidarity.

On the other hand, it is not just the students who have not been accustomed to studying together but also the faculty members who might be suspicious about the importance of different domains than their own. Developing trust seems to be a crucial question. Trust is needed when putting students working together across study programs but it is also needed between faculty members from different disciplines. The teaching profession has traditionally been very independent. After shutting the classroom door each teacher has had the freedom of delivering the content in his/her preferred way and even choosing the content to be delivered. Often the own content is considered to include the most important information to be learnt by the students. To accept that there a many different contents equally important requires understanding and trust on the colleague’s professional competence.

Building trust calls for getting to know each other. The role of the management is to organize occasions where faculty members can meet and get to know each other. Trust is not likely to develop without personal contacts and this is why many discussions are needed and space for them organized. It also possible to organize work supervision, which provides the chance to stand apart from one’s work and to reflect on what is being done, the context and the impact that this has on ourselves as professional people. Work supervision aims at learning through interaction. It is a relationship which is ethical and confidential and where both parties have
rights and responsibilities. Work supervision is also a forum for reflection and learning from our experiences. It can lead to professional growth. (Beddoe, 2010.) In project hatcheries, using work supervision was implemented a few years ago. Counselling sessions are not only used with teachers but also with student tutors. Its implementation has led to remarkable results. Counselling sessions have increased trust, communality and cooperation between teachers and students. For many teachers sessions have been an empowering experience and increased well-being at work. With this model, student tutors have also learnt a new reflecting and conversational method to develop their professional competences which later might be utilized in their future occupations or workplaces.

**Conclusions**

Higher education institutions have a crucial role in training innovative professionals for their future occupations. This requires that students have developed innovation competences and acquired needed experience already during their studies. To succeed in this requires new kind of learning environments. The aim of this article was to present one example of pedagogical practive of innovative learning environment in engineering education.

Innovation development requires risk taking, novel methods and ways to act and think, enthusiastic people, and supportive environments (Assink, 2006). The same elements should be required in education as well. Flexibility and learning to learn are the main success factors in future work according to OECD. Education must prepare students to meet the world where they continuously need to adapt to new ways of working, technologies and business models. However, success in working life is not the only aim for education. Successful education provides also happier individuals and functional societies, improves economic and sustainable development, and adds well-being and equality. This is both a challenge and opportunity for education; we can react, adapt, and have an active influence on the desired future. Competences provided by education are an important tool in shaping the future. The world keeps on changing, but we can have impact on that what kind of world we will have.

**References**


DIGITAL INFORMATION FLUENCY FOR THE FUTURE WORKPLACE: A COLLABORATIVE, INTEGRATIVE DISCIPLINARY APPROACH

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Abstract

The globalised knowledge economy and the rapid integration of information and communication technology (ICT) make it imperative for pre-professionals to acquire digital information skills (DIS) necessary for gaining employment. There is now a growing recognition that the modern workplace needs to move from DIS to digital information fluency (DIF) for enduring career success. DIF is defined as the trinity of critical thinking, net savviness and information source diversity. This study describes a case study, which is a strategic learning collaboration between Nanyang Polytechnic’s business school and library to prepare pre-professionals for the digitalised workplace. As such, this study examined the pedagogical benefits of an integrated disciplinary approach for developing DIF. Digital information literacy instruction and learning activities were integrated into a core foundational business module. A gamified blended learning approach, with elearning modules and gamified classroom activities, was used. The year-long study found that the intervention group consistently outperformed the control group. There were improvements in scored information search strategy articulation and the number of authoritative sources cited increased significantly. Tutors and students reported increased engagement due to the experiential learning experience design and enhanced use of ICT. The DIF strategic collaboration also allowed the initial conceptualisation of a viable working model that helped outlined the co-teaching roles, co-designed learning activities, co-scheduling of teaching, areas of integration, and operational conditions for successful DIF development. This can be extended to and applied in other schools.

Keywords: Digital information fluency, Digital literacy, Information literacy, Disciplinary integration, 21\(^{st}\) Century Skills

Introduction

The job markets’ demand for 21st-century skills that include the ability to find, evaluate and problem-solve using digital information effectively, efficiently and ethically is deemed as essential for continued employment success (Van Laar et al., 2017). This set of skills can be collectively referred to as digital information literacy. Traditionally, digital information literacy leaned more towards the use of ICT to access and assess information as core skills (Bawden, 2008). This technology-use conception has started to change as it is no longer sufficient to be knowledgeable about using a software or online resource. In order for pre-professionals to succeed after graduating, there is a need to shift to digital information fluency (DIF), defined as the trinity of critical thinking, net savviness and information source diversity (Miller & Bartlett, 2012). The shift from literacy to fluency is indicative of the sweeping changes the future workplace is experiencing. More than ever, technical or digital skills, on its own, no longer guarantee job security, let alone promotions or better wages. The 21\(^{st}\)-century workplace has expanded from a technology-use concept to a digital-competence concept.

Digital information skills are assumed by many educators as something that can be picked up as part of disciplinary content instruction. This assumed approach may not be ideal for developing true competence, as even if digital information skills are mastered, it is often done so in an isolated, compartmentalised manner. Building DIF requires a collaborative and integrative effort to better prepare pre-professionals to function in a technologically-rich workplace (Ahmad et al., 2013). Therefore, DIF is of interest to administrators, instructors as well as librarians. It is this partnership that confers the best possible advantage in achieving this desirable 21\(^{st}\)-century skill as DIF requires the use of technology to teach beyond technology. DIF is as much about mastering the skills as it is about applying skills masterfully. In a more ambiguous environment, a learner must be able to apply a skill fluently in any personal or professional situation. A skill is also best learnt when applied in context rather than in a classroom leading to an examination.
This paper describes a case study, which is a strategic learning collaboration between a business school and an institutional library to prepare pre-professionals for the digitalised workplace. DIF has, of late, gained an even greater significance due to the rise of misleading and falsehoods (fake news) as it is perceived as being able to counteract such. Therefore, this study examined the pedagogical benefits of an integrated disciplinary approach for developing DIF. The research questions are meant to illuminate pedagogical practice:

1. What is a viable learning approach for developing digital information fluency for the 21st Century workplace?
2. What is the optimal collaborative approach that allows for cultivating digital information fluency?

Digital Information Fluency

DIF stems from two similar lines of reasoning. Stripling (2007) defined information fluency as the “ability to access, make sense of, and use information to build new understandings…because students must not only know the skills, but also apply the skills fluently in any personal or academic learning situation” (p. 25). Miller and Bartlett (2012) added to the skills-led discourse by expanding it to a tripartite concept of critical thinking, digital savviness and information source diversity. Both studies suggested that the trigger for DIF was the need to better prepare learners as workers for a digitally transformed world. DIF is also often referred to as an amalgamation of literacy skills, having assimilated digitalised workplace. DIF has, of late, gained an even greater significance due to the rise of misleading and falsehoods (fake news) as it is perceived as being able to counteract such. Therefore, this study examined the pedagogical benefits of an integrated disciplinary approach for developing DIF. The research questions are meant to illuminate pedagogical practice:

1. What is a viable learning approach for developing digital information fluency for the 21st Century workplace?
2. What is the optimal collaborative approach that allows for cultivating digital information fluency?

Table 1 DIF-augmented Collaboration Roles

<table>
<thead>
<tr>
<th>Component</th>
<th>Faculty</th>
<th>Library</th>
<th>Instructional Design</th>
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<tbody>
<tr>
<td>Identify</td>
<td>Ensure</td>
<td>Create</td>
<td>Integrate &amp; present</td>
</tr>
<tr>
<td>student</td>
<td>student</td>
<td>awareness</td>
<td>course objectives &amp; resources</td>
</tr>
<tr>
<td>topic</td>
<td>topic</td>
<td>of topic</td>
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<tr>
<td>feasibility</td>
<td>feasibility</td>
<td></td>
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<tr>
<td>Locate</td>
<td>Develop</td>
<td>Provide</td>
<td>-</td>
</tr>
<tr>
<td>students'</td>
<td>students'</td>
<td>training &amp;</td>
<td></td>
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<tr>
<td>ability</td>
<td>ability</td>
<td>support</td>
<td></td>
</tr>
<tr>
<td>Evaluate</td>
<td>Develop</td>
<td>Discuss</td>
<td>-</td>
</tr>
<tr>
<td>students'</td>
<td>students'</td>
<td>source quality</td>
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<tr>
<td>ability</td>
<td>ability</td>
<td>criteria</td>
<td></td>
</tr>
<tr>
<td>Use</td>
<td>Integrate</td>
<td>Demonstrate</td>
<td>Provide IT capabilities</td>
</tr>
<tr>
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<td>course</td>
<td>citation</td>
<td>training &amp; support</td>
</tr>
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<td>objectives</td>
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<tr>
<td>&amp; resources</td>
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21st-Century Skills and Digital Information Fluency

The impetus for the growing recognition of DIF can be attributed directly to the adoption of 21st-century skills. Like 21st-century skills, DIF consists of a broad spectrum of skills meant to prepare a future-ready knowledge worker. Different frameworks address and include DIF differently, ranging from broad generalisations to specific operationalised skills. However, Van Laar et al. (2017) in completing a systematic review of 21st-century skills and digital skills, found that the focus tends to be on knowledge- or content-related skills and on technical use rather than skills required for the workforce. There were limited instances in the frameworks that articulated digital competence or information fluency. This implies that there may be a fundamental disconnect in how institutions, researchers and educators perceive 21st-century skills and its outcomes to develop future knowledge workers. The assessment strategies may also be too narrowly defined and overly focused on functional skills that emphasised knowledge regurgitation and repetitive practice rather than performance. Ferrari (2013) argued it was pointless to focus overly on functional skills as new technologies have made formal digital skills training somewhat redundant. Students can easily learn a software like Excel online on their own. Strømsø and Bråten (2014) also argued that undergraduates needed more training in sourcing, evaluating and applying digital information beyond information search and ICT usage. Siddiq et al. (2016) highlighted that despite the increased use of ICT in the classroom, teachers still characterised students’ digital information skills as lacking. This suggests that DIF may be critical for meeting the working demands in the 21st-century. It also implies that 21st-century skills should incorporate and articulate DIF more expressively.

Method

The intervention study was conducted over an academic year, which involved business students aged 17 to 21 years at Nanyang Polytechnic in Singapore. There was a total of 942 learners in the intervention group and 880 learners in the control group. The control group was the preceding year’s cohort where the intervention was not implemented yet. The learners were taking a foundational business research course and the assessment was to produce a 2,000-2,500 word group report. In the pre-conceptualising stage, the initial pilot trials explored several instructional formats including flipped classrooms, instructor-guided classroom instruction and supplementary elearning. The pedagogical approach also took into account the educational setting where applied learning and outcomes-based learning were dominant educational hallmarks. The resultant intervention chosen was a blended lesson plan comprising three elearning modules (Effective Search Skills, Cite Using Endnote/Mendeley, Copyright and Plagiarism), a 90 mins hands-on workshop (Information Search Strategies, ‘Online Sleuth’ Gamified Activities) tutorial and assessment activities (information search strategy, digital
A gamified approach was chosen as it fitted well with the adopted experiential learning style. The intervention lasted 5 weeks and was presented to instructors and learners as a "Business Research Week@The Library". Content analysis was also used to assess the submitted reports. Several researchers have stated the conditions essential for developing DIF such as the extensive use of digitally formatted sources, digital search using specialised tools, knowledge of intellectual property rights, information evaluation strategies, and authentic application (Moore, 2002; Sharkey, 2006; Fogleman et al., 2013; Heine & O'Connor, 2014; Lombard, 2016). As such, the categories coded included the frequencies of source citations, number of authoritative sources used and digital scholarship (adeptness in the use of digital sources to produce insights, conclusions and recommendations). End of semester self-reported online user satisfaction surveys were also conducted.

Results and Discussion

The study sought to discover the optimal learning approach for developing DIF. The outcomes associated with DIF included the increased use of authoritative sources, increased number of digital sources referenced, digital scholarship demonstration and articulation of an effective information search strategy. It was found that the intervention group consistently outperformed the control group. The study was repeated over two semesters. There was a statistically significant difference between groups as determined by an one-way ANOVA (F(1,363) = 3.853, p = .050). A Tukey post hoc test revealed that the intervention group used more authoritative sources in their group reports (3.14 ± 1.5, p = .050) than the control group (2.81 ± 1.6, p = .050). Authoritative sources were defined as the use of peer-reviewed journal articles and the use of objective industry reports with detailed references produced by reputable consultancy firms. Whitepapers and case studies were excluded as these are often used by companies as marketing tools.

Table 2 DIF One-way ANOVA Descriptives

<table>
<thead>
<tr>
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<th>N</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Std. Error</th>
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<td>1.507</td>
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<td>5.63</td>
<td>1.058</td>
<td>.078</td>
</tr>
<tr>
<td>Intervention</td>
<td>183</td>
<td>6.47</td>
<td>1.171</td>
<td>.087</td>
</tr>
<tr>
<td>Total</td>
<td>365</td>
<td>6.05</td>
<td>1.192</td>
<td>.062</td>
</tr>
<tr>
<td>Info. Search Strategy Articulation</td>
<td></td>
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<tr>
<td>Control</td>
<td>182</td>
<td>5.27</td>
<td>1.321</td>
<td>.098</td>
</tr>
<tr>
<td>Intervention</td>
<td>183</td>
<td>6.15</td>
<td>1.416</td>
<td>.105</td>
</tr>
<tr>
<td>Total</td>
<td>365</td>
<td>5.71</td>
<td>1.437</td>
<td>.075</td>
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</table>

The intervention group (15.12 ± 6.4, p=.00) also significantly outperformed the control group (9.29 ± 3.9) for the total number of digital sources cited. It was observed that the reliance on using news articles was higher in the control group. News articles were considered to be less authoritative as it was difficult to identify and separate opinions, bias and associated political agendas from objectively reported facts. Digital scholarship, scored from 1 to 10, was also significantly higher for the intervention group (6.47 ± 1.2, p=.00) than the control group (5.63 ± 1.1, p=.00). Learners in the intervention group demonstrated a stronger ability to use evidence to produce analytical insights, conclusions and recommendations. The rubric scored learners on the ability to synthesise analytical insights rather than describe and paraphrase, as well as the relevancy of conclusions drawn and recommendations proposed. The intervention group (6.15 ± 1.4, p=.00) was also better at articulating their information search strategies used than the control group (5.27 ± 1.3, p=.00). An effective search strategy articulation, scored 1 to 10, was deemed more effective if it clearly articulated the search keywords used, the diversity of sources considered and a method to filter sources for relevancy and currency. Learner satisfaction ratings from end of semester feedback exercises also improved by 6.2% year on year. Surprisingly, the learners rated the instructors higher showing an increase of 9.3%.

The findings concur with Çoklar et al. (2017) who found that increases in digital information literacy increased digital competencies especially for online information search strategies. The improvements in this study’s intervention group could be attributed to the learning experience design as well as the novel experience of marketing the strategic collaboration as a special learning week. Hess (2015) emphasised the use of a motivational design in information literacy instruction as much of current practices seldom addressed learner motivation meaningfully. The experiential learning approach, learning event branding and the gamified elements were designed to impact learning motivation and achievement through engagement. The inclusion of these motivational elements resulted in increases in learning application as seen in the increases in number of digital sources cited and demonstrated digital scholarship. The learning design used in this study had instructional significance for developing DIF.

The study also sought to identify the optimal collaboration approach for faculty and librarians for developing DIF. The resultant learning approach used in this study could be described as a shared responsibility. Both faculty and librarians contributed their relevant expertise at three distinct stages over a working period of 12 weeks. At the planning and conceptualising stage, faculty instructors shared desired learning outcomes, learning content and lesson plans. Similarly, librarians shared existing training resources and recommended context-specific digital resources for writing a business report. A series of meetings between faculty and librarians then identified opportunities to enhance the learning activities that could better engage learners. The
efforts culminated in a co-developed lesson plan with clear instructional outcomes that were aligned with assessment strategies.

At the implementation stage, a pilot was first completed before the full roll-out to tease out implementation issues and refine instructional delivery. The librarians conducted the workshop-style training sessions on-site at the library, heightening experiential learning. Previously, many learners would only have attended a library tour during orientation. The instructors added a gamified element which introduced a friendly yet competitive element during the workshops. The on-site training sessions were therefore, co-taught by librarians and instructors. Instructors pointed out how to maximise the use of library resources during and at the end of the training session. The core elearning modules were developed by the library and additional elearning were supplemented by the instructors in subsequent weeks. The librarians curated a list of business-relevant research resources which increased the chances of learners exploring and incorporating the use of such resources. At the post-workshop stage, the focus was developing fluency over the next four weeks. The topics covered in the elearning modules (Effective Search Skills, Cite Using Endnote/Mendeley, Copyright and Plagiarism) were discussed in greater depth in subsequent tutorial classes as groups wrote their business reports. Consultations were also integrated into the lesson plan every week over a month. Learners were encouraged to explore the library resources and apply them effectively. Learners were encouraged to approach librarians should they wished to revisit core concepts in using library resources effectively. Deep integration at all three stages were deemed essential and this reinforced Lombard’s (2016) synergistic approach for developing DIF.

The strategic DIF collaboration’s success could also be attributed to a conducive and open partnership that leveraged the strengths of faculty instructors and librarians. It was not without its share of challenges. The first being the increased instructional burden on the part of the librarians. Technostress was experienced by some faculty instructors. Instructors expressed concerns over whether learners could cope with the increased digital teaching content and their own discomfort with the enhanced use of online research tools. While instructor training was made available, it did not reduce anxiety. What worked was a buddy-system where a more technologically savvy instructor was present for the first round of classes.

Conclusions

This case study demonstrated that DIF can be an institutional reality when the synergistic practice of "collaboration with commitment" results in improved learning outcomes that better prepared pre-professionals for the 21st Century. The gamified blended learning approach where both instructors and librarians worked hand-in-hand to develop learning content and activities was also effective in cultivating DIF. This validates the work of DIF researchers that emphasised the importance of digital or ICT-enhanced integration as well as disciplinary integration so that skills are applied in context to build fluency. An element of challenge imbued in experiential activities is also integral in activating DIF. The DIF strategic collaboration also allowed the initial conceptualisation of a viable working model that helped outline the co-teaching roles, co-designed learning activities, co-scheduling of teaching, areas of integration, and operational conditions for successful DIF development. This will serve as an evolving model to guide future endeavours for institutions seeking to develop DIF in a vocational setting.

It is nigh impossible for one to be an expert in curriculum development and delivery, librarianship and computer technology. DIF requires all three aspects to succeed. Thus, the best way forward is to collaborate to leverage core expertise that resides in an educational institution. A pedagogical and pragmatic model is key to unlocking learners' digital scholarship that builds DIF. A possible future direction is to expand the strategic collaboration to include a broader range of disciplines. This is because a widely used framework will contribute to the growing importance to develop this highly desirable 21st-century skill.

References


Abstract

The maritime technology departments in the five National Institute of Technology (NIT) colleges in Japan namely Toyama, Toba, Hiroshima, Yuge and Oshima College have been working together to improve the ability of Japanese students and instructors to use the Maritime English without any troubles. The English study and training program has been performed at NYK (Nippon Yusen Kabushiki Kaisha) - TDG (Transnational Diversified Group) Maritime Academy (NTMA) in the Philippines as they say “NYK project” since 2015. We decided to join the project with Japanese students and instructors. Aside from the students’ English training, we, Japanese instructors were given several chances to have lectures in front of Filipino students. This paper has been reviewed how the English training and teaching experience worked for Japanese instructors at NTMA. For the second step, one of the NIT colleges, Oshima College invited professional instructor from National Kaohsiung Marine University in Taiwan. We requested him to conduct the technical educational program and onboard ship training simulation in English based on STCW (Standards of Training, Certification and Watch keeping for seafarers). We conducted survey questionnaire from the Japanese students, and analyzed the students’ thought about English and the invited foreign instructor depending on each year and course. The results reflect how we should prepare the course information and understandable topics as well as teaching skill by using the active learning style.

Keywords: Maritime English, NTMA, STCW, NIT maritime colleges

Introduction

Maritime officers are specialists handling ship navigation and maritime engineering. As for the international maritime officers, a deep knowledge of theory, operating skill and maintenance for the ship is a very important requirement for them. Aside from that, they should speak English for internal or external communication between ship to ship or ship to shore. Actually, in the practical situation, almost of all the seafarers are foreigners.

All Japanese teaching staffs focus on how to teach maritime English effectively. All trainings in maritime technology department like the Practice of Boat Handling, Experiments and Practice, Onboard Training are conducted in Japanese language, but actually they should speak English for internal communication on merchant ship in the future. There is no doubt to say that.

The maritime technology departments in the five NIT colleges in Japan have been working together to enhance motivation and ability of the students to be international maritime officers and ship managers at sea (2013). We decided to bring the Japanese students to NTMA in the Philippines for a short term English training. The purpose is to experience the importance of English by living with Filipino students of the same age who are strongly aiming to be a maritime seafarer. NTMA promotes the standards in maritime education based on a variety of teaching methods delivered by highly qualified faculty members. We, Japanese instructors were given several chances to
have lectures in front of Filipino students who are involved in maritime technology. It is very important for Japanese teachers who are non-native English speakers to practice to teach maritime technical subject in English. It must be connected with students’ motivation for English studying. This paper has been reviewed how the English training and teaching experience worked for Japanese students and instructors at NTMA.

For the second step, one of the NIT colleges, Oshima College invited professional instructor from National Kaohsiung Marine University in Taiwan. We requested him to conduct the technical educational program and onboard ship training simulation in English based on STCW (Standards of Training, Certification and Watch keeping for seafarers). We collected the data from the questionnaire for the program, and analyzed the students’ thought about English and the invited foreign instructor depending on each year and course. The results reflect how we should prepare the course information and understandable topics as well as teaching skill by using the active learning style.

We concluded that the international maritime English program in the Philippines and Japan was successful to enhance students’ motivation to study English and teachers’ professional English communication ability. Thus, the practice of international maritime English education in the classes should be affordable for teachers and students in maritime colleges in Japan.

Teaching in English on technical subjects at NTMA

NYK-TDG Maritime Academy (NTMA) in the Philippines promotes the standards in maritime education through a competency-based and maritime industry-driven curriculum that employs a variety of teaching methods delivered by highly qualified faculty members.

During the first half of the stay, the Japanese instructors including me had a chance to be a school inspector sitting in the classes, and Japanese student acted as a temporary participants. Photo 1 shows the lecturing view at NTMA which shows U-shape seat arrangement. This arrangement in the classroom is totally different from Japanese style.

A non-native English speaker NIT instructor performed lectures of maritime technical subject such as Marine Auxiliary Machinery engineering in English at regular classes. Also NIT instructor performed a presentation of Japanese culture and geography in English for all NTMA students. They listened intently to my discussion, and there was an exchange of ideas. They raised questions and participated in the class discussion.

At NTMA, the classes were conducted in various ways, such as students’ discussion, presentation and exercise with instructor. Most of the classes, the instructors have their lectures using visual methods such as Powerpoint, Video, etc. to raise the students’ understanding on the subject matter.

Questionnaire to the Filipino students on how they evaluate the invited lecturer from NIT

The question lists are as follows:
Q1. Is the lecturer’s teaching well-organized?
Q2. Are you interested in the topics of the lecturer?
Q3. Have you understood the content of lecture?
Q4. Are you completely satisfied with the lecture?
Q5. Is the lecturer’s English effective?
Q6. Is the lecturer’s attitude (gesture, posture, and eye contact) effective?

For the feedback on the lecture at NTMA, we let the Filipino students choose one number from the list below for each question:
1. Very disagreeable
2. Disagreeable
3. Neither disagreeable nor agreeable
4. Agreeable
5. Very Agreeable.

Figure 1 shows the average values for each question about it. A NIT instructor gave lectures three times for each of classes in Crankshaft, Flywheel, and Journal. They were all 3rd year students and 81 students in total. The class Journal got the highest score while the Flywheel got the middle score, and the Crankshaft got the lowest score. This means the NIT instructor (lecturer) have got used to teaching in English in the classes. The lowest score shows in the Q3 as shown in the figure. That is why the students do not completely understand the content of lecture. Lectures aren’t just boring. They are ineffective too. Overall, they gave high values to the invited lecturer.

Figure 2 shows the average values for each question to the different way. For example, as for the Q1 (Is the lecturer’s teaching well-organized?), the color of purple which indicates number 4 shares about 25% and the sky blue indicating number 5 shares about 75% of 81 students in total. As a result, it is a fairly high score and a good indicator that we did well in the lecture. The Filipino students generally gave high values on number 4 or 5 (means agree or very agree for questions) of 90% in total number. The several students agreed on giving a lower score for Question 2 to 4 (means slightly not interested in the topics of the lecture). There are only two colors in Q1
and Q5. This means that the students do agree or very agree with the effective lecture’s organization and lecturer’s English. We learned a lot from the results how we should prepare the interesting and understandable topics as well as teaching skill by using active learning.

In addition, Figure 3 shows what kinds of teaching methods are effective in the class. Students think the use of video is one of the most effective tools in teaching. They prefer a prepared visual presentation such as Slide, Video and Picture. The trend of preference of students on digital material or media is an indicator of people's fondness of social media. They also want some games or ice breaker to be incorporated in the lesson. That's why the quiz category ranked number 4. The demonstration is also chosen by the student because this activity involves people moving and doing something in actuality.

Teachers don't have to use the same teaching methods all the time. For the purpose of variation, the teacher has to use different teaching methods so that students won't get bored in the class. Followings are the students’ comments about the invited lecturer from NIT.

**NTMA student’s comments for the NIT lecturer in the classes**

- We would like to recommend that more sample quizzes and activities
- Icebreaking for the class needs for the long discussions
- More video or demonstration on each topic will be understandable
- It would be better adding some catching slides that will energize the students
- You could give some personal experiences onboard
- It will be more effective if more examples, videos and pictures will be used.
- Sometimes we must proceed to the engine room to demonstrate the actual process
- It would be better if you will make your voice louder
- We suggest more animation and more interesting examples like the superman example
- Before your talk, you need to find out the things that the students didn’t know.
- You may also ask first what are the student's pre knowledge to know where to start the lecture
- Some pictures could not be seen and should speak more clearly
- There should be some ice breaking and fun discussion to have it lively like having group activities
- It would be much better if there are more examples and seat works
- We needed additional video presentation and more examples for calculations
- We would suggest that some difficult problems must be elaborated for the understanding to everyone
- Let the students answer the problems to see if they know how to solve it
- We could not understand clearly the statement of the lecture in English.
- Having a little joke in the class is good to keep the class good mood

**Maritime English Seminar in Japan**

For the second step, one of the NIT colleges, Oshima College invited professional instructor from National Kaohsiung Marine University in Taiwan (see Photo 2). We requested him to conduct the technical educational program and onboard ship training simulation in English. He was also a non-native English speaker like other Japanese teachers, so English was the only means of communication in the class. The students were able to identify the maritime technical professional words used in every subject, and to determine the meaning of the
maritime terminology and their functions in the classes. For speaking comprehension, students assigned to do a group activity where they have to make a plan on what to do. They could be able to speak in English and use some maritime terms correctly while doing the task.

**Questionnaire for the invited lecturer from Taiwan in Japan**

We conducted survey questionnaire in the Japanese classes on how Japanese students evaluate the Taiwanese lecturer. It is the same survey that we have done in the Philippines.

As shown in the Figure 4, you can see a hexagon chart. S stands for shipping technology department, and the number stands for year level of the students. E stands for course in the department which is the engineering course. Each of year level represents color blue, red, and green. Q1 to Q6 means questions 1-6. Inside of it is the score from 0 to 5. The S1 shown with blue color got the highest score from Q1 to Q6 in the chart. While the S3E shown with red color evaluated the second high score overall, but as you can see in Q3 (Have you understood the content of lecture?) they have got the lowest score among the other group. S3 students have not yet established the basic of professional subjects, so the content seems to be difficult for students to understand in English. The S5E shown with green color had a consistent low score from Q1 to Q2 and Q4 to Q6, but only in Q3 their score is a bit higher than red color. The results speak for the fact that the lower year level of Japanese students are interested in English lecture and they are very satisfied with the invited lecturer. However, as grade level become higher, their evaluation is getting worse.

**Questionnaire about learning English for Japanese students**

The question lists are as follows:
Q7. Do you feel the need to learn English?
Q8. Do you hesitate to speak English in public?
Q9. Do you think that your English ability in the class is more than "Average"?
Q10. Do you have opportunities to expose you to English?
Q11. Do you think that an Active Learning style lesson is necessary rather than conventional lecturing style lesson?

For the feedback on the lecture, the Japanese students chose one number from the list below for each question:
1. Very disagreeable
2. Disagreeable
3. Neither disagreeable nor agreeable
4. Agreeable
5. Very Agreeable.

Figure 5 shows the survey for Japanese students about learning English in the shipping technology department. It is shown in this graph how student responded to the survey. As you can see in Q7, the majority of the students strongly agreed that learning English is very important. Which means the Japanese students are very interested to learn English. In Q8, the opinion of the students are divided. Only few students are confident enough to admit that their English skills are good and that they would not hesitate to speak English in public. In Q9, students answer from maybe to “NO”, means they don't think that their English ability in the class is more than average. Q9 leads Q10. In Q10, students’ opinions are divided but the rating is almost equal from strongly disagree to strongly agree. In Q11 finally, students respond from maybe to “YES” means majority of the students believe that Active Learning style is necessary than conventional lecturing style, even though Active Learning style lesson is not a common way in Japan.

Self-evaluation vs year level of Japanese students about English

As you can see in the Figure 6, it shows the self-evaluation vs year level of Japanese students about English in the shipping technology. The Y-axis is represented by self-evaluation. You will see a score ranges 2.0 to 5.0. On the other hand, the X-axis is represented by the year level of the students from S1 to S5. The S4 is omitted because they had a shipboard training. The Q7 to Q11represent the question lists. Q7 obtained the highest score while Q9 got the lowest score. The students desire to learn English because of the following reasons: 1. Inspiration. They are in shipping technology and they will be using the English language when they become seafarers in the future. 2. Globalization. They might consider working in a foreign country so they really think English is important for them. Q11 ranked second from the highest. The active learning is necessary for their study since there is interaction between the student and the teacher. In this way, they can practice expressing their thoughts about a particular topic and also they can participate in the discussion. For Q10, the students have little opportunity to expose themselves to English. They have experience like by engaging in International Exchange Program and Internship for the upper level. The reason for obtaining a medium score is that the opportunity to go abroad is not enough. For Q7, the S1 students obtained the highest value as compared to other levels. Q9 has the similar trend in slope with Q7. This shows that the desire for the S1 is higher among the other levels. Everything that they learn in Junior High School is perhaps still fresh in their minds. So they are enthusiastic to learn more about English. However as they year progresses, the slope gradually goes down. Lack of enthusiasm. Their interest for learning English gradually fades away because their focus is now diverted to the professional subjects. Hopefully, if the upper level students can join the International Exchange Program and Internship, so they will have the desire again to learn English.

Conclusions

Through the International Maritime English Education in the classes, teachers could improve the management and teaching skills of professional subjects in English, and also students could learn the professional maritime English. For the students, it is expected that the passing rate of CoC and TOEIC score will improve as a result of English trainings. The instructor from Taiwan had gained Maritime English Education experience in
Japan where non-native English speakers are, so we were able to obtain the mutual effects. The questionnaire for the trainings were reported to prove their comprehension about Maritime English (2016, 2017).

However, the motivation to learn English passively cannot last a long time, and it disappears as time goes by. Only the learner's inner desire for improving is stimulated strongly, it could be the real sources of learning English. At the same time, the teachers should meditate the course information to fit students’ needs. There’s no doubt to say that.

Japanese people are not English native speakers and the medium of instruction in schools is not English. Exposure is important because it is one the effective ways of applying and using the English language. Learning is an active process and is activated by the learners. The learners are the center or the key players in the teaching-learning process. All the activities or learning experiences should be Active Learning style to assist in teaching such as applying charts or tables, using videos, web-sites or computer simulators, and collaborative learning or peer tutoring etc. Consequently, Japanese students will have the desire to learn English when they will be willing to join the International Exchange Activities and Internship programs that have been offered by each Japanese maritime college from now on.

References


GAME ON THE SPHERICAL SURFACE

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Abstract

As a mathematical teaching material for students at the national college of maritime technology, we devised the spherical game. A ball is exchanged like tennis on a spherical court in our brains instead of a rectangular court. In this game, one who makes the opponent move a longer distance wins. Both teams have the same number of people. One will throw down a ball farthest from the opponent closest to the falling point and the closest opponent picks it up. The quantity of the distance is the score of the throwing team. The opponent had better be in a position where the maximum value of the distance is the minimum. We came up with this material from the fact that we want our students to understand that the shortest distance at sea is the distance between two points on the great circle. Also, we can understand the strategy of the game by comparing the fixed arrangements, i.e. by using the metric invariant. Another purpose of the research is to observe this process. We clarified the process of thinking the strategy on the sphere and the hemisphere. Further, by using the metric invariants, we can have understanding about the value that characterizes the shape of the space. It is not only educational concern of the sea but also an introduction to geometry and network science. We tried using this material. In the first step, only 30 percent of students thought of the strategy, but by inducing them to compare the fixed arrangements, almost all students understood it. We obtained the following comments from our students: "I understood the meaning of the shortest line at sea." "It was somewhat difficult to master the metric invariant, but I found out the meaning of it and the strategy by fixing some arrangements." Fixing is an important tool. We use it in many fields of mathematics, such as partial derivative. Finally, we presented a similar problem including another theme to the students, and observed that they solved the problem with same strategy. We noticed the diversity of this game and confirmed the educational effect.

Keywords: teaching material, mathematics, geometry, sphere, hemisphere, metric invariants, fix, compare, maritime technology, network science

Introduction

Initially, it was the starting point of the idea of this teaching material that we wanted students studying the ocean to understand through this game that the shortest distance between two points on the ocean is the distance on the great circle. In the figure below, when asking for the shortest path through two points A and B, there were many students who answered that the route with two points on the small circle is the shortest (Figure 1). Actually, the shorter route with two points on the great circle is the shortest (Figure 2). On the map, the shortest path on the great circle may seem to be on the detour, but in fact it is heading straight to the other point on the curved surface.

Figure 1.small circle           Figure 2.great circle

This time, we played the game not only on the sphere but also on the hemisphere. In these spaces, by thinking about each strategy, the students will deepen their knowledge and understanding about the values that characterize the shape of the space, and it will also be an introduction to geometry on curved surfaces. In other words, we think that it will be a bridge to mathematics at university, starting with thinking about the strategy of this game. When considering the game strategy, we will fix moving things and compare their placement. And we find better placement. This time, we observed and revealed this thinking process. The strategy is understood by comparing the fixed placement, and considering the strategy is equivalent to finding the metric invariant \( m_k(X) \). We can know that the shape of the curved surface is characterized by this metric invariant. Finally, in quite different questions (Problem A, Problem B) to which we could apply the same strategy, we investigated whether the students were able to think like the spherical game strategy. In other words,
we examined the diversity of the strategy concept of this game.

In this paper, we denote the 2 dimensional unit sphere as $S^2$ and the 2 dimensional unit hemisphere as $S^2_2$. Here, the lower limit of the length of the curve connecting the two points $x$ and $y$ on the curved surface is called the geodesic distance of $x$, $y$. Or it is simply referred to as the distance, and is represented by $\text{dist}(x, y)$. The curve connecting two points is called a geodesic. When two points are antipodal points on the 2 dimensional unit sphere, there are countless geodesics, and the length of the geodesic is $\pi$ as a length of half of the great circle. A triangle with geodesics on three sides is called a geodesic triangle.

### Materials and Methods

(1) Spherical game rules

Battle game is performed on the spherical surface with $k$ people versus $k$ people. First of all, members of both teams move freely and decide their placement. One out of $k$ people in the attack-first team will throw a ball on the spherical surface. It is assumed that 2k members of both teams cannot move until the thrown ball falls. At the moment the ball falls, $k$ members of the opponent team leave at the same time for the position of the ball and head for picking it up at the same speed. At that time, $A_k$ in order for team $A$ to score high. In other words, at the minimum value of the distance from $k$ persons of team $B$ to the falling position picks up the ball. At that time, $A_k$ will throw as far away as possible from $B_k$ to $B_k$ in order for team $A$ to score high. In other words, at the minimum value of the distance from $k$ persons of team $B$ to the falling point $x$, we consider the maximum value by moving $x$. This value is $p_k(x_1, x_2, ..., x_k)$ and it is the score for team $A$. Therefore, in order to reduce the score of team $A$, members of team $B$ may move in advance to the arrangement that minimizes $p_k(x_1, x_2, ..., x_k)$. This value is $m_k(X)$. If team $B$ is in the optimal arrangement, $m_k(X)$ is the score for team $A$. In this way, team $A$ and team $B$ can similarly make strategies in this game by using the metric invariants.

(2) Metric invariant

In the game, we consider the strategies that both teams should take by using the metric invariant $m_k(X)$. First, we consider the maximum value when $x$ is moved at the minimum value of the distance from $k$ points to a point $x$. Further, when $k$ points are moved at this maximum value, the minimum value is represented by $m_k$. Its value in space $X$ is represented by $m_k(X)$. That is, a point $x$ on $X$ is set such that $\min_{i=1, 2, ..., k}\text{dist}(x, x_i)$ is maximized with respect to $k$ points $x_1, x_2, ..., x_k$ on the curved surface $X$, and its maximum value is represented by $p_k(x_1, x_2, ..., x_k)$. Furthermore, $x_1, x_2, ..., x_k$ are selected so that $p_k(x_1, x_2, ..., x_k)$ is minimized, and this minimum value is denoted as $m_k(X)$. That is,

$$p_k(x_1, x_2, ..., x_k) = \max_{i=1, 2, ..., k}\min_{x \in X} \text{dist}(x, x_i)$$

$$m_k(X) = \min_{x \in X} \max_{i=1, 2, ..., k}\text{dist}(x, x_i)$$

Here, $m_k(X)$ is a metric invariant known as $k$-covering radius, and several values are known in sphere $S^n$, hemisphere $S^n_2$, real projective space $RP^2$, etc. ([3]). Since we deal with the minimum value, we take an initial letter "m" and denote it by $m_k(X)$. K-covering radius is studied not only in mathematics but also in code theory in network science ([1], [2]).

(3) Relationship between the game strategy and the metric invariant $m_k(X)$

On $X$ (sphere $S^2$, hemisphere $S^2_2$), members $A_1$ to $A_k$ of team $A$ play against members $B_1$ to $B_k$ of team $B$. It is a match of $k$ people to $k$ people. First, $A_1$ throws and drops a ball on $X$. One out of members of team $B$ closest to the falling position picks up the ball. At that time, $A_1$ will throw as far away as possible from $B_1$ to $B_k$ in order for team $A$ to score high. In other words, at the minimum value of the distance from $k$ persons of team $B$ to the falling point $x$, we consider the maximum value by moving $x$. This value is $p_k(x_1, x_2, ..., x_k)$ and it is the score for team $A$. Therefore, in order to reduce the score of team $A$, members of team $B$ may move in advance to the arrangement that minimizes $p_k(x_1, x_2, ..., x_k)$. This value is $m_k(X)$. If team $B$ is in the optimal arrangement, $m_k(X)$ is the score for team $A$. In this way, team $A$ and team $B$ can similarly make strategies in this game by using the metric invariants.

(4) Teaching method

In the previous paper ([5]), we treated only the sphere. Then about 30% of students could understand the strategy immediately in the case of 2 to 2 battles on $S^2$. But most students could understand the subject by comparing the fixed arrangement. This time, we also deal with the sphere and the hemisphere.

1. First, we have students consider the following problem A. We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. After students' consideration, we explain this problem. Problem A: "Suppose the radius of Mars is 1. Martians set up missile intercept system at $k$ locations on Mars. However, the following conditions should be satisfied. Q1. When a missile bombardment is made at a point $x$ on Mars, martians intercept the missile at the point $x$ at the shortest distance from the point closest to $x$ in the k points. Q2. The entire Mars is subjected to intercepts and bombardments.

Q3. Martians set up $k$ bases so that the interceptable distance (the distance in Q 2) is minimized."
In the case of \( k = 2 \), consider the arrangement of bases on the spherical area of Mars. Also consider the placement of bases when targeting only the hemispherical area of Mars in the case of \( k = 2 \).

2. We explain the rules of the spherical game. Let students think about 1 to 1 matches on \( X \) (sphere \( S^2 \), hemisphere \( S^2_2 \)). We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. Here, our aim is to have students understand the rules and get interested in the game. In addition, we will explain the hemisphere by using a ball. After students’ consideration, we explain this problem.

3. We consider 2 to 2 battles on \( X \) (sphere \( S^2 \), hemisphere \( S^2_2 \)). We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. We explain the shortest line and the metric invariant by using a ball. Since it is difficult to explain the definition of the metric shortest line and the metric invariant by using a ball, we explain the definitions of the diameter, \( \text{diam} X \) and the radius, \( \text{rad} X \) which are simpler metric invariants by using a ball. The diameter, \( \text{diam} X \) represents the maximum value of the distance \( \text{dist}(x, x_1) \) from an arbitrary point \( x \) to an arbitrary point \( x_1 \) on \( X \). The radius, \( \text{rad} X \) is the minimum value when \( x_1 \) is moved at the maximum value of the distance \( \text{dist}(x, x_1) \) from an arbitrary point \( x_1 \) on \( X \). The metric invariant \( m_k(X) \) is obtained by replacing the distance from one point in \( \text{rad} X \) with the minimum value of the distance from \( k \) points. We explain \( m_k(X) \) by fixing the arrangement of points, so that the students can understand the relationship between the game and the metric invariant \( m_k(X) \). After students’ consideration, we explain this problem.

4. In case of stall, we instruct them to fix some placement and to consider the value of \( p_2(x_1, x_2, \ldots, x_k) \), and to compare it with the value in other placement. In the case of the arrangement for which it is difficult to calculate the distance, we measure the shortest distance by using a piece of string.

5. If we can afford it, we think about 3 to 3 battles. In order to calculate an accurate value, we explain the spherical trigonometry.

6. Finally, we ask students to consider the following problem B:

We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. After students’ consideration, we explain this problem.

Problem B: "Suppose that the radius of the earth is 1. We establish rescue bases at \( k \) locations on the earth to make an international safety system. It may also be installed on the seawater surface. However, the following conditions should be satisfied.

R1. When there is an accident at one point \( x \) on the earth, we head for rescue from the point closest to \( x \) in \( k \) points.

R2. We cover the whole earth area for rescue.

R3. We set up the bases so that the movable distance is minimized.

Consider the placement of rescue bases on the spherical area of the earth in the case of \( k = 2 \).

Also consider the placement of bases when targeting only the Earth's hemispherical in the case of \( k = 2 \).

Results and Discussion

1. Value of \( m_k(S^2) \) and strategy

   Members \( A_1 \) to \( A_k \) of team A fight against members \( B_1 \) to \( B_k \) of team B on \( X \). First, \( A_1 \) throws a ball. One out of members of team B closest to the falling position goes to pick up the ball. The results of several cases are listed below.

   a. The case of \( k = 1 \)

   In the case of \( k = 1 \), \( m_1(S^2) = \text{rad} S^2 = \pi \) holds. A point \( x \) which realizes \( m_1(S^2) \) is the antipodal point of \( B_1([5]) \). Here, an antipodal point of a point \( p \) on the sphere \( S^2 \) is a point \( \pi \) different from \( p \), where a straight line connecting \( p \) and the center \( O \) of the sphere intersects \( S^2 \). A member \( A_1 \) of team A plays against a member \( B_1 \) of team B on \( S^2 \) by 1 to 1. First, \( A_1 \) throws a ball. \( A_1 \) throws as far as possible from \( B_1 \). Since team B consists of only one person, \( B_1 \) is in the same condition no matter where \( B_1 \) is. Since \( m_1(S^2) = \pi \) holds, \( A_1 \) may drop the ball to the opponent's antipodal point (Figure 3).

   ![Figure 3](image)

   Figure 3. \( m_1(S^2) = \pi \)

   b. The case of \( k = 2 \)

   We should consider the value of \( m_2(S^2) \). In the case of \( k = 2 \), \( m_2(S^2) = \pi/2 \) holds. Then \( B_1 \) and \( B_2 \) are antipodal each other on the spherical surface, and \( x \) is the middle point between the two points ([5]). In Figure 4, no matter where \( A_1 \) throws the ball, the minimum distance from the members of team B is \( \pi/2 \) or less. Therefore, it is a good strategy to drop a ball on the point where the distance from \( B_1 \) and \( B_2 \) is \( \pi/2 \). For team B, one out of \( B_1 \) and \( B_2 \) closer to \( x \) goes to pick up the ball and the other goes to the opposite antipodal point and prepares for the next. If the distances from \( B_1 \)
and $B_2$ to $x$ are equal, the ball can be picked up by either.

Figure 4. $m_2(S^2) = \pi/2$

In the case of $k = 3$

We should consider the value of $m_3(S^2)$. In the case of $k = 3$, $m_3(S^2) = \pi/2$ holds. When three points are on the great circle (equator) and the sum of the distances between any two points is $2\pi$ (we call this situation "not biased"), and $x$ is at the pole position, $m_3(S^2)$ is realized (Figure 5). In particular, when two of the three points are at the antipodal position and the other one is arbitrary, and $x$ is in the middle of two points which are antipodal, and the distance from the other point to $x$ is $\pi/2$ or more, then $m_3(S^2)$ is realized (Figure 6). It is only necessary for three people to stay on the great circle without being biased. If two people are at the antipodal position, it is only necessary for the remaining one to be at an arbitrary position. In the case of Figure 5, there are three people who are not biased on the great circle. Since the minimum distance from members of team B to an arbitrary falling point is $\pi/2$ or less, it is better to drop a ball on the pole to which the distance from three people is $\pi/2$. In the case of Figure 6, since $B_1$ and $B_2$ are antipodal points, it is good to drop a ball on the point at the distance $\pi/2$ from $B_1$ and $B_2$ and $\pi/2$ or more from $B_3$. One closest to $x$ among $B_1$, $B_2$ and $B_3$ goes to pick up the ball and the others prepare for the next.

Figure 5. $m_3(S^2) = \pi/2$

Figure 6. $m_3(S^2) = \pi/2$

(2) Value of $m_k(S^2_k)$ and strategy

The results of several cases are listed below.

1. In the case of $k = 1$

   In the case of $k = 1$, $m_1(S^2_1) = \text{rad } S^2_1 = \pi/2$ holds. Then $B_1$ is in the middle of the hemisphere (we call this position the pole), and the point $x$ that realizes $m_1(S^2_2)$ is an arbitrary point on the great circle of the boundary (Figure 7).

Figure 7. $m_1(S^2_2) = \pi/2$

2. In the case of $k = 2$

   In the sphere, $B_1$ and $B_2'$ are antipodal points. Move $B_2'$ to $B_2$ symmetrically with respect to the great circle of the boundary containing $x$. Since $B_1x + B_2'x = \pi$ holds, we obtain $B_1x + B_2x = \pi$ (Figure 9). Since there are countless great circles passing through $B_1$ and $B_2'$ (Figure 10), $B_1x + B_2x = \pi$ holds at arbitrary point $x$ on the great circle of the boundary (Figure 11, Figure 12). $m_2(S^2_2) = \pi/2$ is realized in the arrangement of Figure 11 which satisfies $B_1x = B_2x = \pi/2$. Also, as shown in Figure 13, even if $B_1$ and $B_2$ are shifted up and down, $B_1x = B_2x = \pi/2$ is kept. However, if $B_1$ and $B_2$ are shifted to the left and right, the maximum value at the shortest distance will exceed $\pi/2$. From the above, in the case of $k = 2$, $m_2(S^2_2) = \pi/2$ holds. Then two points $B_1$ and $B_2$ are on a semicircle containing the pole between the two points (Figure 13). A point $x$ is on the great circle of the boundary and it is in the position where $B_1x = B_2x = \pi/2$ holds (Figure 13).

Figure 8. $m_2(S^2_2) = \pi/2$

Figure 9. antipodal points

Figure 10. great circles

Figure 11. $m_2(S^2_2) = \pi/2$
The case of k = 3

In Figure 14, B, C and D are three points on the great circle, and it is assumed that $AB_1 = DB_1 = BB_1 = AB_2 = BB_2 = CB_2 = AB_3 = CB_3 = DB_3$ holds. Here, let $A$ be the pole point that satisfies $AB = AC = AD = \pi/2$. There is a point $x$ which realizes $m_3(S^2_4)$ at any position of $A$, $B$, $C$, $D$ on the hemispherical surface. Let $E$ be the foot of the perpendicular drawn from $B_2$ to BC. Let $BB_2 = l$, then we get $B_2E = \pi/2 - l$. $BE = \pi/3$.

The cosine theorem on the spherical surface in the geodesic triangle $B_2BE$ is $\cos(B_2E) = \cos(B_2E) \cos BE + \sin(B_2E) \sin BE \cos 2B_2EB$. By applying the above numerical values to the equation, we get $\cos l = \cos(\pi/2 - l) \cos\pi/3 + \sin(\pi/2 - l) \sin\pi/3 \cos\pi/2 = 1/2 \sin l$. Furthermore, since $\sin^2 l + \cos^2 l = 1$ holds, we get $l = \sin^{-1}\sqrt{4/5}$. From the above calculation, in the case of $k = 3$ we have $m_3(S^2_4) = \sin^{-1}\sqrt{4/5}$. Here, three people of team B are arranged at equal intervals on the circumference where the distance from the pole is $\sin^{-1}\sqrt{4/5}$, and $x$ is at the pole position A, or B, C, D on the great circle of the boundary.

Figure 14. $m_3(S^2_4) = \sin^{-1}\sqrt{4/5}$

(3) Consideration on teaching materials

At the college of maritime technology, we used the spherical game as the teaching material for about 100 students in mathematics classes and personal contributors. We pass paper with spheres and hemispheres to students and instruct them to draw all the thinking processes on the paper. In a few 90-minute math lessons, we asked the students about Problem A, spherical game, and problem B in this order. We carried out problem B after several days after training of the spherical game. Problem A, spherical game, problem B have different themes, but those problems can be considered with the same strategy. In the following, the correct answer rates in the case of $k=2$ are summarized in Table 1.

Table 1. correct answer rates on $S^2$, $S^2_2$ for $k = 2$

<table>
<thead>
<tr>
<th></th>
<th>Problem A</th>
<th>Spherical game</th>
<th>Problem B</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S^2$</td>
<td>82%</td>
<td>90%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Here, on the hemispherical surface $S^2_2$, it is divided into two STEPs. The degree of achievement is expressed in two stages. In the case where $m_2(S^2_2) = \pi/2$ is obtained by drawing at least one arrangement of Figure 8 or Figure 11 or Figure 13, we call this case STEP 1. In the case where $m_2(S^2_2) = \pi/2$ is obtained by drawing two or more arrangement of Figure 8 or Figure 11 or Figure 13, we call this case STEP 2. For $S^2_2$, the numerical values in Table 1 above are those in the case of drawing at least one (STEP 1).

Problem A was an introduction to deepen the understanding of the spherical game. As a concrete problem that could be solved by the same strategy as the spherical game, we initially presented Problem A and asked the students to think about it. After that, we had students think about the spherical game which could be thought with the same strategy, and explained that we used the metric invariant as the strategy. Finally, since even the problem of another theme could be solved with the same strategy as the spherical game, we presented problem B to the students to touch the diversity of strategy of this game.

Problem B seems to be unrelated to the spherical game, but "going to rescue from nearest base" in the condition R1 means "a closer person goes", and "the whole earth is to be rescued" in the condition R2 means "to think about the maximum value at the shortest distance to the trouble point", and "considering the establishment of the bases so that the movable distance is the shortest" in the condition R3 means "to think of the minimum at the maximum value in R2". In other words, we should think about $m_4(X)$.

The defense problem of problem A is essentially similar to problem B and the spherical game.

In the 2 versus 2 battles, by moving the points little by little and comparing the fixed placement on $S^2$ and $S^2_2$, we may arrange it so that the opponent's score is the smallest.

Table 2 shows the correct answer rates in the cases of two STEPs on $S^2_2$ for $k = 2$.

Table 2. correct answer rates on $S^2_2$ for $k = 2$

<table>
<thead>
<tr>
<th></th>
<th>Problem A</th>
<th>Spherical game</th>
<th>Problem B</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEP 1</td>
<td>76%</td>
<td>82%</td>
<td>87%</td>
</tr>
<tr>
<td>STEP 2</td>
<td>29%</td>
<td>34%</td>
<td>63%</td>
</tr>
</tbody>
</table>

In the students who reached STEP 1 in Problem A, 50% of the students drew Figure 8 before others and the remaining 50% of the students drew Figure 11 or Figure 13 before others. In the students who reached STEP 1 in the spherical game and Problem B, about 70% of the students drew Figure 8 before others, then they thought by shifting the points and comparing it with Figure 11 or Figure 13, etc. In the students who have reached STEP 2, in all problems, they came up with Figure 8 before others, then drew Figure 11 or Figure 13, and
there were many cases considered as compared with the case where the points were shifted as Figure 12 or Figure 13.

Conclusions

From the above, it can be said that understanding the game strategies is related to the ability to use the characteristics of geodesics; "there are countless geodesics of length π between B_1 and B_2 when these two points are antipodal on the unit spherical surface". (we denote this property by P1)

Also, we can say that "the length of the geodesic drawn to the opposite side from the vertex of the geodesic equilateral triangle with sides of length π/2, which is a 1/8 sphere, is all π/2" is related to reaching STEP 2. (we denote this property by P2)

For both S^2 and S^2+/2, many students noticed that the placement with not biased reduced the opponent's score.

It is one of the conclusions obtained by fixing and comparing the placement.

Problem A, spherical game, and problem B have different themes. And Problem A, spherical game, and problem B are presented to the students in this order, but we carried out problem B after several days after training of the spherical game. Looking at Table 2, we see that more than 60 percent of the students answered that m_2(S^2+/2) = π/2 held by understanding the metric invariant when they considered problem B. As the result, what the students had got before was settled and the students noticed that these problems could be solved with the same strategy. In other words, we think that the way of thinking became established in the students and the rate of correct answer rose.

From the above, it can be considered that the handling of geodesic characteristics such that (P1) and (P2) was improved through this training. And by fixing and comparing the placement, they noticed that the unbiased placement was related to the better strategy.

After this training, there were a few students who found that m_k(X) is the minimum value of the radius r when covering X entirely with k disks with radius r. For S^2 and S^2+/2, the metric invariants for k = 2 are the same value, but in the case of k = 3 they are different values. When covering the sphere or the hemisphere with the same two disks, the radius of disk is π/2. When covering the sphere with the same three disks, the radius of disk is π/2. But the hemisphere can be covered with the same three disks with radius less than π/2. It can be seen that the value of m_3(X) varies by the shape of the curved surface. In the case of k = 3 we will treat it as a teaching material in the future. Next time, we are going to summarize the battles on the real projective space.

Finally, we conducted a questionnaire. There were nearly 90% of students who said that they had understood the diversity of the spherical game idea.

Acknowledgements

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References


INDUSTRIAL ENGAGEMENT IN ENGINEERING EDUCATION TO NURTURE SMART PEOPLE
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Abstract

In the end of 2017, the Office of the Government Chief Information Officer (OGCIO) of the Government of the Hong Kong SAR released a report of consultancy study on Smart City Blueprint for Hong Kong. The blueprint includes ‘Smart Mobility’, ‘Smart Living’, ‘Smart Environment’, ‘Smart people’, ‘Smart Government’ and ‘Smart Economy’. To co-creating a smarter Hong Kong, there is a necessary to sharpen and nurture students’ practical skills in an authentic “real-world” work experiences. The Hong Kong Institute of Vocational Education (IVE) Engineering Discipline of Vocational Training Council (VTC) encourages teaching and learning with the engagement of industry exposure and in a Project-based environment in order to encounter complex systems and processes in a competitive environment.

To nurture smart people fit for the future and fulfil the needs of industry, it requires collaboration and good team player skills from engineers working in industry, bringing both theory and practice together in the students’ study. A solar car team project under that philosophy is developed and more than twenty students from electrical and mechanical engineering field participated the team year by year. The project features collaborative teaching and learning where the industry stakeholders and institution supervisors work together to provide practical environment. Design thinking process is adopted to engage and motivate students to learn and develop in the project, which include ‘Empathize’, let student learn about the audience for their designing process; ‘Define’, construct a point of view that is based on user needs and insights; ‘Ideate’, brainstorm and come up with creative solutions; ‘Prototype’, build a representation of one or more of student ideas to show to others and ‘test’, return to original user group and testing their ideas for feedback.

This paper would further elaborate how the industry engagement help students in terms of developing important soft skills and their technical capability, which beneficial to their whole person development and hence co-create a smarter Hong Kong.

Keywords: Smart people, Industrial Engagement, Project-based environment, Design thinking process

Introduction

The Smart City Blueprint for Hong Kong issued by the Office of the Government Chief Information Officer (OGCIO) of the Government of the Hong Kong SAR is set to build Hong Kong into a world class Smarty city, the policy objectives are to make use of innovation and technology (I&T) to address urban challenges, enhance the effectiveness of city management and improve people’s quality of living as well as Hong Kong’s sustainability, efficiency and safety, to enhance Hong Kong’s attractiveness to global businesses and talents, and to inspire continuous city innovation and sustainable economic development. The blueprint made recommendations in six major areas, namely ‘Smart Mobility’, ‘Smart Living’, ‘Smart Environment’, ‘Smart people’, ‘Smart Government’ and ‘Smart Economy’.

Figure 1. Smart City Blueprint of Hong Kong

In particular, the goal of ‘Smart people’ is to have more students selecting Science, Technology, Engineering and Mathematics (STEM) as their education and professional careers and thus have a local supply of data scientists and other technology practitioners in need, hence having more successful entrepreneurs in their new ventures.

To co-creating a smarter Hong Kong, there is a necessary to sharpen and nurture students’ practical skills in an authentic “real-world” work experiences especially in the STEM area. The Hong Kong Institute of Vocational Education (IVE) Engineering Discipline of
Vocational Training Council (VTC) encourages teaching and learning with the engagement of industry exposure and in a Project-based environment in order to encounter complex systems and processes in a competitive environment.

The higher diploma programme in engineering discipline provides an opportunity for students to apply their professional knowledge acquired from the lecture to the real workplace, solving problems that happen in the real world and obtaining working experience before graduation via an authentic working environment with industry partners in a Project-based environment. The scheme stated is Industry-based Student Project (IBSP), which aims to equip students with technical knowledge and help them to get ready for the workplace as well as to facilitate their transition from study to work.

Engagement with Industry Stakeholders

Involvement of and collaboration with industry partners are the critical factors for the success of the IBSP scheme. Students will gain knowledge through their own research and application of findings to solving problems associated with the work in a creative manner and will be under the similar work pressure as the employees of the company, students will also be required to take certain level of responsibility for their projects. To support the students, teachers will act as facilitators and guide the students throughout the project. Borego et. al. (2013) provide a review to assist engineering educators in understanding and applying industrial and organizational psychology to engineering education.

In this connection, the facilitator and the second project assessor which nominated from the industry, will assess the students’ performance in terms of engineering and professional competence and soft skills aspects. The engineering and professional competence aspects include the comprehension of the problem; idea, concept, design and build; testing and development, realization and implementation; problem solving skills and environmental and safety awareness, meanwhile, the soft skills aspects include planning of the work; investigation and research; motivation and independent work; communication skills and leadership and team work. Students will also be required to maintain a project log of activities, which includes the project plan and details of work undertaken, including results obtained.

There are some major differences when IBSP comparing with the traditional internship scheme, first, the involvement of the teachers and industry assessors will be more and assess students in an all-round aspect, second, students are required to develop theoretical and engineering solution to specific problems in carrying out design work on system, hardware or software and third, students need to have proper documentation and presentation throughout the process.

To unleash student’s potential and build up their confidence, “Design Thinking Process” is adopted to give them inspiration. Brown (2008) and Kumar (2009) discussed design thinking as part of the innovation process. Under facilitator’s guidance and supervision, students learn how to empathize and identify the needs or problems, conduct data analysis, and find suitable solutions to address the needs in the industry. Through brainstorm and technical exchanges with facilitator and industry assessor, students are able to identify a topic in the industry based on their experiences gained in the workplace. Students are encouraged to build out a prototype of his/ her solution and test it with improved version of these prototypes, and thus the project outcomes are being demonstrated. Throughout the whole process, most of the students realized they cannot simply applying the theory to the workspace since in a real environment, there would be a lot of limitation. These experiences broaden their view in terms of problem solving, design concept and technology application, thus self-confidence was highly enhanced.

Results and Discussion

A set of survey was given to each of the collaborating industry stakeholders from 58 different companies to (a) Evaluating Student’s improvement in (i) Communication skills, (ii) Managing information, (iii) Critical thinking and problem solving and (iv) Demonstrating positive attitudes and behavior, while 1 means no improvement; 10 means great improvement.

![Figure 2. Student’s Improvement Evaluated by Employer](image)

The figure and the observation support that while IBSP is implemented, there is a positive improvement in students’ communication skills, managing information aspect, critical thinking and problem-solving performance and able to demonstrate positive attitudes and behavior. For modern engineers, his communication skills also need to expand to good listening, visual, interdisciplinary and intercultural skills as well (Riemer (2007)). Students could be benefited by exchanging ideas with peers, teachers and industry supervisors. Students could also practice knowledge and applying ideas by...
action, giving them an enhanced learning experience which a traditional lecture cannot offer.

**Advanced Industry-based Student Project (IBSP)**

The project groups will normally be formed with one or two students per group. On a need basis, facilitators can put more project groups to work together on a large-scale project. There is an innovative and sustainable project which consists of students from Electrical Engineering and Mechanical Engineering working together, aiming to design a solar powered vehicle called ‘SOPHIE’, in order to demonstrate the viability of renewable energy through using the green transportation. Students learnt about solar power technology and advanced application, high-tech automotive design and fabrication, logistic management and team cooperation via the IBSP platform. Students gained practical knowledge and hands on experience from the discussion and working with industry stakeholders.

Figure 3. Students were working on molding at car garage

Figure 4. Students designed suspension system and CNC with magnesium alloy

Figure 5. Students were learning wheel alignment

The vehicle ‘SOPHIE’ allow students to learn by doing and applying ideas, which is also the key feature of project based learning (PBL) which discussed in Bulmenfed (2000). With the supporting of industry stakeholders, seven ‘SOPHIE’s were built under the massive effort of students. Four of them participated in world class races under students’ leadership, ‘Shell Eco-Marathon Asia 2012’ with SOPHIE SEM, ‘World Solar Challenge 2013’ with SOPHIE IV, ‘World Solar Challenge 2015’ with SOPHIE V and ‘World Solar Challenge 2017’ with SOPHIE VI. In each competition, students demonstrated their talents in building solar vehicles. Students have applied the knowledge learned in classroom to design and fabricate the solar vehicle for competitions and showed their confidence and interest in building the solar vehicle.

As a kind of PBL, IBSP showed positive attitudes toward learning itself, team communication, and collaborative behaviour which were discussed in literature (i.e. Dominguez & Jaime, 2010; Kaldi, Filippatou & Govaris, 2011; Van Rooij, 2009). Furthermore, PBL was examined with respect to increasing students’ interest, self-confidence, and self-efficacy, found by Baran & Maskan (2010), which was highly related to the components of PBL such as collaborations in group work and contextual problems reflecting students’ real-world experiences.

**Conclusions**

The IBSP enriches students’ professional knowledge and develop their creativity, innovation, collaboration, communication and problem-solving skills throughout the engagement with industry stakeholders. This engagement is also important for nurture students to embrace changes and future development of technology and hence co-create a smarter Hong Kong.

To nurture more young talent as ‘Smart people’, facilitator’s guidance and team collaboration play important roles, resources and structured planning are also required for implementation.
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THE COLLABORATIVE INTERACTIONS BETWEEN NIT, KURE, JAPAN AND RADFORD COLLEGE, AUSTRALIA

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Abstract

This paper aims to provide the report on how effective the collaborative interactions between National Institute of Technology, Kure College, NIT, Kure, and Radford College in Australia in order to achieve the tandem education where both sides aim to develop their different target languages, English for the students in NIT, Kure and Japanese for those in Radford College. The collaborative sister-relationship between our schools has been conducted for 7 years. We send our students each year on the homestay programs with the purpose of the international exchange between our schools.

We also have Skype-used classes where both sets of the students exchange their cross-cultural information with each other both in English and Japanese. Within our collaboration we set about our next adventure, doing Skype with the students from the English classes at NIT, Kure and Radford College. This was difficult as timetable structures were different and there was always competing demands of classes and courses. However between the determination of us the teachers in charge of these classes, we successfully managed to have about 40 mins a fortnight in class time. What this provided to our students are as follows.

1. An opportunity within the learning environment for something new and exciting to look forward too.
2. An opportunity to actually use our different languages in a real face to face situation.
3. This Sharing of different cultural aspects of young people’s lives.
4. An opportunity to build relationships between students through language and culture, so soon the students would be on Skype and recognise the students on the other end of the Skype, which made for more and more opportunities for students to feel more relaxed in using their language for communication.

This program will give you some unique educational insights from different cultural perspectives. Our goal and desire in the future is to have cross collaboration, Skype sessions, exchanges both short and long term. We know that this continues to help students to cross cultural barriers, think globally and build understanding. I believe in the future this will help to build peaceful relationships across differences and divides.

Keywords: sister-relationship, Japan, Australia, homestay program, tandem education, cross-cultural understanding, cultural differences

1. What are the Purposes of this Paper?

This paper is focusing on how effective the collaborative interactions between NIT, Kure, and Radford College in Australia, under the collaborative sister-relationship. We made the official contract on March 25, 2015. Since then, we’ve been sharing the common goals to achieve: the tandem education where both sides aim to develop their different target languages, English for the students in NIT, Kure and Japanese for those in Radford College; the enhancement of cross-cultural understanding among both sets of the students; and the increase of the students’ motivation toward learning.

How we have been conducting the interaction between our colleges effectively and collaboratively is presented from our different cultural points of view, which can give the future perspectives to our educational field in the different cultural context.

2. How We Started the Sister-Relationship

Why do students choose to study what they do? What motivates that choice of study? Most likely it is a combination of:

What they might be good at
What they think might get them a job in the future
Their parents advised them that this would be a good career choice.
Best of a bad choice.

However, at the time of the choice this probably doesn’t matter as there is still a long way to go before
the actual beginning of their working life. What matters, which perhaps they are also equally unaware of is that in the global world we live in we all need to be able to speak languages other than the native language we speak. The more languages we speak the more doors will open up to our students.

Which brings me to, how are we teaching and what are we actually teaching to motivate and help our students be successful in a world where collaboration and communication between multinational countries will play a part in the work you are preparing them to do. So while it lasted important to teach the skills it is equally important to teach them about being a global citizen on a global stage.

This is where having a sister school where we can exchange our different languages has been an interesting journey, bringing about new learning opportunities for students in Australia and our sister students in Japan. It started with a friendship between myself and a member of staff at NIT, Kure. This then developed into a Memorandum of understanding to allow our two Colleges to enter into exchange opportunities. This included: both schools coming to each school on a two yearly basis on a study tour. This is where it started.

3. The Bridge over Cultural Gaps

There is so much more to explore than just a two yearly exchange, which in itself is an amazing opportunity for students to bridge cultural gaps. We will pause here to explain some of these gaps which has shown the huge cultural diversity from Australia to our neighbouring Japanese students. So picture it: You are a 16 year old Japanese student sitting in class eager to hear about life in Australia from the same age student.

What are they going to hear?
1. In Australia, we don't clean our classrooms at the end of the day.
2. In Australia, we eat our lunch outside in rain hail and shine.
3. In Australia, students can do more than one club activity after school. At public schools they just go home at 3:30.
4. In Australia, the students walk around the school to their different classes.
5. Size of classes are 26-28 students.
6. Most students are driven to school by their parents, we don't come by trains at our school as in the capital city in Australia there are no trains. Some students come by bus and bicycle.
7. On the weekend the school is shut, there are no students at the school or teachers.
8. We all get 12 weeks of holidays a year and there is no lengthy summer homework.
9. Studying a language is by choice.
10. There is a large amount of integration in the classroom between teachers and students with students asking and posing questions and solutions to the curriculum.

How do you react to this as a student in a Japanese school without thinking that life for you is unfair or way too difficult. Well it is a real opportunity in English classes to think and look at different aspects of culture that make up a nation. There is no right or wrong but just different and this builds understanding and global perspectives in your students.

4. Collaboration through Skype Communication

Within our collaboration we set about our next adventure, doing Skype with the students from the English classes at NIT, Kure and Radford College. This was difficult as timetable structures were different and there was always competing demands of classes and courses. However, between the determinations of us, we managed to have about 40 mins: 20 mins for English time and 20 mins for Japanese time, a fortnight in class time. It is so-called a reciprocal “Tandem education” which can provide both of us the merits of learning the target languages, Japanese and English. What did this provide to our students?
1. An opportunity within the learning environment for something new and exciting to look forward too.
2. An opportunity to actually use our different languages in a real face to face situation.
3. This Sharing of different cultural aspects of young people's lives.
4. An opportunity to build relationships between students through language and culture, so soon the students would be on Skype and recognise the students on the other end of the Skype, which made for more and more opportunities for students to feel more relaxed in using their language for communication.

Thanks to one or two hour difference between our schools, we could arrange our class schedules and conduct the Skype sessions 10 times in 2017. Since we exchange our students regularly with each other, the students can have a reunion or re-reunion through the Skype sessions and the study tour program. They can make friends even before they go on a study tour, which is a remarkable element to point out. NIT, Kure students are shown a list of the topic for the semester in April 2017 so that they can prepare for the topic, using the Internet or books. Some students are well-prepared for the class with the PPT or pictures to show. This is the list of the topics for the Skype sessions in 2017.
An example of these lasting friendships is a young boy Thomas who is now studying Architecture and Japanese at RMIT University in Melbourne. The family which hosted Thomas for his 6 weeks exchange when he came to NIT, Kure had three boys who all studied at NIT, Kure. Thomas is now their fourth boy, and his host mother and grandmother talk to him and Skype with him when he is studying for his Japanese exams at a Melbourne University. Reciprocally, Radford hosted Koki their son for one month and he got the opportunity to stay with Thomas's family and become their second son. These are relationships that have bridged cultural differences and will last a lifetime.

In March, 2015, 10 students and one chaperone had a 11 day homestay program in Radford. They had a schedule Radford College prepared, and there they enjoyed being a part of the family and learning cultural differences very much.

Between Mar 2016 and Dec 2017, one Radford student, Michel came to NIT, Kure. He had a homestay with a NIT, Kure student for 6 months and then decided to live in a boarding school. This is his own choice to experience different life styles. He joined a brass band club and played oboe in some concerts in public. He also volunteered to be an assistant in public lectures for the Kure citizen twice, which I organized. He gave a presentation about cultures, nature, and history in Australia, Canberra, and educational systems at Radford College. It was quite a unique opportunity to teach his native language, English as an assistant to the local people in Kure. He was very popular among the attendees and enjoyed himself teaching English and different cultures.

Our fourth tier to our program came when Dianne decided to organise students from NIT, Kure to our ALT in the Japanese department at Radford. We had our first one last year and it was a great success. Toi Murai, who was studying electrical engineering came and stayed with home stay families for his time at Radford with families who had either a son or daughter who was attending the school.

Then with some local funding another opportunity came into play. Last year NIT, Kure provided this opportunity for our IT teacher who leads our school’s Robotics Club to go over to Japan with two top students to compete with the NIT, Kure team in the Tsuyama Robotics Competition. The team had to develop and to compete with the hockey playing robot. They spent two days collaborating and working with the NIT, Kure team and two days at the competition. While we didn't win the competition, we did take out the design award. We are hoping to make this a yearly collaborative event. As a result of this collaboration and the courses which NIT, Kure teach we are welcoming this year an IT Assistant teacher to work within the IT department and help in the Computing Club. This is a young girl who is taking time off her study in NIT, Kure to come and experience education in Australia. We are also hoping she may be able to attend some of our design classes as part of her knowledge gathering. Hopefully we will win another design award in 2019. This was an opportunity

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<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>May 8</td>
<td>11:30~12:00 Self-introduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major, Hobbies, Hometown</td>
</tr>
<tr>
<td>2</td>
<td>Jun. 5</td>
<td>11:30~12:00 Food Culture</td>
</tr>
<tr>
<td>3</td>
<td>Jun. 19</td>
<td>11:30~12:00 Sports</td>
</tr>
<tr>
<td>4</td>
<td>Jul. 17</td>
<td>11:30~12:00 Campus Life</td>
</tr>
<tr>
<td>5</td>
<td>Jul. 31</td>
<td>11:30~12:00 Sightseeing Spots</td>
</tr>
<tr>
<td>6</td>
<td>Oct. 16</td>
<td>11:30~12:00 ‘The students’ questionnaires</td>
</tr>
<tr>
<td>7</td>
<td>Oct. 23</td>
<td>10:30~11:00 ‘The students’ questionnaires</td>
</tr>
<tr>
<td>8</td>
<td>Nov. 6</td>
<td>10:30~11:00 ‘The students’ questionnaires</td>
</tr>
<tr>
<td>9</td>
<td>Nov. 13</td>
<td>11:30~12:00 ‘The students’ questionnaires</td>
</tr>
<tr>
<td>10</td>
<td>Nov. 20</td>
<td>10:30~11:00 ‘The students’ questionnaires</td>
</tr>
</tbody>
</table>

According to the questionnaires done in NIT, Kure, the students felt the world is small because they can talk to the students in other country and see face to face in their study tour again. NIT, Kure students were amazed at the competency of Japanese of the Radford students. It can be a great incentive for NIT, Kure students to keep on mastering English. Finding difficulties in understanding the language and cultural differences can bring both sets of the students great motivation even though they felt confused and embarrassed at first. Having a companion in study encourages the students to get over the difficulties.

In fact, having a study friend beyond the monitor brings the students unique and positive effect on the course of studying a foreign language and culture.

5. Building our Sister-Relationship

We had to build closer ties. As sister school’s we then sought to do more long term exchanges with students from each of the learning institutions. I decided to start to send some of my senior students on exchange on the long summer break in Australia as in Japan. They were continuing to have school throughout this period. Upon return after 6 weeks of school and homestay their language was vastly improved and they had built deep friendship bonds with homestay families and students at NIT, Kure. This then led to opportunities for my students to go for longer period of time. This has happened to two students who chose to go for one year in between finishing Year 12 our last year of High school. For many students in Australia this would replace a gap year which many take in between Year12 and their first year of university. This provided a longer time for these two students to study in NIT, Kure, learn the language, mix with the students, help in the English classes and form lasting friendships with the homestay families and friends at school.
to share tandem education in robotics and share design ideas across two very different schools.

In 2016, I hosted the principal of Radford, Ms. Fiona Godfrey as a host family for a week. We developed our bond even privately through some activities, such as taking hot spring baths together, showing her some viewpoints in Kure, and serving her traditional Japanese food. In return, Fiona took Uesugi and her husband out to a traditional Japanese restaurant. This event surely contributed to making our sister-relationship stronger and steady.

From April 16 to 23 in 2018, NIT, Kure accepted 9 students and 2 teachers from Radford College. The preparation to accept them started in March in 2018. The preparation is as follows: the recruit for the host families among the students; making the schedule including cross-cultural and exchange events such as watching a baseball game; visiting museums; visiting Peace Memorial Park in Hiroshima; and visiting a local junior high school nearby. The schedule was well-prepared in the hope of involving not only the students in NIT, Kure but also the local people and students nearby so that both sets of the students and people can get benefit of getting to know different cultures and broadening their own perspectives.

6. Future Perspectives

Where do we go from here? Dianne recently took her school’s Media Studies and Design teacher to NIT, Kure. We hope that we can do something in the future that may involve some kind of collaboration in a design or project that will benefit the students learning and project building skills. As they venture forth in the world it will be a good learning experience to work with people from all different cultures and backgrounds and how they manage the design process.

Our goal and desire in the future is teacher exchange to allow for professional development for teachers from both schools. We will continue to explore every opportunity in the future to have cross collaboration, Skype sessions, exchanges both short and long term. We know that this continues to help students to cross cultural barriers, think globally and build understanding. We believe in the future this will help to build peaceful relationships across differences and divides.

References


CULTURE AS A TOOL FOR INTERNATIONALIZATION: HANDS-ON INTERNATIONAL WORKSHOP

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Abstract

The internationalization of the working market makes essential to train students to work with people from a different cultural background. The Japanese government has altered the education curriculum and included English language courses in the elementary school to answer to this problem. Unfortunately learning English is not enough. Lately, although Japanese students have raised their scores in languages tests and improved their English skills, they still show difficulty to express their ideas in a multicultural workshop or group discussion. In a global context, cultural identity and self-confidence are more important than foreign language skills.

The first international workshop realized at Akashi college was in 2014 when the architecture department received 16 students from Australia for one week. Now, only four years later the number of events involving short-term international students increased exponentially. At Akashi College, we believe that those events help the students to develop a global perspective. The students do not only become bilingual, but they became bi-cultural too. The short-term international workshops help the students to practice their English skills and their capacity of understanding different cultural points of view.

In this paper is described Akashi college experience with international exchange activities on campus and explain how the use of hands-on activities and Japanese traditional culture related themes helped to instigate communication between the students. At first, we describe the different workshops and events held at Akashi college, how those events were held and organized. Later using data from students' surveys of the workshops we will discuss and evaluate the educational impact of those activities on the students. Finally this paper will show that hands-on events, where the students have to build something together instigate more interaction between the students, and that the use of a theme typical of Japanese traditional culture for the workshops is not only attractive to international students but also provides self-confidence to Japanese students, improving their participation in the workshop.

Keywords: Akashi college, international students workshop, Japanese traditional culture, students' surveys, communication

Introduction

The Global Education Center of NITA has promoted several international workshops and cultural exchanges since it was established in 2016. The Department of Architecture has always been very active and organized several of the international workshops. This paper describes the activities and analyzes the impact of international activities in our students. At first, It will explain the long-term international activities. Here we considered as long-term workshops or programs that were longer than one day. Furthermore, we will describe the short-term workshop and based on surveys results evaluate its educational value.

Long-term International Exchange Programs

The first long-term international workshop was in 2015, with students from Australia, Griffith University. Later, in January 2016, in partnership with a university from Brazil (UFRGS), the NITA Architecture Department started to host a three weeks' program. Also, was realized in 2016 the first Summer Program, promoted by the GEC but organized and executed by Akashi students.

Griffith University students workshop 2015

The Architecture Department first international exchange program was in 2015. We were asked to host for one week 16 students from Australia. Our objective was to have the Australian students interacting with as many Akashi College students as possible. There was no time available for extra curriculum activities and the workshops needed to fit in the Akashi College Architecture Department March-August semester classes schedule. We organized the activities according to the academic years. Akashi's 5th and 4th-year students were involved in activities that required more talking, such as field trips and the tea room design workshop, while the 1st, 2nd, and 3rd-year students participate in simpler workshops, where the students had to craft something together to create situations to stimulate them to communicate. Tea architecture, because it is a topic
peculiar to Traditional Japanese architecture and the small scale of the tearoom was perfect for such a short time design workshop. Through the one-week international exchange activities with the Australian students we learned that:

1. It is possible to include international exchange and workshops into the courses scheduled.
2. The tearoom is an excellent theme for international exchange workshops.
3. Workshops with lower academic years require preparation and teacher assistance.
4. Field trips, especially when on foot should be organized with time to spare.
5. It is necessary to stimulate interaction and communication without forcing it.
6. Not all students may be positively involved when the workshop was included in the required courses.
7. Too busy schedules may turn international exchange into a negative experience.

This first experience was essential because it proved that it was possible to fit international workshops on the regular course's schedule. Having no time for international workshops have always been a problem because the National Institute of technology colleges have a hebysitic course schedule. The colleges have classes from 9 to 4, and during the vacation periods, the students have sports activities. Therefore, it is challenging to organize any extra curriculum activity.

**UFRGS Japanese Traditional and Contemporary Architectural Course**

The first edition of this course was in January 2015 and had a two-week duration. From the second edition, we extended the course to 3 weeks. In January 2019, we will hold the 5th edition of the course. This course is an elective subject in UFRGS Faculty of Architecture curriculum, and each of the UFRGS students received six credits for participating in the course. The average number of participants' students from Brazil is 6. From the second edition of the course, the students stayed on campus dorm facilities. The course included the activities with Brazilian students in the Akashi College Architecture Department October-March term courses schedule. The course included lectures on Traditional Japanese Architecture, several field trips and workshops with different academic years. Here again, our goal was to maximize the interaction between students. The level of interaction of the activities was according to Akashi students' academic level. 1st, 2nd, 3rd, 4th-year students participate on field trips and simpler workshops while the 5th and Advanced Course students worked together on assignments and developed design projects with the students from UFRGS. The tearoom design workshop was the main event of the course and was included in the Architecture Planning III course, a 5th-year elective course. Since the course is elective, all students were eager to participate in the workshop.

The course has shown that experiencing international exchange activities has improved the students' communication skills. During the tea room design workshop, all groups were able to work on a concept for the design of a tea room and to finish their designs with a minimum interference from the teachers. The final presentation of the Tea Room Design Workshop was in the school auditorium room, and all the students in the Architectural department watched it.

As part of the course and to extend the experience to other departments every year we organize a weekend a trip to Nara. All students from Akashi College can participate, but usually, most of the students are from the Department of Architecture.

According to the results of the course evaluation survey, most of the students enjoyed the workshop and affirmed that Tearoom as a theme was very interesting because it is a small space and unique to Japanese Culture, appropriate to such a short time design workshop. Brazilian students said the workshop not only gave them the opportunity to learn about Japanese culture but also to learn different ways of developing architectural projects. Akashi students said that since this was not their first experience working with international students, they could better communicate and enjoy the activity. Some students pointed out that communication was not about the ability to speak English, and by using drawings and body language they were perfectly able to communicate and transmit their ideas. The fact that the Brazilian students stayed on campus allowed the students to interact more.

From the Japanese Traditional Architecture course, we concluded that:

1. International exchange experience is a cumulative process, and gradually exposing the students is more important than training their English language skills.
2. Lodging international students inside the college campus increase interaction between students.
3. The necessity to extend international activities to other departments in the college.
4. Communication is more comfortable when both students are not English native speakers.

**Japanese Culture Summer Program**

Studies that compare the Japanese language structure with Japanese space structure (A. Berque, 1982) explained that in the Japanese language the subject is defined by the environment. Differently from English or Latin languages, which the subject is absolute, “I” is always “I,” independent of the situation, in Japanese “I” changes according to the situation. For example, a teacher will refer to himself as “sensei” (teacher) while speaking with his students, and if he is at home, he will be “otosan” (father) to his children if he goes shopping he is “okyakusan” (client), etc. In the Japanese language, the subject changes according to the social environment he is involved. These studies help to understand why Japanese students have difficulty to communicate with people from different cultures when they do not understand the environment they are in more difficult to define the subject or “I.” Consequently, in a multicultural context, cultural identity and self-confidence are more important than foreign language skills. The students need to learn how to be bicultural and not only bilingual. Using the principle that the best way to understand something new is by comparing with something we already
understand, working with themes related to Japanese culture, bring the students aware of their native culture and facilitate Japanese students to communicate and understand different cultural contexts. The results from the Tearoom workshops confirmed that Japanese students performed better in international activities when the theme was related to Japanese culture. Therefore, we decided to extend the experience for students other than the architecture department. We used Japanese Culture in general as the theme for a summer course, open to students from all different majors. This program developed activities involving Japanese culture where Akashi College students acted as tutors. The students organized the course under the supervision of the faculty in charge, and the college international plaza capacity limited the number of international students’ participants. It was a five days’ course, from Monday to Friday. The activities started with Japanese lessons, and Akashi students taught international students how to write in the Japanese alphabet (hiragana and katakana) and some basic expressions in Japanese. During lunch time the students cooked traditional Japanese food, such as Takoyaki, Somen or Okonomiyaki. The course included several activities such as Origami workshop, Ayatori play, Calligraphy (Shodo), Hana Fuda Game and visits to Himeji Castle. The participants were students from Hong Kong IVE, Philippines Della Salle University and UFRGS Bazil. The students’ course evaluation survey showed that all students that participated in the course were delighted and that the program overturned their expectations. All the students said they would like to join again. The international students also highly appreciated the program, said it was well organized and more interesting than expected. Was observed by the advisor faculty that the students went out together after the activities, and the interaction between students expanded beyond the program schedule.

**Figure 1: Summer Program Calligraphy lesson**

The Summer Program showed that:

1. It is possible to have international activities organized by the students and with no financial cost to the hosting institution.
2. Japanese Culture can be used to stimulate communication between Japanese and International students.
3. To avoid field trips during summer.

**Short-term workshops**

There were several short-term workshops and here we will focus on the bigger ones, realized with students from IVE Hong Kong.

The first workshop was in 2016 when 40 students from IVE Tsing Yi Department of Architecture visited Akashi college and Himeji Castle. Here again, the most challenging point when organizing the workshop was to combine Akashi courses schedules with IVE trip schedule. The second problem was to find a room big enough for a workshop of 80 students. Based on our positive experience with the tea room as workshop theme, we used the Okoshie or paper model of a tea room. The exchange activity was composed of a lecture in English about Japanese Architecture, building a paper model of a tearoom in the morning and the afternoon a visit to Himeji castle. In the morning IVE students interacted with Akashi 1st years students. The workshop was in May, so the 1st year students were fresh, they had been studying in Akashi for about a month only. Also, in the afternoon IVE students visited Himeji castle together with the 4th years’ students.

The students answered a survey and evaluated their experience in the workshop.

**Table 1: 2016 Akashi 1st year and IVE workshop survey**

<table>
<thead>
<tr>
<th></th>
<th>Akashi</th>
<th>IVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop in general</td>
<td>easy</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>16%</td>
<td>56%</td>
</tr>
<tr>
<td></td>
<td>OK</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>difficult</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>very interesting</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>interesting</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>boring</td>
<td>11%</td>
</tr>
<tr>
<td>Workshop Schedule</td>
<td>too long</td>
<td>just fine</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>86%</td>
</tr>
<tr>
<td></td>
<td>OK</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>difficult</td>
<td>5%</td>
</tr>
<tr>
<td>Communication between the students</td>
<td>easy</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>difficult</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>78%</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Even though Akashi students were at 1st year, and were experiencing international workshop, and model making for the first time, the workshop went well. Most of the students from both institutions evaluated the workshop as very interesting, the workshop schedule as fine and did feel difficulty in communicating with each other (table 1).

However, the visit to Himeji castle did not work as well as the morning workshop. The students were divided into groups to instigate communication, they left the parking lot in groups but when they arrived at the castle the groups dissolved and the IVE students gather by themselves. Akashi students complained that IVE students would not talk to them. Interesting here is that the former international exchange experience of Akashi 4th year students seems to have backfired. They had been, when they were younger, to several field trips with students from Brazil. Apparently, they got used to have a passive attitude and wait for the international students to communicate with them. Students from Brazil are never shy and very talkative, but most students from other
countries, especially from Asian countries tend to be as shy as the Japanese. Also, it was a mistake to change the interacting group, because both institutions students are shy and need time to get along.

The second short-term workshop was in 2017 with IVE Tue Mun Department of Architecture students. In these case IVE students interacted with 5th-year students and the schedule allowed to organized a full day workshop. The theme of the workshop was modern architecture, and the students worked in groups, half of the members from IVE the other half from Akashi. In the morning, there was a lecture about Hong Kong modern architecture and modern Japanese architecture. Later in groups, the students were assigned icon buildings to investigate. Each group built models and panels explaining the building they were assigned. The workshop finished with a final presentation of the buildings. In general, the workshop went well, most groups were able to finish their assignment on time, and the students enjoyed working together.

Figure 2: Modern Architecture Workshop

The last workshop was held last May with IVE Tsing Yi Architecture students. Here again, we used the tea room paper model. The IVE students interact with Akashi 4th year students. In the morning, the students had a lecture about Hong Kong public housing project and Traditional Japanese Architecture. After the lecture, they worked on groups at the tea room paper model. Later they went on groups to lunch and explored Akashi’s fish market. The activity finished with a visit to Takenaka carpenter’s museum in Sannomiya.

Table 2: 2018 Akashi 4th year and IVE workshop survey

<table>
<thead>
<tr>
<th></th>
<th>Akashi</th>
<th>IVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often have you participate in international workshops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st time</td>
<td>47%</td>
<td>90%</td>
</tr>
<tr>
<td>2 times</td>
<td>26%</td>
<td>5%</td>
</tr>
<tr>
<td>3 times</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>4times</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>more than 4 times</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Hong Kong Housing Lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>interesting</td>
<td>29%</td>
<td>32%</td>
</tr>
<tr>
<td>Ok</td>
<td>21%</td>
<td>32%</td>
</tr>
<tr>
<td>interesting but difficult</td>
<td>48%</td>
<td>5%</td>
</tr>
<tr>
<td>Not interesting</td>
<td>0%</td>
<td>32%</td>
</tr>
<tr>
<td>Japanese Architecture Lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>interesting</td>
<td>45%</td>
<td>47%</td>
</tr>
<tr>
<td>Ok</td>
<td>39%</td>
<td>24%</td>
</tr>
<tr>
<td>interesting but difficult</td>
<td>29%</td>
<td>16%</td>
</tr>
<tr>
<td>Not interesting</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Paper Model Workshop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fun and easy</td>
<td>47%</td>
<td>53%</td>
</tr>
<tr>
<td>OK</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>fun but difficult</td>
<td>45%</td>
<td>21%</td>
</tr>
<tr>
<td>very interesting</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>interesting</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>boring</td>
<td>8%</td>
<td>26%</td>
</tr>
<tr>
<td>Building paper model help communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>61%</td>
<td>74%</td>
</tr>
<tr>
<td>maybe</td>
<td>24%</td>
<td>5%</td>
</tr>
<tr>
<td>no</td>
<td>16%</td>
<td>21%</td>
</tr>
<tr>
<td>Would you like to participate again</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>61%</td>
<td>74%</td>
</tr>
<tr>
<td>maybe</td>
<td>40%</td>
<td>21%</td>
</tr>
<tr>
<td>No</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>How many stars to the Workshop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>29%</td>
<td>32%</td>
</tr>
<tr>
<td>4</td>
<td>47%</td>
<td>42%</td>
</tr>
<tr>
<td>3</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>2</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>1</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>0</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Some groups got along well and went to visit Sannomiya and Harbor Land area together. The students’ surveys results (table 2) show that most of the students think that working together on the paper model activity helped to improve communication between the students.

Figure 3: 2018 Tearoom paper model workshop

Figure 4: Visit Takenaka Carpenters Museum
Finally, to evaluate the impact of the short-term workshop was realized a second survey with the first group of Akashi students. At the time of the workshop they were 1st-year students and now they are 3rd-year students (table 3). The survey asked if the students remember the 1st-year workshop and if they felt influenced by it. It also inquired if the students have participated in international exchange activities such as workshops, field trips, or abroad study trips.

Table 3: 2016 Akashi 1st year 2 years later survey

<table>
<thead>
<tr>
<th>Participation in International Workshop</th>
<th>0</th>
<th>42%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>more than 4 times</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Would you like to participate again</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Maybe</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>Went to study abroad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Participated in field trips with international students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>42%</td>
<td></td>
</tr>
<tr>
<td>Nara</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>Naoshima</td>
<td>48%</td>
<td></td>
</tr>
<tr>
<td>SA Tours</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Do you remember the 1st year workshop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Do you think the 1st year international workshop influenced you?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>47%</td>
<td></td>
</tr>
</tbody>
</table>

According to the survey results, 53% of the students think that having participated in an international workshop when they were 1st-year head a significant impact in their academic life. This group of students’ participation in international workshops and field trips with international students is high. Also, 36% of the students went on a short study program abroad!

Conclusions

In this study, we have shown that international workshops have a positive impact on the students. We have demonstrated that we can include a long-term or short-term workshop in the regular course schedule. The results also confirmed that exposing the students to international exchange is more effective than merely teaching them English. International workshops help the students to understand that communication is not only verbal and that are manners of overcoming language barriers. Moreover, workshop themes related to Japanese culture are attractive to international students and to give confidence to Japanese students. Also, students that have to participate in international workshops at an early academic stage showed to become more active and to go to study abroad.

References


Abstract

This paper reports on teacher training at the University of US and dispatching international students to Universities of Thai. Teacher training at the University of Arizona has been implemented in 2017 with the objective of improving the instruction skills for teachers to lecture the engineering fields in English. In practical training, introduction of digital books and necessity of academic vocabulary, use of non-linguistic expressions, teaching material improvement and development etc. have been lectured. Furthermore, I have visited King Mongkut's Institute of Technology Ladkrabang (Thailand) in 2017 with exchange students of Kushiro college. Then, I was able to receive some impression University of Southeast Asia. In this paper, activities of teacher training and international exchange between Kushiro college and these Universities institution are introduced.

Keywords: Teacher and Student Exchange, Teacher Training, Material Development

1. Introduction

This paper reports deals with teacher training at the University of US and dispatching international students to Universities of Thai. Teacher training at the University of Arizona implemented in 2017 with the objective of improving the instruction skills for teachers to lecture the engineering fields in English. As an advance training, the second language acquisition theory and evaluation method etc. were introduced using site (online learning) of the University of Arizona. Also, impressions and remark in observing the online learning were considered and a report was written to post. Practice training contents have lectured on introduction of digital books and necessity of academic vocabulary and use of non-linguistic expressions are developed as teaching material improvement and development. In addition, classroom observation and formats of observation reports were treated, and teaching demonstration were conducted based on the lesson planning sheet. Lectures using papers and boards were also included, but there were many groups discussion style in classroom. Furthermore, the instructors had attitudes of "Help" and "Support" to the students.

Secondary, I have visited King Mongkut's Institute of Technology Ladkrabang in Thailand in 2017 with exchange students of Kushiro college. The training items were orientation, research work, city tourism, contents mainly based on academic and cultural exchanges. In the campus, professors responded to classes and research, and the staff responded to the private matters of the students, that is, a clear division on works was found. As a result, students were able to receive prompt and smooth response to consultation on the college life. In addition, it was found that teachers are in an environment where they can devote themselves to preparation of classes, development of teaching material and self-reflection, etc. The educational culture experienced in the two countries is different in detail from Japan, but it turned out that it is common to conscious of the support to student in each educational institution.

2. Teacher training in University of US

In this section, contents of teacher training in the University of Arizona are described. Participants were teachers other than the English teacher of the Hachinohe college and colleges in Hokkaido.

2.1 Online course program

Participants have taken the following online learning before field training. Assignments are imposed in each item and the trainee has to submit assignments to a site due dates. In that case, the trainee can argue with instructor variously about assignments. Therefore, it is possible to deepen an understanding for assignments.

2.1.1 Observation

Trainees may choose to observe classes as online class MOOCs (Massive Open Online Course). MOOCs are online classes in a wide of field and often free. Trainee can also choose to suggest students to enrol in course related to major class. Also, participants write the responses to observation form and submit the form as assignment. Observation form has the contents about development of learning objective, instructional material, educational climate, preparation for class, instructional
methods and difficulties, etc. Furthermore, the argument was deepened with instructor about the report.

2.1.2 EMI
Trainees obtained opportunity to learn the history, theory and practice of English Medium Instruction (EMI) in online course program. Participants evaluated their own and other EMI setting, and created EMI manual for major classes. Therefore, the trainee set up a student's number, a special field of study, degree, country, level, school name and age in order to create summary form.

2.1.3 Assessment
The method and importance which are related with evaluation of a major subject were shown by this module. This course gave primarily about developing effective class assessment policies and practice. Trainees learn how to use and create the rubric for assessment in major classes. Rubric is a set of criteria for student's work that includes description of the level of performance. When evaluating a student, especially five principles (validity, reliability, practicality, washback, authenticity) in evaluation are effective, and fundamental.

2.1.4 SLA
Trainee learned about general concepts in the field of Second Language Acquisition (SLA) through the online course. Theoretical approaches and general principles of SLA are suggested in this module. How to learn language more easily, and kinds of practice helpful in language learning were introduced in this module. Also, it was very interesting that SLA can be studied from many perspectives as linguistic, psychological (or cognitive), social (interactional), neurological.

2.2 Face to Face course program
Participants have taken the following Face to Face training in University of Arizona for two weeks. Lectures using papers and boards were also included, but there were many groups discussion style in classroom. As for practical training, three contents of modifying and developing materials, reflection and practicum were mainly carried out in the seminar room of University of Arizona.

2.2.1 Modifying and Developing Materials
In this module, trainees learn how to identify variety of techniques for lesson planning, modifying and developing materials. Also, sourcing materials in English is introduced here. For example, internet searching, university libraries system and e-books are shown.
Difference between digital native and digital immigrants is indicated by using related paper, too.

2.2.2 Reflection
Teacher reflection gives trainees to evaluate their teaching. For example, self-assessment of instructional, self-study, audio-video recording and writing of teaching philosophy statement are useful reflection. And, differences in teaching behaviour between native and non-native teachers of English, and then specifies the causes of those differences.

2.2.3 Practicum
This module has instruction and demonstrations of teaching methods, approaches and strategy with respect to EMI (English Medium Instruction). Trainees give teaching demonstrations to colleague and observe each other’s demonstration, and receive feedback from each other as well as from instructors. Outcomes of this course are that trainees can recognize and evaluate a variety of teaching methods and approaches relevant to EMI and select from those methods to effectively design lessons and class activities.

Moreover, the director and instructor of University of Arizona visited the Hachinohe college in 2018, and follow-up seminar was implemented for two days. As for the contents of training, review of EMI and demonstrations of teaching were developed. The content of the practical training was remembered and the motivation for introducing English skills into the class was improved, and it was a meaningful training for participants.

3. Student exchange with University of Thai

I visited King Mongkut's Institute of Technology Ladkrabang(Thai) in 2017 with short-term exchange students of Kushiro college. The regular course students participated for one week, and the advanced course students participated for one month in the exchange program. The training contents were orientation, research work and cultural exchange from a research work to sightseeing. At that time, we received helps from the division of international affairs very much. All the processes of resulting in the inside of a training term,
dormitory procedure, a campus tour, the assignment procedure to a laboratory, and sightseeing were corresponded from staff of the division of international affairs. Also, about assignment in a laboratory, departments to which the students belong and field of investigation were investigated in advance. Therefore, it can be supposed that exchange students were able to experience useful research work.

Professors corresponded about a research work, the staff were treating about clerical matters of students, and clear "division-of-work organization" was able to see. As a result, the student could receive quick and smooth correspondence to the consultation about a various procedure and life items. Also, it is conjectured that professors have the environment that they can concentrate on preparation of the lesson, teaching materials development and self-reflection, etc.

All students were kindly, and when I asked the root, the students took me to the destination. The students of Thai have hard work, and it was seen that students can have environment for striving the study of the major field. Also, it was guessed that the student can develop a sensibility through learning activities.

Fig.9 Campus tour at King Mongkut's Institute of Technology

Fig.10 Laboratory(Electric engineering) of King Mongkut's Institute of Technology

Fig.11 Sightseeing to Wat Arun

Fig.12 Sightseeing in Bangkok city

Summary

This paper described about the exchange program of a teacher and a student. The teacher training and the lecture contents in University of Arizona were described. Also, the director and instructor of University of Arizona visited the Hachinohe college, and follow-up seminar carried out. Moreover, impression and comment at the time of visiting with exchange student to King Mongkut's Institute of Technology were expressed. Precious informations about the work contents of the international affairs division ans how to treat international student were acquired through the visit to each Universities. Moreover, the motive was acquired very much also about implementation of the class which uses English and the practical use of English.

I would like to utilize these experiences for activities of international exchange. Impressively, any Universities had the help and support to a student about various problems of study work and the college life in common.

Acknowledgements

I would like to appreciate to University of Arizona and King Mongkut's Institute of Technology Ladkrabang which gave the precious opportunity for exchange program, teacher training and inspection. Similarly, I would like to express gratitude here to directors, coordinators, instructors and the staff of the international affairs division of the exchange program of Universities.
FRANCE – JAPAN EXCHANGE PROGRAM FOR GLOBAL TECHNOLOGY EDUCATION

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Abstract

To foster the urban revolution in the frame of smart-cities, smart education models should be ideally defined across global institutions, industry and community partners. In particular, teacher and student international exchanges for technology through multiple institutions collaboration are beneficial for the students' degree of understanding at the international level. In this frame, a France-Japan Exchange program has been successfully established between the IUT 'A' of Lille and 8 Kosen in Japan since 2005. A thorough analysis of the Exchange program based on our experience is detailed and discussed.

Keywords: exchange incoming students, international connectivity, global technology education

Introduction

The ‘Instituts universitaires de technologie’ or IUT (translated as "University Institutes of Technology") are part of the university system in France. The IUT were created in 1966. There are 116 IUTs which are attached to 80 universities including the ones in the French Overseas Territories and Departments. The IUTs allow the preparation of a two-year undergraduate technical diploma called a “Diplôme universitaire de technologie” or DUT. After finishing their DUT, students have the option to work, do a one-year professional degree called “Licence Professionnelle” (a course also offered by IUTs), or further their studies in a university or "école".

Situated in French Flanders, near France’s border with Belgium, Lille is the fifth-largest city in France. Lille is connected to the Brussels-Paris-London TGV network. The journey to Brussels takes little more than 30 minutes, to Paris about an hour, and to London about an hour and 25 minutes. IUT ‘A’ of Lille established in 1966, is an undergraduate college of applied sciences of the University of Lille. For 50 years, IUT ‘A’ has turned out more than 30,000 graduates and it has kept abreast of scientific and technological advances. This original vocational training has proved to be successful over all these years. Its permanent aim is to make young people efficient and adaptable.

IUT ‘A’ consists of 7 departments:

- Chemistry (Chimie)
- Biological engineering (Génie biologique)
- Electronics and automatic control engineering (GEII)
- Mechanical and production engineering (GMP)
- Business studies (GEA)
- Computer science (Informatique)
- Physics and applied sciences (Mesures physiques)

The courses consist in lectures, seminars or tutorials (TD), laboratory sessions (TP), for a weekly workload of about 50 hours (35 hours/class contact) per student. Besides, tutored projects enable students to run some work of their own on a specific subject. At the end of the second year, students have to complete an industrial placement of at least 10 weeks. The curriculum is clearly defined in a national syllabus (in French) approved by the Ministry of Education.

From the Japan side, Colleges of technology (KOSEN) were first founded in 1962, and since then, about 310,000 students have graduated during the 46 years so far. The Institute of National Colleges of Technology, Japan (INCT), which organizes 51 KOSEN (55 Campuses), was established in April 2004 as a single legal entity, and it has become a massive-scale institution which has approximately 50,000 students and 6,300 academic /administrative staff.

The mission of the KOSEN, which were established in response to a strong demand from industry, is to foster creative and practical technical engineers. In order to accomplish this aim, the KOSEN conduct practical and professional engineering education based on a five-year integrated system with general learning and specialized learning organized systematically. About 60% of students find employment after completing the five-year associate degree course, and 40% of them go on to a two-year advanced course, or transfer to a university and receive a bachelor’s degree. Some of them continue
their study in postgraduate schools. The variety of career courses after graduation creates many possibilities for their careers, and leads to the production of excellent talents such as practical and creative engineers, entrepreneurs, managers, and researchers, who can be inventive and have problem-solving skills. Receiving extremely high acclaim in personnel training from industry, KOSEN are conducting positive activities in relation to technological innovation from the local community and technology with global competitiveness, and cooperating with industry and government.

France-Japan exchange program

The France-Japan Exchange program has been successfully established in 2005. A timeline of events is described is given in the following:

- 2005: bilateral agreement between Hachinohe NIT (National Institute of Technology) and IUT ‘A’
- 2007: Japanese classes taught at IUT ‘A’
- 2008: bilateral agreement with Akita NIT
- 2009: bilateral agreement with Sendai, Tsuruoka and Ichinoseki NITs
- 2010: MoU between Tohoku Federation of NITs and IUT ‘A’
- 2011: The IUTs of Lens, Béthune, Calais and Valenciennes join the programme
- 2015: The IUTs of Le Havre and Blois join the programme
- 2016: MoU between Gifu NIT and IUT ‘A’
- 2016: MoU between Chiba University of Commerce and IUT ‘A’

The establishment of a student/teacher exchange agreement is implemented to ensure optimal effectiveness.

A. Sending and receiving students

The partners have agreed to welcome students by giving them orientation of the city and university. Students will also be assigned a tutor to help them in their daily life inside and outside the school. Tutors should initiate contact with the foreign students a few weeks before their arrival in the host institution. There will also be cultural events where the new exchange students can meet and interact with long-term foreign students. Partners will try their best to pick students up from the nearest airport or at least train station.

On each side, there should be no more than thirty students sent to the host country at the same time. Moreover, it is our hope that students have a TOEIC score of at least 500. In cases where students somewhat lack English skills, but are extremely motivated and possess good communication skills and diligence, the teacher will advise and may permit such students to apply.

B. Research

The members of the Japanese consortium understands that providing and managing research projects is a challenge due to the short period for which Japanese students come. Using a unified English application form (including gender, and picture), when students apply, they will describe their research field, keywords, and desired project. Before Japanese students come to France, the host institution will send documents and research materials so that students can effectively prepare in order to make the most of their relatively short period of stay.

C. In the dormitory

As some dormitories in Kosen may have stricter rules compared with the French system, slight modifications may be considered (extended curfew time for instance). French students are guests of kosen, and receive ample financial and academic support, and as such, must respect their host institution, students and teachers.

D. Internship presentation in Japan

In order to alleviate the logistic and financial burden of a collective presentation by all students in one location and time, from the 2015-2016 school year the Kosens will host local events, where only students of the institution will present their internship. The presentations will take place at the end of June, near the very end of the program. Students will then be evaluated by one or two guest members on the French side, the lead teachers and other volunteer staff from the host institution.

Figures 1 and 2 illustrate the trends in outgoing and incoming students. From these data, one can note that around 10 students participate to the student exchange program since 2011. A pic of students is also denoted in 2014-2015 corresponding to new French IUTs that have joined the programme.
Results and Discussion

From a general point of view, a first foreign exchange program in France or in Japan is an unforgettable experience. In addition to theoretical and technical skills acquired during lectures and practical works, the students develop their language, whether it is French or Japanese or English and their cultural awareness. Indeed, cultural and linguistic immersions for students for both sides are a unique opportunity to bring language skills to life.

Another benefit is the possibility to add new knowledge that can be learned in the foreign course by trying new specialisations and learning in a different cultural context. Indeed, they may also be able to undertake classes that are not available at their school.

Students will experience learning in a different education system, which will expose them to a different style of teaching. Therefore, the willingness to put itself outside his comfort zone is seen as great experience to future employers.

Students will become more independent and will learn a variety of life skills while they are away from home. Although they will be boarding at a host university, they learn to think more independently and develop their problem-solving skills.

Conclusions

The experience gained from this educational system significantly enhances the student’s pedagogic and professional experiences. The success of the program is demonstrated through new initiatives. Among them, UCLL (Belgium) has applied to join the programme and successfully did it in 2017. 3 more kosen from Hokkaido (Kushiro, Asahikawa and Tomakomai NITs) have joined the programme. Iwaki kosen eager to strengthen our cooperation in the field of business studies.

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A CASE STUDY OF CROSS-BORDER EXCHANGE PROGRAMME IN ENVIRONMENTAL PROTECTION EDUCATION

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Abstract

International exchange programme can serve as an effective tool to enhance personal growth and acquisition of subject knowledge. Visiting places away from home town provides a chance to refresh the mind, and usually lead to a better learning atmosphere. As an international city, Hong Kong always look for opportunities to exchange innovative ideas with other places. Considering a wide-range of environmental technologies being adopted all over the world, it is particularly important for incorporating international exchange in environmental education to enrich students’ learning experience. Year one students from the Higher Diploma of Environmental Protection and Management, Applied Science Discipline, IVE have participated in an exchange programme held from 26 to 29 March 2018 at the Shenzhen Polytechnic. Through the collaboration between the two institutes, students are expected to learn about the environmental protection issues and management strategies being adopted in Shenzhen. This programme has been held since year 2016. There are two kinds of delivery mode, which includes student projects and exchange tour. Based on the suggestions and feedbacks from the students and teaching staff, improvements have been implemented incrementally throughout the years. Owing to the tight schedule, arranging exchange activities requires good planning in advance to ensure archiving the educational goals. This paper aims to share the engaged educational activities during the programme, and the challenges involved in the planning and delivery stages. We reviewed the activities held during the exchange programme, which includes lecture, site visits and student presentation. The value of fun as well as the educational value of each activity were described. The main contribution of this paper is to review the characteristics of the exchange activities from an international connectivity perspective, and their relationship with learning and teaching.

Keywords: cross-border exchange programme, exchange activities, environmental protection, educational value, learning and teaching

Introduction

Enhancing the curriculum with international content is always an important strategy to cope with the global academic environment. Cross-border collaboration such as exchange programme has long been considered an initiative to motivate knowledge acquisition (Altbach & Knight, 2007). It is not just the technical knowledge but also the behavioural changes that play a key role in environmental education (Valderrama-Hernández, Alcántara, & Limón, 2017; Varela-Candamio, Novo-Corti, & García-Álvarez, 2018). Engaging students in exchange programme has been proposed as an indicator to reflect the achievement of an environmental higher education programme (De Andrade Guerra et al., 2018). However, the success in bilateral exchange of environmental protection ideas depends on the design of the exchange activities. In view of the time management and logistics support, there can be various mode of delivery for the exchange programme. Our collaboration with the Shenzhen Polytechnic in organizing an exchange programme under the “Ten Thousand Student Interflow Programme of the Ministry of Education”, Ministry of Education of the People's Republic of China (hereafter referred to as the exchange programme) started in year 2016. It aims at organizing technology and cultural exchange activities among students from the two institutes. This paper provides an overview on the design and delivery of the exchange programme focusing on environmental protection education.

Methodology

The design of the exchange programme has been reviewed in relation to the types of exchange activities, time management and the learning outcomes. The experience in fine-tuning the design over the past three years are summarized, and the impact of introducing new designs on the fun element and educational values of the programme would be discussed.

Keywords: cross-border exchange programme, exchange activities, environmental protection, educational value, learning and teaching
Roles of regional exchange activities in environmental protection education

Environmental protection has been known to be a cross-border issue. Regional cooperation are necessary to tackle green issues such as air and water quality monitoring and management. The policies and technologies adopted by nearby regions are good references for local discussion and subsequent decision-making to formulate appropriate strategies. Exchange activities shall offer opportunities for the participants to broaden their horizon.

Mode of delivery

The exchange programme has been delivered in two different modes: student project and exchange tour. Student project mode engaged year 2 students from the Higher Diploma programme studying environmental protection and management. Students from both institutes would teamed up in groups to conduct the project in both Hong Kong and Shenzhen. Numbers of project titles would be selected with agreement among the teaching staff from both institutes. The project would last for three months, and with four full days in total for the field work. Working days are scattered over the whole period, and with a final student presentation for reporting the results. This mode of delivery usually involves three groups of students, and with around five students as well as one teaching staff from each institute in a group.

Exchange tour served as another mode of delivery, which engaged year 1 students and all of our programme team teaching staff. The tour could last for 4 – 7 consecutive days, and covered a range of activities including technical visits and lectures. Students were asked to give a presentation on the last day of the tour sharing about the acquired subject content. This mode of delivery usually involves three groups of students, and with around five students as well as one teaching staff from each institute in a group.

Learning outcome – fun and educational value

The exchange activities in two different modes of delivery varies, but serve the same purpose of enriching the learning experience of the students. The activities are expected to be with high uniqueness and offering new experience to the participants.

Considering the time constrain and the differences in the learning outcome in the curriculum between the two institutes, the investigation topic of the student projects focused on conventional environmental studies. Projects related to river water quality, roadside air quality and monitoring of water quality of sewage treatment work have been carried out in Hong Kong and Shenzhen. Students learnt the differences in the environmental regulatory standards and testing procedures among different administrative entities. Sharing the findings from the cross-border studies allow students to get familiar with thinking environmental protection in a global perspective.

The exchange tour, on the other hand, provides a larger flexibility in the design of learning activities. Table 1 summarized the activities that had been included over the last three years. At the planning stage, we considered the fun element as well as the educational value of the proposed activities. Some visits are more technically-oriented, while some of them taking an implicit learning approach. One should notice that striking the balance between having fun and rich in educational value is always difficult, and it is a progressive improvement process over the past three years. There are teaching team meetings reviewing the activities after each exchange tour. Visits organized in year 2016 mainly focused on technical know-how with numerous hard facts. Students had been hard to learn efficiently as they are in a relax state in a foreign place. This year we firstly included the visits to the Shenzhen Safari Park and the Waste-to-Energy Incineration facilities.
Table 1. Fun element and educational value of the exchange activities.

<table>
<thead>
<tr>
<th>Exchange tour Mode</th>
<th>Fun element</th>
<th>Educational value</th>
<th>Student Project Mode</th>
<th>Fun element</th>
<th>Educational value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural exchange</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Campus tour</td>
<td>✓</td>
<td>✓</td>
<td>*Lunch gathering</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>*Cycling</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*History museum</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field work (a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Air &amp; Water sampling / measurement</td>
<td>✓</td>
<td>✓</td>
<td>*Air &amp; Water sampling / measurement</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lecture</td>
<td></td>
<td></td>
<td></td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>*Regulatory standards</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Water / Wastewater treatment</td>
<td>✓</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>*Sustainable urban planning</td>
<td>✓</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Student Presentation</td>
<td>✓</td>
<td></td>
<td>Student Presentation</td>
<td>✓</td>
<td></td>
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<tr>
<td>Technical Visit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Landfill site</td>
<td>✓</td>
<td></td>
<td>*Air monitoring stations</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>*Safari Park (a)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Water supply systems</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Water treatment plant</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Wastewater treatment plant</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Waste-to-Energy Incineration facilities (a)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Activities newly introduced in 2018.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Visiting the Safari Park served as an implicit learning to raise the student awareness in nature conservation, while the MSW incineration plant echoed the increasing local concern on the environmental impact of adopting such MSW treatment technology. Both site visits have fun element and high education values due to the uniqueness of the facilities.

Another new trial being taken this year is to deliver teaching content of the Higher Diploma module during the exchange tour. Laboratory session with field practical work has chosen to be delivered during the tour. Air and water sampling and on-site measurement have been conducted. Teaching staff noticed a strong learning motivation among students. The application of field practical techniques in a foreign place is a refreshing experience for the students.

Cultural exchange

Cultivating mutual understanding has always been one of the major objectives of any exchange programme. For the project-based mode, there has been lots of conversation among the exchange students. Students from both institutes built a close collaboration during the field work and lunch time. Mutual assistance has been common in such an alternate host-guest relationship. Jang, D. and Kim, D.-Y. (2010) suggested that adhering to the host cultural norms and values is a crucial factor for the acculturation of exchange students. We observed such phenomenon during the exchange programme, in which there were raised awareness in self-initiated food waste collection by our students. This is mainly due to the cultural norms at the campus of the Shenzhen Polytechnic. The closely engaged project groups guaranteed an exchange in various depth.
It has always been a challenge to arrange cultural exchange activities between students from different institutes (Rohrbaugh, 2016). Numbers of approaches have been tried out in the exchange tour: (i) common lecture; (ii) leisure group activities; (iii) common site visits. We observed the common lecture and site visits approach have limited impact on promoting cultural exchange. Blanchet-Cohen and Reilly (2013) noticed the challenges including value clashes and lack of common lived experiences in environmental education within a multiculturally-diverse classroom setup. Conventional lecture is an undesired scenario for sharing opinions among students. While leisure group activities are usually considered as an effective approach to cultivate culture exchange, it may suffer from constrains in time management and logistics supports. To encourage students discovering the cultural characteristics, we arranged some free time slot for the students and adopted a nearly complete laissez-faire approach. Regular checking on students’ status have been done only for safety and security reasons.

Conclusions

Environment education is an inter-disciplinary subject requiring students to apply the acquired skills in different time and space. The exchange program provided an opportunity for students to practice the generic and technically-specific knowledge in an unfamiliar situation. We demonstrated an exchange program, with a continuous review on the exchange activities, could boost the learning motivation and encourage positive acculturation on environmentally friendly behaviour.

We noticed this study is subject to several limitations. First, there are only descriptive assessment on the learning outcome for the exchange activities. There is lack of empirical analysis on the instructional sensitivity, which could be critical in evaluating the vocational educational training (Carleton-Hug & Hug, 2010; Deutscher & Winther, 2018). Second, the language issue occurring in similar exchange programmes is not a concern in this case and not being discussed. There is also a limited understanding in the appropriate incorpration of implicit learning throughout the programme. Future work on implementing a variety of exchange activities would be crucial for continuous improvement of the exchange programme.

References


CAN JAPANESE EXTRACURRICULAR ACTIVITIES IMPROVE ENGINEERING STUDENTS’ GENERIC SKILLS?

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Abstract

Generic skill is not a very new aspect to look at students’ abilities in educational fields; however, not a sufficient number of studies has reported specific methodology to train students' generic skills. Moore (2011) calls it “transferable [skill] to a multiplicity of situations” which students can apply in their next level schools or their professional working fields, such as creativity, teamwork, leadership, communication skill, time management skill, critical thinking, and so forth. Hamana (2010) mentioned it is essential for teachers to implement some educational methodologies “both inside and outside of the classroom.” School teachers spend most of their time on preparing lessons for “inside the classroom.” Nevertheless, Mizokami (2009) pointed out that students who can successfully combine their management in learning in their regular classrooms and their extracurricular activities showed higher improvement in their generic skills. Therefore, in some extent it is difficult to just ignore students’ extracurricular activities. This study focuses on the implementation of "outside classroom" extracurricular activities and how it works in a setting of National Institute of Technology [Kosen]. Based on the Mizokami’s (2015) questionnaire on Japanese high school students, the author arranged it for the Kosen students. The number of participants was 101. The questionnaire asks how they spend their daily lives, (whether they have breakfast every day, read newspapers, read books, and etc.) and their typical school lives on weekdays and weekends. The purpose is to figure out what type of students can improve what specific generic skills. Moreover, the questionnaire was also conducted on the members of the author’s swimming team. This club is one of the extracurricular activities in Nagaoka Kosen and the members practice competitive swimming six days a week. This study also reveals whether the members could improve their generic skills through their school lives and how they are different from the others, because they have participated Utimate project which the Society of Water Rescue and Survival Research conduct in ASEAN countries in order to prevent Asian children from drowning. In this way, it might be possible to suggest that one of the methodologies to improve students’ generic skill is to participate in an extracurricular activity and to get involved in an international activity.

Keywords: extracurricular activity, generic skill, swimming, UITEMATE

Introduction

Things are getting really complicated for teachers who are in charge of club activities at their extracurricular activities in Japanese junior high and high schools. Traditionally, Japanese school teachers are assigned to coach some sports or cultural activities after school. Large amounts of teachers spend their valuable preparation time for their lessons for coaching his/her club team in their schools. Kosen in Japan also has club activities and most of the Kosens in Japan have club activities, but Kosen teachers have choises whether they take care of those club activities or not because club activities are not officially considered as an educational task for teachers like junior high and high schools in Japan. However, Japanese Kosen has a common standards for teacher to teach at their Kosens called Core Curriculum, and it requires us to improve students’ generic skills such as communication skills, leadership, problem-solving skills, and so forth.

Literature Review

The questionnaire was created by Mizokami (2015) and he conducted his research on 165,687 Japanese high school students (sixteen to seventeen years old: 21,238 boys, 22,588 girls, and 1,485 unknown) in 2013, and 16,829 (37.1%) responded his questionnaire. Conducting some cluster analysis on his data, his research figured out that there were seven different types of high school students among his participants such as (1) Study Type, (2) So-so-Study Type, (3) Club Activity Type, (4) Playing with Friends & SNS Type, (5) Reading & Manga Type, (6) Game Type, and (7) Less Participation in School Event Type. Regarding club activity, his finding was that the students who were categorized in Study Type and who could spend both their study and club activities compatibly showed the highest score in their improvement on their generic skills compared to the other types of students. Here, the “generic skills” indicate eighteen different students’
skills and attitudes. For instance, students are able to (1) plan a schedule, (2) analyze problems in society, (3) have strong leadership, (4) search information in libraries and on the Internet, (5) discuss with others, (6) write in their own words, (7) make presentations in front of people, (8) cooperate with others, (9) use computers and the Internet, (10) use time efficiently, (11) create new ideas, (12) challenge difficulties, (13) listen to others, (14) respect opinions from others, (15) concern others, (16) work on tasks patiently, (17) be interested in different cultures from different countries, and (18) understand themselves objectively. He asked those questions above in five point Likert. The details how he conducted research will be mentioned in the Method section in this research.

Methods

In order to figure out what types of students can improve what kind of skills and attitude throughout their Kosen lives, the author has arranged his questionnaire for specifically for Kosen students based on Mizokami's (2015) study. The questions used on the questionnaire are as below;

Q1-1: Sex
Q1-2: Major
Q1-3: What type of Entrance Exam did you take (paper test or recommendation from his/her junior high school?)

Q2: Daily Activities <4 point Likert> 1: all of the time, 2: some of the time, 3: hardly ever 4: never
Q2-1: I take breakfast every day
Q2-3: I read newspaper every day
Q2-4: I read news on the Internet
Q2-5: I have regular habits on everyday life
Q2-6: I am late for school
Q2-7: I understand what I learn in school
Q2-8: I have high motivation toward learning
Q2-9: I make plans for learning
Q2-10: I solve any problems while studying
Q2-11: I seldom study if it is nothing to do with university entrance examinations
Q2-12: I participate actively in school events (e.g. school festival, sports day, etc.)
Q2-13: I often participate in volunteer activities
Q2-14: I have joined internship programs
Q2-15: I would like to study abroad
Q2-16: I would like to work abroad in the future

Q3-1: Is your study and club activity compatible?
1: yes, 2: so so, 3: not really, 4: no, 5: I do not belong to any club
Q3-2: Do you often involved in discussions and presentations?
1: all the time, 2: some of the time, 3: hardly ever, 4: never, 5: no opportunity in my Kosen
Q3-3: Do you participate in comprehensive schools hours or homeroom activities?
1: all the time, 2: some of the time, 3: hardly ever, 4: never, 5: no opportunity in my Kosen

Q3-4: Are you satisfied with your Kosen life?
1: strongly agree, 2: agree a little, 3: neither agree or disagree, 4: disagree a little, 5: strongly disagree

Q4: Daily activities: Write how many hours you spend for the following activities. The total should not exceed 24 hours including 7 to 8 school hours.
*write hours for weekday and weekend separately
Q4-1: Club Activity
Q4-2: Study (other than classes in school)
Q4-3: Play with friends
Q4-4: Watch TV
Q4-5: Exchange messages on mails, LINE, or SNS (twitter) etc.
Q4-6: Play games
Q4-7: Reading (other than mangas nor magazines)
Q4-8: Read mangas and magazines
Q4-9: Sleep
Q4-10: Other

Q5: Relationship with their friends <5 point Likert> 1: strongly disagree, 2: disagree a little, 3: neither agree or disagree, 4: agree a little, 5: strongly agree
Q5-1: I am trying to make more friends
Q5-2: I can make friends with people whom I meet for the first time
Q5-3: It is comfortable to be alone rather than to be with friends
Q5-4: If I have a different opinion from others, I can discuss it until it is solved
Q5-5: I feel anxious if I cannot make contact with my friends
Q5-6: I try not to have deep relationship with friends
Q5-7: I have friends to study with
Q5-8: I have friends who can give me advices
Q5-9: I have many friends online

Q6: Generic Skills and their Attitude <5 point Likert>
1: not improved, 2: not improved that much, 3: neither improved nor not, 4: improved a littler, 5: improved
“Students are able to…”
Q6-1: plan a schedule
Q6-2: analyse problems in society
Q6-3: have strong leadership
Q6-4: search information in libraries and on the Internet
Q6-5: discuss with others
Q6-6: write in my own words
Q6-7: make presentations in front of people
Q6-8: cooperate with others
Q6-9: use computers and the Internet
Q6-10: use time efficiently
Q6-11: create new ideas
Q6-12: challenge difficulties
Q6-13: listen to others
Q6-14: respect opinions from others
Q6-15: concern others
Q6-16: work on tasks patiently
Q6-17: be interested in different cultures from different countries
Q6-18: understand themselves objectively
Q7: Self-esteem <5 point Likert> 1: strongly disagree, 2: disagree, 3: agree, 4: strongly disagree
Q7-1: I am satisfied with myself
Q7-2: I have good points about myself
Q7-3: I can achieve things to the extent that most people can do
Q7-4: I am not good at anything
Q7-5: I want to respect myself more
Q7-6: I show a positive attitude toward myself

The number of participants in this study was 101 students (80 boys, 19 girls, and two N/A) in Nagaoka Kosen. They were all the fourth graders, 19 to 20 years old, majoring in three different engineering departments; Electrical and Electronic Systems, Materials, and Civil Engineering. The author adopted 76 out of Mizokami’s 88 questions, and the questionnaire was conducted during the author's English classes in February, 2018.

First of all, 19 out of the total 101 questionnaire (18.8%) were excluded from the analysis due to missing data. So as to sort out the data, the author focused on their total hours of their daily activities (Q4). If the total amount of hours is too big or no hours are provided on their questionnaire, they are excluded from the analysis. However, it is better to keep as many data as possible; therefore, we left the data according to the following two conditions.

(1) Total Hours: 5.5 hours to 20.0 hours on weekdays, and 5.5 hours to 25.0 hours on weekend.
(2) Sleep hour should be more than 3 hours.
As a result, four data were excluded from the analysis. The total number of data analyzed was 78. The total hours of their daily activity and its average is shown as below in Table 1.

<table>
<thead>
<tr>
<th>hour</th>
<th>weekday</th>
<th>weekend</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.5-5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5.5-10</td>
<td>128.2</td>
<td>29.5</td>
</tr>
<tr>
<td>10.5-15</td>
<td>796</td>
<td>2572</td>
</tr>
<tr>
<td>15.5-20</td>
<td>101.5</td>
<td>764</td>
</tr>
<tr>
<td>20.5-30</td>
<td>0</td>
<td>268.5</td>
</tr>
<tr>
<td>30.5-35</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>35.5-40</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>965.7</td>
<td>1319</td>
</tr>
<tr>
<td>Ave. h (SD)</td>
<td>14.2 (2.5)</td>
<td>19.4 (3.1)</td>
</tr>
</tbody>
</table>

Using those 78 data, the author also looked at students’ self-esteem (Q7), and their relationship with their friends (Q5). Especially Q7-2, Q5-2, and Q5-8 were used to categorize student types. Q2-5, Q2-7, Q2-12, Q2-13, and Q-15 were also considered to be effective to describe students-types, so they were included as categorizing factors. In Mizokami’s (2015) study, he mentioned that students’ consciousness about their carrier path is one of the most important factors, nevertheless, in this study the author focused on students’ generic skills and their club activities, so they were excluded from the analysis this time.

On the questionnaire, the scales were different depending on questions; therefore, all the data was standardized at first, then cluster analysis was conducted. IBM® SPSS® Statistics 19 was used to group the students into four to eight clusters, and looked at characteristics of each cluster. Mizokami (2015) checked his cluster as its independent variable and its scales as dependent variable and conducted ANOVA on his gained clusters; however, this study did not go through the same statistical process. However, seven clusters produced by this cluster analysis explained well about the students’ types of this group; consequently, this seven clusters were adopted as clusters to describe these seven student-types (Table 2).

<table>
<thead>
<tr>
<th>cluster</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Judging from the characteristics of each cluster, the author named them as following types; (see Figure 1 at the end of this paper for this cluster analysis)

(1) SNS Type (cluster 1)
They spend more time online like SNS compared to the other types (average SNS hours on weekdays: 5.40h, weekend: 6.20h). The score on “Playing games” is the lowest of all. The score on “Club & studying are compatible” and “be satisfied with Kosen life” are the highest. (average study hours on weekdays: 0.80h, weekend: 1.20h)

(2) Reading Type (cluster 2)
They spend more time on reading books excluding manga and magazines. (average reading hours on weekdays: 4.00h, weekend: 8.00h) The hours they spend on club activities, studying playing with friends, using SNS, reading manga and magazines, are the lowest. They tend not to have friends to get advices from.

(3) Club Activity Type (cluster 3)
They have the highest score on club activities (average club hours on weekdays: 3.22h, weekend: 4.31h) They tend to spend their times on volunteer and school events, but they tend to feel comfortable when they are alone.

(4) Manga Reading Type (cluster 4)
Manga Type students spend more time on reading manga and magazine of all. (average manga reading time on weekdays: 3.00h, weekend: 6.00h) Compared to the other types of students, they are hoping to study abroad in the future. They tend not to read books, which is the lowest score of all.

(5) Game (& Less Participation in School Events) Type (cluster 5)
They spent more time on playing games. (average game playing hours on weekdays: 3.43h, weekend:
5.00h) They tend not to participate in school activities, even though they participate in discussions and homeroom activities. They cannot get along with people easily and tend to have weak self-esteem.

(6) Studying Type (cluster 6)
They spend the longest hours on studying. (average study hours on weekdays: 1.17h, weekend: 1.62h) They tend to have more regular habits in their everyday lives than others.

(7) Playing with Friends Type (cluster 7)
They use more time on playing with friends (average playing hours with friends on weekdays: 1.85h, weekend: 5.00h) This type of students spend the second longest time on studying. (average study hours on weekdays: 1.12h, weekend: 1.46h) They also participate in school activities and volunteer activities often, and have friends to get some advices. However, they are not satisfied with their Kosen lives, and do not participate in discussion and presentation activities in school.

Results and Discussion

The next step is to figure out which types of students above improved what kind of skills and attitude (generic skills) through their Kosen lives (see Figure 2). Playing with Friends Type, SNS Type, Club Activity Type, and Studying Type show high score on improving their generic skills. In contrast, Game Type shows the lowest score on their generic skill improvement.

Since they are all engineering students, the skills in searching for information in libraries and on the Internet, and the ability to use computers and the Internet are improved in every Type. Manga Reading, SNS, and Game Type students did not improve their skills in using their time efficiently.

Playing with Friends Type shows the biggest improvement in generic skills, such as skills in discussing with others, making presentation in front of people, cooperating with others, concerning others, working on tasks patiently, and understanding themselves objectively. Club Activity Type and Studying Type students made the next biggest improvement, and they are high on average. They both can cooperate with others and seems to be good at keeping good relationship with others.

The result of the Game Type indicates that they are avoiding contacting with other people, because their scores on discussing with others and making presentations in front of people are the lowest. They also do not challenge difficult tasks and work on tasks less patiently; therefore, they tend to rely on other people.

Mizokami (2015) indicated in his research that Study Type students who belong to club activities showed the biggest improvement in their generic skills; however, in this research at Japanese Kosen, the consequence is different. Students in Playing with Friends Type showed the biggest improvement. This result points out that students with communication skills have more opportunities to improve themselves in Kosen. In other words, in order to improve Kosen students’ generic skills, we, teachers, are required to step in a little bit deeper to improve their interpersonal skills so that they can attain better generic skills in the future.

What club activities have to do with these generic skills? The author also extracted the data from Q3-1: Is your study and club activity compatible? (1: yes, 2: so so, 3: not really, 4: no, 5: I do not belong to any club). 1 and 2 means study and club are compatible for students, 3 and 4 means students cannot do both club and study at the same time, and 5 means he/she does not belong to any club activity. These three kinds of compatibility and seven student-types make new 21 compatibility types of students to be analyzed. (See Table 3)

<table>
<thead>
<tr>
<th>Student Type</th>
<th>Compatibility type</th>
<th>Student’s TOEIC score</th>
<th>Student’s study time</th>
<th>Student’s club activity time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friends Type</td>
<td>Compatible</td>
<td>800.00</td>
<td>1.20</td>
<td>0.80</td>
</tr>
<tr>
<td>SNS Type</td>
<td>Compatible</td>
<td>800.00</td>
<td>1.20</td>
<td>0.80</td>
</tr>
<tr>
<td>Club Activity Type</td>
<td>Compatible</td>
<td>800.00</td>
<td>1.20</td>
<td>0.80</td>
</tr>
<tr>
<td>Studying Type</td>
<td>Compatible</td>
<td>800.00</td>
<td>1.20</td>
<td>0.80</td>
</tr>
<tr>
<td>Playing with Friends Type</td>
<td>Compatible</td>
<td>800.00</td>
<td>1.20</td>
<td>0.80</td>
</tr>
<tr>
<td>Swimming Club</td>
<td>Compatible</td>
<td>800.00</td>
<td>1.20</td>
<td>0.80</td>
</tr>
</tbody>
</table>

There is one student in Club Activity Type and answered “no club activity,” so this student was excluded from the analysis. The compatibility types which have more than 5% of the total students were chosen to be analyzed. They are star-marked in Table 3. So Compatibility Type 3, 7, 14, 15, 16, 18, 19, and 21 were selected. Plus the data from the author’s swimming club was added as Compatibility Type 22 and 23.

As a result, Compatibility Type 19 and 21 showed the highest score on improving their generic skills (see figure 3). Although the average score of Type 19 (compatible) is slightly higher than Type 21 (no club activity), Playing with Friends factor seems more influential on this matter. Again, Compatibility Type 14 and 15 (both Game Type) showed the lowest result. The author’s swimming club data is similar to Compatibility
Type 3 (SNS + no club) and 7 (Club Activity + compatible).

Conclusions

This study revealed not only the influence of club activities but also what teacher for engineering are required now in Japan. Even though the number of participants is limited, it is sufficient to grasp the current state of Kosen in Japan. Many of the engineering students in Kosen are not very good at communicating with others; however, this study found out that how important it is to increase their chances to interact with other people (not on the Web) in order to improve their generic skills.

Acknowledgements

This work was supported by Grant-in-Aid for Scientific Research (C) 16K02871.

References


Figure 1. Seven Students Types (cluster analysis)
Figure 2. Improved skills and attitude (generic skills) throughout Kosen lives

Figure 3. Relationship between Students’ Compatibility Type and Their Generic Skills
PRODUCTION OF SOLAR CAR BY STUDENTS PROJECT

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Abstract

The students of the National Institute of Technology (NIT), Nagano College have been taking the initiative to produce solar cars since 1992. Ten student volunteers produced a solar car using solar cells and a brushless DC motor, and participated in the competition held in Ishikawa Prefecture.

In 1993, they participated in the competition held in Akita Prefecture as a solar car team, which was launched in the same year as an extracurricular activity at the college. This competition was approximately a round course of about 30 km (currently 25 km round trip), and participants could compete for 25 h in an endurance race lasting three days. Nagano College took part in the competition for 22 consecutive years until 2014. Its team achieved 844 km as its longest running distance and won the class title in the preceding seven competitions.

In 2015, the team began to participate in another competition held in Mie Prefecture. In this competition, a 3-h endurance race of 5.807 km per lap was held. This circuit is uneven and therefore requires solar cars to have stable running capability. Because of the lack of experience in this competition, the longest running distance record for the team remains at 162.596 km, and its highest average speed is 57.2 km/h.

Approximately 20 students produce solar cars after school currently. Students are classified into three groups: the Mechanical Group, which is responsible for the design and creation of car bodies; the Electricity Group, which is responsible for working on the design and production of electrical systems; and the Cowl Group, which is involved in the production of car bodies. The students conceive an idea for new cars almost every year, make a design, and implement it for operation. The students have been making efforts to improve their skills by obtaining technical information from the top teams and by starting to socialize with the Hong Kong IVE since 2015. Some students have found employment at auto companies, while others have participated in the competition by establishing a team consisting of volunteers. The students’ knowledge is growing significantly through the production of solar cars.

Keywords: Solar cars, extracurricular activities, solar cells, motor, racing

Introduction

Recently, energy problems have become worse worldwide. In the automotive industry, much progress has been made in hybrid cars powered by gasoline engines coupled with motors, as well as in electric vehicles and fuel cell cars.

Solar cars are automobiles that are driven by motors powered by electric energy that has been created by solar cells from sunlight, charged, and stored in batteries (For example, Kimura et al. (2000), Taha et al. (2010), Singh et al. (2013)). These cars are noted for cleanliness, in that they take advantage of solar energy without relying on fossil fuels. Because of cost issues, however, they have yet to be adopted in commercial cars.

In Japan, auto makers and power companies, as well as students in universities and industrial high schools, tackled manufacturing solar cars in the 1990s (Kimura (2011)). Conventions are held, both in Japan and abroad. For example, the World Solar Challenge (WSC) to be held in Australia is a famous competition (For example, Ozawa et al. (1998), Elshafei et al. (2016)). At the National Institute of Technology, Nagano College, students started solar car production in 1992 and made entries in competitions to verify the performance of the car. In this research, how the solar car manufacturing proceeded at the NIT, Nagano College is described.

Manufacturing solar cars for racing competitions

Figure 1 shows the electrical system architecture of solar cars. Electricity generated by solar cells is supplied to motors and batteries by way of a buck-boost converter or charging controller. In case sufficient electric power generation is secured, the motor is driven by electricity supplied by solar cells; however, if such generation is deficient because of cloudy weather, power is supplied by the batteries to the motor. Effective utilization of batteries holds the key to winning or losing in the race.

Figure 1. Construction of electrical system architecture of solar cars
First participation in solar car race

Ten volunteers of fifth graders in the department of electric engineering, who aspired to participate in Japan’s first solar car rally to be held in Noto Peninsula, Ishikawa Prefecture, initiated the manufacturing of solar cars and motors. Because the rally was held on the Chirihama Nagisa Driveway, a sightseeing road running on a sandy beach, they adopted front-wheel drive to simplify the drive system.

Figure 2 shows the exterior appearance of the solar car manufactured. It had one wheel on the front and two wheels on the rear. The car used the solar panels for power generation (Kyocera Corp., LA361J48, 48 W × 10 sheets), and the motors used an industrial DC servo motor donated by the manufacturers (Sanyo Denki Co. Ltd., F1470). More than 100 cars entered the rally from auto makers, power companies, universities, technical colleges, and so on. At the competition, it was notable how solar cars attracted interest in terms of the effective use of solar energy.

Production of solar car by extracurricular activities

In 1993, a circle of like-minded solar car researchers was founded on campus, and they worked on producing solar cars as an extracurricular activity. The produced solar car was entered at the World Solar-Car Rally (WSR) held on the village road (solar sports line since 1994) in Ogata-mura, Akita Prefecture. In this competition, we used a round course of about 30 km (currently 25 km round trip) and competed for the distance we ran between 25 h in 3 days. Since 1999, the All-Japan Intercollege Solar Car Championship (JISC) has joined for university students, and the All-Japan Intercollege Solar & Fuel Cells Car Championship (JISFC) was added for simultaneous competition in 2006. In 2011, JISFC merged into the World Green Challenge Solar & Fuel Cells Car Rally (WGC), which has remained to this day.

The circle was promoted to a club in 1997, and its activity grew to be able to manufacture vehicles, with subsidies from student bodies and technology promotion associations. Solar cars are designed every year for manufacturing to participate in the rally.

Figure 3 shows the exterior appearance of the solar car manufactured in 1997. It used 12 solar panels (Showa Shell Sekiyu Co., Ltd. / KIS Co., Ltd., FT132-E) for solar car racing, with the total electric power generation rated at 480 W. For the motor, it used a brushless DC motor (Honda Motor Co., Ltd., DDW4060) of 600-W output. Batteries were sealed in lead storage batteries. Solar cells were positioned in the rear, lowering the car body’s center of gravity. Further, considering the driver’s long hours of driving, air intake vents were installed. At this rally, the running distance was 558 km, winning the second place in the WSR fresh category.

Figure 4 shows the exterior appearance of the solar car manufactured in 2000. The solar panels and the motor were of the same specifications as those of the 1997 vehicle. For the first time this year, adjustable panels were adopted so that the solar panels could be oriented toward the sun (adjustable panels were banned later). At this rally, the running distance was 593 km, winning the 4th place in the JISC half-size category.

Figure 5 shows the exterior appearance of the solar car manufactured in 2001. The solar panels and motor used were of the same specifications as those of the 1997 vehicle. It used four sealed lead storage batteries (GS Yuasa Corp., NP24-12B). A canopy was installed in the center of the solar cell module, thereby allowing for a...
smaller, lighter, lower-gravity vehicle. Furthermore, the space accommodating the driver has been made as minimal as possible and thinner in size to lessen specific air resistance. As a result, the running distance at the rally increased to 844 km, a record distance for the school, winning third place in the JISC half-size category. In addition, as a result of letting another solar car participate, we ran the 4th place by running 656 km.

**Figure 5.** External appearance of the solar car BJIN produced in 2001 (3rd JISC, Rank: 3rd place in half-size category)

Figure 6 shows the exterior appearance of the solar car made in 2006. The solar panels and motor were of the same specifications as those of the 1997 vehicle. It used four sealed lead storage batteries (Furukawa Battery Co., Ltd., FPX12240H). For the past five years, vehicles of thinner types were manufactured, but, to reduce air resistance further, full cowl bodies were also made. Further, efforts for suppressing the power consumption of electric components were made by employing LEDs in winkers. Because of failure to use materials like lighter-in-weight carbon fibers, the gross weight of the vehicle increased and compromised the driving performance. However, thanks in part to good weather, the running distance grew to 600 km, winning first place in the JISFC half-size category.

**Figure 6.** External appearance of the solar car Hopeless Inverse produced in 2006 (8th JISFC, Rank: Winner in half-size category)

Figure 7 shows an exterior appearance of the solar car made in 2013. The solar panels and motor used were of the same specifications as those of the 1997 vehicle. Two motors were installed to beef up the output to 1.2 kW, and the solar cells were increased to 16 panels to generate a gross power of 623 W. For the battery, one lithium iron phosphate battery (Shenzhen O’CELL Technology Co., Ltd., IFM48-300E2) was used. To make the vehicle lower in cost and lighter in weight, the students used residential heat insulation material (Sekisui Chemical Co., Ltd., Zettoron) in manufacturing the streamlined cowl. As a result, the running distance turned out to be 475 km, finishing in victory in the WGC solar car sector of the challenge class.

**Figure 7.** External appearance of the solar car Azusa produced in 2013 (2013 WGC Solar car Rally, Rank: Winner in challenge class)

Figure 8 shows a scene at the students’ camping event. Students stayed at the camping spot near the rally site. It was considered that the students gained life experience from both entering the race and also from living with their peers. In addition, some of the students experienced volunteering of the rally.

**Figure 8.** Camp life by students in 2004

(3) Entry in solar car race at Suzuka

The team participated in the rallies held at Ogata-mura 22 times consecutively from 1993 to 2014, with the team’s record running distance at 844 km and seven victories in the class. However, as the number of units entering the rally has decreased to a minimum in recent years, the students debated switching their entry in 2015 to the rally at Suzuki-shi, Mie Prefecture, where there were many entrants. This rally is held at the 5.807 km circuit of the international racing course. The course,
with large undulations, demands a vehicle’s stable driving performance.

Figure 9 shows the exterior appearance of the solar car made in 2017. In this figure, (a) is an overview of the solar car, (b) is an overview of the front-wheel steering, (c) shows the inside of the car, (d) shows the state of the rear wheel, and (e) is the electric system diagram. 182 solar cells (2.6 W per cell) with a gross output of 480 W were used, with an in-wheel motor of 1.5 kW rated output and sealed lead storage battery of 57 Ah total capacity. For the solar cells, two units of buck-boost-type DC/DC converter were used to obtain direct current of 60 V. For the tires, 14-in tires exclusive for solar cars were used.

(a) Appearance of the solar car Asanagi

(b) State of front-wheel steering

(c) Inside the car

(d) State of the rear wheel

(e) Electrical system diagram

**Figure 9.** External appearance of the solar car Asanagi produced in 2017 (Solar car race Suzuka, Rank: 10th place in Enjoy I class)

The vehicle made in 2015 ran only 23.228 km because of technical trouble, but the 2016 vehicle ran 104.526 km to finish in 13th place in the Enjoy I category. Later, after improvements made for entry in the 2017 race, the running distance extended to 162.596 km, attaining a maximum average speed of 57.2 km/h. Thus, the students steadily improved the technical level.

Table 1 shows the specifications of the solar car. Assuming the speed of the car is 60 km/h, the frame was made with aluminum alloy. In addition, a solar cell was used that is taut to the curved surface of the body.

**Status of manufacturing**

At present, approximately 20 students in three groups are tackling solar car manufacturing after school, with the Mechanical Group designing and manufacturing the body by means of three-dimensional computer-aided design, the Electric Group in charge of designing and manufacturing of electric circuits, and the Cowl Group responsible for body manufacturing.

There are three teachers to advise the club in its activities, whose functions are to provide technical consultation to the students and support them on traveling to participate in the rally. In addition, students receive advice from several technical staff as necessary. The students come up almost each year with new ideas for the vehicle, engage in designing, install components, and operate the vehicle, always keeping themselves busy with problem-solving types of experiments and manufacturing.
Table 1. Specification of solar car Asanagi produced in 2017

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (L×W×H)</td>
<td>3,500×1,700×1,000 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>120 kg*</td>
</tr>
<tr>
<td>Material of body</td>
<td>Insulation material, Mirafoam, GFRP</td>
</tr>
<tr>
<td>Material of chassis</td>
<td>Aluminum alloy (7N01)</td>
</tr>
<tr>
<td>Tire (3 wheels))</td>
<td>Size: 14 in (Sumitomo Rubber Industries, Ltd., D850)</td>
</tr>
<tr>
<td>Solar cell (single crystal silicon)</td>
<td>Total Output: 478 W (Nomura Corp., 2.6 W × 184 cells)</td>
</tr>
<tr>
<td>In-wheel type direct drive motor</td>
<td>Rated output: 1.5 kW, 60 V (Mitsuba Co. Ltd., M1560D)</td>
</tr>
<tr>
<td>Buck-Boost Converter</td>
<td>Output: 250 W (Kashiwakai, KW-BBMPPT × 2 units)</td>
</tr>
<tr>
<td>Control valve type lead storage battery</td>
<td>12 V, 57 Ah (Panasonic Corp., N-S65D26R/HV × 5 series)</td>
</tr>
<tr>
<td>Integrating ammeter</td>
<td>Amount of integrated current: 0.00-999.9 Ah (Namikoshi Electronics Corp., AH-703)</td>
</tr>
</tbody>
</table>

* Excluding driving battery, driver, onboard baggage

There were times when the control circuit of the motor and electric power measuring circuit were manufactured by using microcomputers. Currently, commercially available products are commonly used in view of the decreased manufacturing time and lack of technical capabilities. Some teams measure the current consumption of vehicles remotely using wireless technology (Yamada et al., 2013). We hope students to positively challenge the technology of electronic circuits.

However, energy management has now become possible by measuring and analyzing the running position and speed remotely with the use of GPS built-in smart phones, as shown in Figure 10. Hereafter, turning out technicians skilled with circuits will become an issue.

Figure 10. Monitoring the position and speed of the solar car

The students are getting technical information on higher-ranking winner teams from production workshops and the Internet, and will make solar cars based on these technical information. Of late, they are trying to improve their technical capability by exchange with the Hong Kong IVE (IVE Engineering Vocational Training Council) solar car team, which has been manufacturing high-performance solar cars since 2015, as shown in Figure 11. Some students join auto makers after graduation or team up in a volunteer group to enter the rally. Therefore, they are putting techniques learned during their club activities to useful purposes after graduation.

Figure 11. Visit from the Hong Kong IVE solar car team (March 23, 2015)

Figure 12 shows the solar cars exhibiting at local events. Students also exchange ideas with citizens. Students not only explain technical matters to citizens and children but also talk about their thoughts and dreams on the development of solar cars. Future engineers must confront energy issues. Through the production of solar cars, it is hoped that students will be interested in energy conservation and aim to become engineers who can solve environmental problems.

Figure 12. Display of the solar car Azusa (Nakano City Industry Exhibition, Nakano-shi, Nagano Prefecture, November 23, 2013)

Summary

This study addressed the status of solar car manufacturing as addressed by the students at National Institute of Technology, Nagano College since 1992. Although the budget was limited, the students sourced technical information from other solar car teams to further improve the performance of their vehicles. Dramatic progress may be difficult to achieve, but the
students’ activities will be supported by the college. We look forward to the success of our students.

Acknowledgements

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References


METHOD OF MAKING MOVIE FOR FLIPPED CLASSROOM AND ITS EDUCATIONAL EFFECT

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Abstract

A popular strategy of active learning is the flipped classroom method. The flipped classroom is an instructional method and a type of blended learning that reverses the conventional learning environment by providing instructional contents, often with internet. Students will not get a lecture from a teacher, because they have already viewed, at home, various lectures as movies on on-line. Students can use time for discussion, solving the exercise problems, and practice of their knowledge with their classmates in the classroom. The teacher looks around in the classroom without unilateral explanation. Amount of speaking of teacher is little in the flipped classroom. Then a teaching load of the teacher can be reduced with the flipped classroom. I have applied the flipped classroom to two classes of lecture of the electromagnetism. The learning text for my lecture include explanations, figures, example question, and some exercises. The movie learning materials include explanation of theories, laws, and how to solve exercises as well as the conventional teaching method. The length of the movies is around 5 minutes. 1 to 3 movies files are used for a lesson. The movies are uploaded onto YouTube. All of lectures and teachers are evaluated by students to research their learning effect yearly. Important items of that evaluation are volition of teacher, general evaluation of a lecture, and acidity of students. Students decided that the flipped classroom was better than the conventional teaching method for the volition of teacher. They comprehended teacher's effort for prepare of leaning contents, such as movie. Activity of students which was evaluated by themselves obviously increased. In this year, students who study electromagnetism were answered questionnaires for an impression of the flipped classroom. Students who appreciated the lesson, had high exam results in the 3rd grade. Their relationship is a nearly linear. The 4th grade students had not such a trend. Teaching load of teacher can be reduced by the flipped classroom, since, talking in a lesson can be decreased by using the movie. The preparation of the movies is necessary only once. The movies can be used again in same lesson next year.

Keywords: flipped classroom, movie learning material, making method, web-based learning, load saving

Introduction

There are many formats of active learning method, and witness from the paper shows that they can be good in improving student learning compared to conventional teaching method (e.g. Bonwell & Eison, 1991, Prince, 2004). A popular strategy of active learning is the flipped classroom method. The flipped classroom is the one of the most popular active learning format used in many schools, college, and university all over the world. The educational effect of the flipped classroom had been evaluated and described in some reports (e.g. Cheah, 2016, Kee & Wan, 2016, Ngai, 2016). Recently, an environmental for the flipped classroom has been ready, since any students have own smartphone or tablet PC. I have applied the flipped classroom on my lecture of electromagnetism since 2016. Some leaning contents for the flipped classroom could be prepared easily by myself using ICT technologies. This paper describes some techniques to prepare and to provide the leaning contents for the flipped classroom, and progress of a lecture of the flipped classroom. In addition, educational effects of the flipped classroom are evaluated based on the results of questionnaires and examinations.

Flipped classroom

The flipped classroom is an instructional method and a type of blended learning that reverses the conventional learning environment by providing instructional contents, often with internet. Students will not get a lecture from a teacher, because they have already viewed, at home, various lectures as movies on on-line. Visual images of the conventional teaching method and the flipped classroom are shown in Fig.1. In the conventional teaching method, the teacher is the central focus of a class and the primary provider of information during the class period. Student engagement
in the conventional teaching method may be limited to activities in which students work independently or in small groups on an application task designed by the teacher. Class discussions are typically centered on the teacher, who controls the flow of the conversation. (Ryback and Sanders, 1980). Typically, in the conventional teaching method, students must work their homework or review of last lesson in their house, alone. The philosophy behind the flipped classroom is that teachers can spend time working with students who need their help in the classroom and students can work together to solve problems rather than sitting home alone with work they might not understand and with nobody to ask for help (Strauss, 2012).

In the flipped classroom, students often receive learning contents with online in anywhere. The learning contents are often movie or pdf file prepared by the teacher or third parties. The movie can be watched repeatedly and can be stopped in anytime. Students can use time for discussion, solving the exercise problems, and practice of their knowledge with their classmates in the classroom. The students can take counsel together. Thus, the classroom is not quiet in the flipped classroom. The teacher looks around in the classroom without unilateral explanation. Students can ask teacher about what they do not understand.

It is very hard to keep talking for 90 minutes in the conventional teaching method. However, amount of speaking of teacher is little in the flipped classroom. Then a teaching load of the teacher can be reduced with the flipped classroom.

How to make movie contents

I have applied the flipped classroom to two classes of lecture of the electromagnetism. The learning text for my lecture include explanations, figures, example question, and some exercises. Length of the text for a lesson is usually 6 pages, a maximum of 8 pages. The text consists of 2–3 pages explanations and example question and 3–4 pages exercises. Fig. 2 shows that examples of my text for a lesson of electromagnetism. Introduction, theory, law, and important matters are explained with figure in page of the beginning of the text. In the example part, the problem is often provided with a key for solving the problem and a solving process with some blanks. The exercises are given with a few hints. Most difficult problem places at the final page. The problem can be solved by a few excellent students. The text is produced by using Microsoft Word and it exports to pdf file which has some blanks hide description partially.

The movie learning materials can be make easily by using Microsoft PowerPoint. I recorded my explanation by "screen recording" on a function of PowerPoint.
function records visuals and movement on the computer display with voice and can form a movie file in brief. Process to make the movie is shown in Fig. 3. On the "Recording" tab of the ribbon, select "Screen Recording". On the Control Dock, click "Select Area". To save the recording itself as a separate file on a computer, right-click the picture on the slide that represents the recording and select "Save Media as". In the "Save Media As" dialog box, specify a file name and folder location, then click "Save" (Microsoft, 2018). The movie includes explanation of theories, laws, and how to solve exercises as well as leaning contents of the conventional teaching method. The length of the movies is usually around 5

![Fig. 3. Process to make the movie file for the flipped classroom using Microsoft PowerPoint.](image)

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Fig. 3. Process to make the movie file for the flipped classroom using Microsoft PowerPoint.

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![Download the pdf file of the learning text](image)

---

**Download the pdf file of the learning text**

---

**Watching the movie on YouTube**

---

**Filling word or formula into the blank in text**

---

**In their home**

---

**In the classroom**

---

**Mini examination**

---

**Working alone**

---

**Group activities**

---

**Making groups (3~4 students)**

---

**Ice break and solving exercises**

---

**Checking their answers using model answers**

---

**Fig. 4. Activities of students and its flow of the flipped classroom.**

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![Fig. 5. Example of questions for a mini-examination.](image)

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**Fig. 5. Example of questions for a mini-examination.**
minutes, since a long movie is not favored by the students. 1 ~ 4 movie files are prepared for a lesson. The movies are uploaded onto YouTube. I have a "mychannel" in YouTube. Its URL is https://www.youtube.com/channel/UCo0Eo3I7Yt-1hp-0wl76z3w. The mychannel has all of upload movies and "playlist". The playlist includes some movies for every lesson. Students can access easily the movies which they need in the mychannel. The pdf file of the leaning text is uploaded onto my web site (http://www.tsuyama-ct.ac.jp/oke/contents/class.html). Students can access the movies in YouTube using links in the pdf file too.

Procedure of my lecture

The lecture applied the flipped classroom is composed of activities in home of students and that in the classroom. Activities in the classroom can be classified into working alone and group activities (Fig. 4). Students are required to download the pdf file of the learning text and to watch the movie in YouTube before a lesson. They fill some words or formulas into the blanks in their text.

At the begging of the lesson, students take a mini-examination (Fig. 5) to check their understanding themselves. Difficulty of the examination is as easy as a lot of student can solve completely. Then, small groups are formed by 3 or 4 students. They can work together to solve exercises after an ice break. Students can talk each other and ask their classmate or teacher in the lesson. In addition, they can move freely their own desk or seat. Fig. 6 shows that appearances of the classroom on a lesson. Students were sitting in their seats in the begging of the lesson, however, as time went on, they moved to talk or to ask for solving problems with their classmate.

Model answers of problems are prepared and opened to students in the classroom. Many students use the model answers to verify their answers (Fig. 7). They pointed out error in my model answer occasionally. On the other hand, a few students, who has not volition to study, copy the model answers into their notebook or smartphone.

I am always walking in the classroom with a small whiteboard to explain at the side of student's desk. Students can ask me anytime about what they do not understand. And, I talk to student who has some problems to support them. I keep on walking around the classroom during the lesson.

Educational effects

All of lectures and teachers are evaluated by students to research their learning effect yearly. Important items of that evaluation are volition of teacher, general evaluation of a lecture, and acidity of students. Fig.8 shows that results of that evaluation from 2011 to 2017. These results were provided by the 4th grade students (18~19 years old). The flipped classroom has started from after 2016. I would also like to mention that students of 2014 and 2015 had very particular characteristics. The former was very excellent and earnest class, the later students had many dissatisfactions for any lectures and school. In this study, the result is discussed except the 2 years students.

Students decided that the flipped classroom was better than the conventional teaching method for the volition of teacher. They were comprehended teacher's effort for prepare of leaning contents, such as movie. Activity of students which was evaluated by themselves obviously increased after 2015. This is an effect of activities that students initiatively talk each other in my lecture. On the other hands, the general evaluation of my
lecture was not increase. I have no ways to analyses that reason.

In this year, students who study electromagnetism were answered questionnaires for an impression of the flipped classroom on Forms of Office 365 every lesson. The questions were follows:

Q.1. Do you consent to contents of this lesson?
Q.2. Is this a worthwhile lesson for you?
Q.3. Do you think that the problems can be solved by yourself?
Q.4. Do you think it was good to work on the problems?
Q.5. How satisfied are this lesson?

Students answered these questions in 5 grades. Fig.9 shows that the relationship of the average score and their exam results. Fig.9 (a) and (b) are the result of 3rd grade students (17~18 years old) and result of 4th grade students (18~19 years old), respectively. Students who appreciated the lesson, had high exam results in the 3rd grade. Their relationship is a nearly linear. The 4th grade students had not such a trend. The relationships between the evaluation score and their exam results cannot be found clearly, since their evaluation score is higher than that of 3rd grade students. Teaching load of teacher can be reduced by the flipped classroom, since, talking in a lesson can be decreased by using the movie. The preparation of the movies is necessary only once. The movies can be used again in same lesson next year.

Conclusions

I have tried the flipped classroom for lecture of electromagnetism. Some techniques to prepare learning contents for the flipped classroom and its educational effect based on the results of questionnaires and examinations are described in this paper. The movie learning materials for the flipped classroom can be make easily using some functions of Microsoft PowerPoint. Students can access easily the movies which they need in the mychannel of YouTube. It is found that the mini-examination to check themselves their understanding is effective in beginning time of the lesson. Students can work hard and enthusiastically in the lessons applied the flipped classroom. Students decided that the flipped classroom was better than the conventional teaching method for the volition of teacher. Activity of students which was evaluated by themselves obviously increased. Students who appreciated the lesson formed the flipped classroom, had high exam results. Their relationship is a nearly linear.

Teaching load of teacher can be reduced by the flipped classroom, since, talking in lesson can be decreased by using the movie. The preparation of the movies is necessary only once. The movies can be used again in same lesson next year.
References


BASIC INFORMATION SECURITY EDUCATION BY FLIP TEACHING

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Abstract

At National Institute of Technology, Sasebo College, a new subject was established in 2017. It is called Basic Information Security. The targets of this subject are the first grade of all students at Sasebo College and the subject holds the first semester. It is expected that all our students study basic information security skills in the early stage of their life. In this paper, we report education method and effect of Basic Information Security. We made a survey for all students of the first grade at Sasebo College in 2018. We teach our students using informational literacy materials created in Human Resource Education Project on Information Security (KOSEN Security Educational Community, K-SEC), one of projects of National Institute of Technology. The materials include e-learning contents, presentation slides, quizzes and so on about not only information security but also information literacy. In Basic Information Security, we use their materials by flip teaching, one of active learning methods. Before the lesson starts, students watch movies related to course contents of the lesson using e-learning on Blackboard, a learning management system (LMS), as homework. In the beginning of each lesson, carrying out quizzes on Blackboard, students and teachers confirm the level of understanding of e-learning contents. In the main part of each lesson, students do works related to e-learning contents such as group works and exercises using personal computers. These works contribute to enrich their understanding of contents of learning. In the survey, we examined from three points of view, flip teaching, education using Blackboard and goals of Basic Information Security. There are a lot of positive answers of flip teaching and technology enhanced learning, and the effect of information security also shows. More than 85% of all students are satisfied with flip teaching and more than 90% of all students achieve goals of Basic Information Security.

Keywords: information security, flip teaching, survey, e-learning, learning management system

Introduction

As information technology such as the Internet has made progress over recent years, security threats have increased and their damages have been more serious problems. At National Institute of Technology, we provides an environment for our students that are from 15 to 20 years old to be able to use much hardware and software. Our education in the early stage of their life can contribute to society in the field of information security. National Institute of Technology established Human Resource Education Project on Information Security (KOSEN Security Educational Community, K-SEC). We support to be not only information security specialists but also students learned fundamental information security skills. To achieve this goal, at National Institute of Technology, Sasebo College, we established a new subject, Basic Information Security, in 2017. The targets of this subject are the first grade of all students at Sasebo College and the subject holds the first semester. We expect that all our students study basic information security skills in the early stage of their life.

In the new subject, Basic Information Security, we practice flip teaching using e-learning contents, presentation slides and quizzes created by K-SEC. Flip teaching (or flipped classroom) is one of active learning methods proposed Baker (2000). They can study basic skills before lessons and experience proactive learning. By flip teaching, it is assumed that students aspiringly study, learn problem-solving ability and increase learning efficiency.

We use e-learning contents, presentation slides and quizzes on Blackboard, a learning management system (LMS). Blackboard can be used at all colleges of National Institute of Technology. It is easy for teachers of National Institute of Technology to use Blackboard. For example, we can use Blackboard by distributing course materials, submitting homework, taking tests and so on. Students maybe consider that Blackboard have a number of advantage.

In this paper, we report education method and effect of flip teaching and technology enhanced learning using Blackboard in Basic Information Security. We examined from three points of view, flip teaching, education using Blackboard and goals of Basic Information Security. We made a survey for all students of the first grade at Sasebo College in 2018.
Materials and Methods or pedagogy

We explain method of lessons of Basic Information Security. We teach our students by flip teaching using information literacy materials created by K-SEC including e-learning contents, presentation slides, quizzes and so on. The contents of these materials are utilized for not only informational security but also informational literacy. The materials can be run on Blackboard. Before each lesson of Basic Information Security, students watch movies on Blackboard related to the course content of lessons using smartphones or personal computers and so on as homework. It takes students about thirty minutes to watch movies in each lesson. Figure 1 is a screen capture of a movie used in Basic Information Security.

In each 90-minute lesson, first, the students take quizzes which are ten four-choice questions in most cases on Blackboard. The students and teachers can confirm the level of understanding of e-learning content. Then, they review the part they do not understand and retry quizzes. Figure 2 shows quizzes on Blackboard to check understanding of prior learning.

The main part of each lesson is works relate to e-learning contents, for example, work for discussing informational moral (Figure 3) and work for suggesting new information system to improve daily life (Figure 4). These works contribute to enrich their understanding of contents of learning.

Results and Discussion

We made a survey for all students of the first grade at Sasebo College in 2018 to measure effectiveness of Basic Information security. The circle graphs in Figures 5-7 show the results of the survey. We examined the survey from three points of view.

The first is that we evaluate teaching methods themselves, flip teaching (Figure 5). (a) denotes that 85% of the students think that I think so, whereas the remaining 15% do not think so. (b) shows that more than 90% of the students think that I think so. In (c), almost all students feel satisfied with works in lessons. A lot of students are satisfied with flip teaching, whereas it is seen that small number of students want to participate in traditional concurrent lessons such as teachers explain students from the beginning to end of lessons.

The second is an education using Blackboard (Figure 6). (d), (e) and (f) denote that about two third or more than two third of students think that I really think so. It seems that it is useful to utilize Blackboard.

The third is whether students achieve three goals of Basic Information Security (Figure 7). (g), (h) and (i) show that more than 90% of students feel to achieve three goals. Moreover the number of students I really think so is roughly equal to that of students I think that is says either so.
Figure 5. Results of the survey from the viewpoint of flip teaching

(a) It is easier to understand by taking lessons using flip teaching than concurrent ones.

(b) You can confirm how much you understand e-learning contents by carrying out quizzes at the beginning of lessons.

(c) When you study a lot of works in lessons, you can acquire the knowledge you studied e-learning before lessons start.

(d) It is easy to take lessons to check course contents on Blackboard at any time.

(e) It is easy to check results of quizzes and homework on Blackboard at any time.

(f) It is easy to study for regular examinations to utilize Blackboard.

Figure 6. Results of the survey from the viewpoint of using Blackboard
Conclusions

At National Institute of Technology, Sasebo College, a new subject was established in 2017. It is called Basic Information Security. In this subject, flip teaching is used on Blackboard. More than 85% of all students are satisfied with flip teaching and achieve goals of Basic Information Security. There are a lot of positive answers of flip teaching, technology enhanced learning, and the effect of information security shows.

On the other hand, it is seen that small number of students want to participate in traditional concurrent lessons such as teachers explain students from the beginning of lessons. It is assumed that flip teaching is not completely perfect. There are needs to help students which are not adapted to flip teaching individually.

Moreover in the future we are going to expand the method of Basic Information Security to other colleges at National Institute of Technology. There seems to be classes to teach information literacy for first grade in every colleges at National Institute of Technology. We have advertised the method of Basic Information Security to introduce in various regions.

References


BUILDING YOUR OWN RAPID eLEARNING AUTHORING TOOL

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Abstract
This paper will discuss the benefits of building one's own rapid eLearning authoring tool vis-a-vis using commercial software packages. These benefits range from cost savings in the long run, customised features and capabilities to a consistent user experience standard.

Keywords: eLearning, content, authoring, HTML5, web, application

Introduction
Rapid eLearning authoring tools are widely used by subject matter experts or teachers to develop eLearning content in a very short time frame, usually in terms of weeks. These tools allow content authors to assemble text and media objects into files that run on HTML5-compliant browsers. As HTML5 is supported by various devices, learners can use computers, tablets or smartphones to consume the eLearning content. This paper argues that while most commercially available tools are powerful and user-friendly, choosing which tool to use may not be that easy as the decision involves many factors. At the end, it may be easier if one builds one’s own tool.

Why use rapid eLearning authoring tools?
In recent years, there is an increasing demand for teachers to design and develop their own eLearning materials. After all, teachers, especially the experienced ones are in the best position to understand their learners’ needs. If it is not unusual for teachers to prepare their own course materials for conventional class delivery, they can also learn new ways to publish their course materials on an electronic platform.

Teachers who are involved in blended learning\(^1\) feel all the more necessary to develop and manage their own eLearning materials. If it is not unusual for teachers to prepare their own course materials for conventional class delivery, they can also learn new ways to publish their course materials on an electronic platform.

Modern rapid eLearning authoring tools are designed for users who have little or no programming background. Most of these tools come with a graphical user interface that allows users to assemble text and media objects on the computer screen a la PowerPoint.

Choosing the tool
Rapid eLearning authoring tools come in two categories in terms of costing: commercial packages and freeware tools. It is fair to say that most content developers will not be bothered too much about the cost of acquiring such tool so long as it is useful. In fact, many popular commercial packages (such as Adobe Captivate and Articulate Storyline) are cost effective. As for freeware tools, some (such as Adapt) come with a comprehensive set of features and functionalities comparable to those of the commercial packages.

If you are an independent developer, you can choose your tool according to your needs and liking: you may need certain features and functionalities and prefer certain design and architecture. There are many product guides\(^2\) available on the internet to help you identify the tool that suits you most.

If you work in an organization, your choice may be constrained by your organization’s software policy, IT infrastructure, eLearning strategy, etc. For example, your organization may have a learning management system (LMS) in place. In this case, the tool you are going to choose must work well with the LMS. In the best scenario, they can complement each other in terms of features and functionalities.

At the Foreign Language Centre (FLC), Nanyang Polytechnic, Singapore, our choice of eLearning authoring tool is governed by three major considerations:

1. Course delivery – Our foreign language courses are delivered in blended learning mode whereby students learn in part through conventional class teaching and in part through online learning. At Nanyang Polytechnic, we use a learning management system (LMS) called Blackboard to administer students’ online learning. The LMS provides us with tools to monitor the

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\(^1\) In this paper, we adopt the definition of “blended learning” as stipulated in Christensen, Horn and Staker (2013).

\(^2\) For a comprehensive product guide, see “The Ultimate List of HTML5 eLearning Authoring Tools” by Christopher Pappas (2017).
students’ learning progress and to create assessments with marking schemes (which consist mainly of multiple choice questions), but we have to develop our own learning content using third party tools.

2. Instructional design – We design our learning content with the textbook metaphor in mind: learning content is organized in lessons according to communication themes. A typical lesson consists of situational dialogues, explanatory notes, vocabulary lists and reinforcement exercises (such as grammar drills, fill in the blanks and cloze passages).

3. Media objects – Our learning content contains lots of voice recordings of our own production. Audio is played at various levels: word, phrase and passage. We use images to illustrate various language situations. Many of the images are acquired through licensing. As video production is resource-taxing and beyond our budget, we make use of public domain video wherever appropriate.

While most of the rapid eLearning authoring tools available in the market allow content authors to build engaging learning content, they are not well-suited for creating materials specific to our language courses. For example, with the popular authoring tools we have tested, it is very difficult to include inline audio (i.e. words or phrases with clickable sounds) and to make cloze passages with draggable word items.

On the other hand, as these tools are meant for general purpose use, they contain many features and functionalities which our teachers would never use. In fact, instead of helping us to build our learning content, they could stand in our way and contribute to the steep learning curve.

Building your own rapid eLearning authoring tool

If you cannot find a suitable authoring tool in the market, then how about building your own tool? It is not as intimidating as it may sound. As mentioned earlier, what the tool does is to help you assemble text and media objects into HTML5-compliant files that run on web browsers. In other words, the output is a set of web pages, albeit web pages with a higher complexity.

Therefore, for those who are familiar with building web pages (which is considered to be an IT skill quite common in the age of the internet), they may very well consider developing their eLearning content from the ground up by leveraging on the versatility of HTML5. Indeed, many web-savvy teachers have been using commercial HTML editors (such as FrontPage and Dreamweaver) for years to build eLearning content.

A simple framework for a rapid eLearning authoring tool

At FLC, Nanyang Polytechnic, we have created our own rapid eLearning authoring tool using the framework as follows:

![Figure 1: The FLC rapid eLearning authoring framework](image)

For the content authors, the tool is basically a web-based text editor which they run from the web browser on their PC. As it is web-based, the editor supports practically all natural language scripts, including those of Japanese and Korean which are among the foreign language courses that we offer.

![Figure 2: The FLC web-based text editor running from a browser](image)

Our language teachers use a pre-defined set of mark-up tags to assemble text and media objects in the text editor. For example, the {dialog} tag is used for formatting a dialogue passage, the {audio} tag for inserting a clickable inline audio recording, and the {embedExo} tag for embedding a reinforcement exercise in the lesson.

A teacher with no programming background may need to spend 3 to 4 hours to learn how to use the most common mark-up tags before he/she can start building a typical lesson. Indeed, most of our language teachers managed to pick up the editing skill within hours, and some of them became masters within weeks.

The text editor will format the lesson content in XML data and save it in our web server. Together with the relevant media object files, the XML file will be uploaded to the LMS where a pre-built lesson file in HTML5 format will interpret the XML data accordingly and display the learning content on the learner’s browser screen:
If the content of a lesson needs to be amended for one reason or another, the author can retrieve the XML file from the web server into the text editor for editing. After the amendment, he/she just needs to upload the updated XML file (and eventually new versions of media object files) again to the LMS.

Who needs an in-house eLearning authoring tool?

Admittedly, building an eLearning authoring tool even as basic as the one mentioned above will require some coding techniques. Based on our experience, an authoring tool with basic features and functionalities will require a skillful programmer to work over a period of three months. The cost is justifiable if the development involves a large group of content authors who share among them the same instructional design, similar sets of media objects and computer-mediated activities.

For instance, at FLC, our in-house authoring tool is used by some 10 language teachers across four foreign languages: French, German, Japanese and Korean. Every semester, they create and update the learning content of some 20 course modules catered to over 1,000 students. The media objects and the HTML5 lesson files are shared among the modules to a great extent.

As it is built in-house based on the HTML5 standard, the tool is highly extensible and scalable. It can grow to include more features and functionalities if need be. Indeed, by taking full advantage of the web community where an abundance of open source HTML5 templates, JavaScript snippets and CSS libraries are available, our authoring tool has grown into a powerful tool just nice and fit for our language teachers.

Results and Discussion

The major benefit of building our own tool is that it allows us to custom-make exactly the features and functionalities that we need. This helps to cut down on the time we would otherwise need to spend on exploring the full capability of a commercial package before we could use it effectively. Furthermore, our eLearning content can achieve a unique brand image and consistent user experience in terms of look and feel across all our language courses.

Conclusion

Our experience shows that it is possible to build eLearning content rapidly and directly on HTML5 without relying on third-party tools or add-ons. With our own authoring tool, language teachers only need to focus on certain features and skills required to create their learning content, thus avoiding the learning curve and heavy runtime overhead as entailed by the use of commercial tool packages.

Acknowledgement

We would like to thank the management of the Nanyang Polytechnic for their strong support for the FLC rapid eLearning authoring tool project. We would also like to thank our language teachers for their valuable feedback.

References


Enhancing Learning in Pharmaceutical Care Services with an E-Learning Platform

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Abstract

A two-year government-funded project is aimed to enhance the learning experiences of post-secondary students in pharmaceutical care studies in Hong Kong with e-platform support. A project-website and a related mobile app are set up for registered users to access online lectures with multimedia content (audios, videos and animations) and hyperlinked reference materials via personal computer, tablet, and smart phone with commonly employed search machines and operating systems. Moodle, a free and open-source system, is adopted as the learning management system (LMS) for managing the project teaching and learning materials with additional integrated features, such as an online game with live score results. Based on a well-established, higher diploma curriculum in dispensing studies, two-level learning programs with carefully selected topics are designed and developed to facilitate self-learning for post-secondary students with a diverse science background and at different levels of English proficiency. Concepts and knowledge in natural science are integrated into the teaching and learning materials so as to enhance students’ understanding on professional knowledge, skills and techniques in pharmacy practice. Word parts and roots, many of which are of Greek or Latin origin, are introduced in order to facilitate students tackling difficult scientific and medical terms as well as English vocabulary. Learning and memorizing drug names becomes easier with audio pronunciations available on demand to users with online access. Each lecture with suitable multimedia content and quiz breaks is carefully planned and paced to optimize learning. On-screen hyperlinked lecture script in English with Chinese translation for selected vocabulary is available as the lecture video is streamed. To complement traditional face-to-face teaching and learning, the project aims to employ technology to enhance vocational professional education training (VPET) for better results. The project is funded by the Quality Enhancement Support Scheme (QESS) under the Self-financing Post-secondary Education Fund of the Education Bureau, HKSAR.

Keywords: Pharmaceutical Care, dispensing practices, English, e-learning, self-learning, technology enhanced learning (TEL), Moodle, multimedia, vocational professional education training (VPET)

Introduction

Due to the secondary education reform in Hong Kong, the basic entry requirement to higher diploma programs in Hong Kong Institute of Vocational Education (HKIVE) has been changed to students who have completed 6 years of secondary education instead of the previous 5 years and have obtained a minimum score of 2 in five principal subjects in Hong Kong Diploma of Secondary Education Examination (DSE). The corresponding duration of study of higher diploma programs has been reduced from 3 years to 2 years.

The change has a significant impact on the curriculum in a well-established 3-year, full-time program of Higher Diploma in Pharmaceutical Technology at the Chai Wan campus, which the core areas of study covering both pharmacy dispensing and pharmaceutical manufacturing. Two 2-year full-time Higher Diploma programs were launched in 2012-13, one in Dispensing Studies providing students as potential dispensers working in a pharmacy and the other one in Pharmaceutical Science serving the local pharmaceutical manufacturing industry.

With the reduced duration of study, a number of challenges for the teaching team in Dispensing Studies program surfaced. Firstly, there has been an overall change in the academic background of the students applying to the program; fewer students admitted have been those with a strong science background compared to the pre-DSE era. The teaching team realizes there is a growing need to bridge the knowledge gap as well as showing relationship between basic scientific knowledge and concepts in chemistry and biology and study of drug use for the incoming students. Secondly, the students have to assimilate basic knowledge in disease, pharmacology and dispensing practices, which involve acquisition of a large number of drug names and medical...
They have to accomplish this within two years, instead of the previous three years. Ability to pronounce English words, including vocabulary and names, is vital to memorize drug names and medical terms. Websites with audio recordings of drug names and medical terms are available throughout the internet, which these links have been introduced to students. To incorporate these resources into the curriculum systematically can be challenging for the teaching team.

Long and difficult scientific and medical terms are made up of word parts that can be traced back to their Greek or Latin origin. Many word parts, such as hyper- and hypo-, repeatedly occurs in many commonly used medical terms. Recognition of these commonly used prefixes and suffixes as well as word roots and knowledge about the meaning of these word parts in any given vocabulary by the students have been incorporated in the curriculum since 2015-2016 with low success in terms of facilitating students to learn medical terminology. The list of word parts with meaning and sample terms for each word part is provided to the students; the list is long and hard to use effectively. How to use the list is introduced to the students in mass lectures supplemented with small group tutorial sessions. Availability of scheduled contact time is limited; the potential usefulness of the list is greatly hampered.

Lastly, industrial attachment is mandatory for graduation; students are assigned to different pharmacies in order to gain actual work experience during the summer break. With the shortened 2-year program, summer available for industry attachment has been reduced from two to one only. To compensate for the deficiency, an alternative is sought to supplement the reduced industrial exposure. Demonstrative videos can be an invaluable tool to enhance the learning experience of the students in order to gain competency in performing dispensing and pharmaceutical compounding.

Technology enhanced learning (TEL) is a much talk about topic in education. High definition video image capturing with high fidelity audio recording is a powerful tool for design and develop teaching and learning materials in this age of information technology. According to the 2017 Thematic Household Survey on Information technology usage and penetration from Census and Statistics Department of the Hong Kong Government, internet access via personal computer, laptop, tablet, and smart phone is extremely prevalent among the age groups which our students fall into. Internet is the platform of choice for dissimulation of lectures beyond the four walls of a classroom.

Funding was granted from the Quality Enhancement Support Scheme (QESS) under the Self-financing Post-secondary Education Fund of the Education Bureau, HKSAR. The project titled Enhancing learning in pharmaceutical care services with e-platform support is aimed at enhancing the learning experiences of our post-secondary students in our Dispensing Studies program as well as other students in related areas of study.

### Materials and Methods or pedagogy

An information technology company is commissioned to design, develop, and maintain the project website and a related mobile app, which are searchable by commonly used internet search engines as well as via smartphones using the two most popular mobile operating systems. Moodle is chosen as the basis of the project learning management system with project-specific features. Moodle is a free and open-source learning management system (LMS), which is also adopted by HKIVE as the web-based platform for online communication and management of teaching and learning with all students under Vocational Training Council (VTC) of Hong Kong. The teaching team are already familiar with the LMS and can manage and expand the online contents with ease. The project website and the mobile app are expected to be launched in September 2018. Users are required to register for access to the learning materials.

A production company with experience in producing multimedia content and, more importantly, in developing educational online materials is selected to create and produce project-specific learning programs. PowerPoint-based lecture videos, demonstrative videos on pharmaceutical compounding skills, and animations and videos for pharmaceutic experiences for explaining scientific concepts are planned from June to November 2018.

Two programs are planned: A bridging program and a commentary-remedial program. The bridging program is aimed to equip incoming students with a weak science background. It covers basics in chemistry and biology as well as a reviewing English sentence structure. The commentary-remedial program is aimed to help progressing students in core study modules, which are Pharmaceutics, Pharmacology, Dispensing Practices, etc. This program covers key pharmaceutical concepts, areas in pharmacy practices and dispensing practices, pharmaceutical compounding and aseptic dispensing, word parts and medical terminology, medical and prescription abbreviations, and pronunciation of drug names.

Online quizzes are planned for each online lecture. In addition, a quiz-based game is planned for all users. The game is based on knowledge of word parts, abbreviation, and drug names. A live scoreboard will be published online to enhance the interest and participation from users.
Abstract

The aim of this research is to improve teaching effectiveness of Bachelor-level human–computer interaction courses by integrating visual learning techniques, including mind mapping and flowchart techniques. The research is an extension of an earlier study, which incorporated mind mapping during a semester-long course. The research included 83 students enrolled in the 2017 course. A pre-test/post-test mixed methods design was used for the study, with students tested before and after the mind mapping technique on their initial knowledge of HCI concepts at the start of the course. The intervention consisted of a teaching session on the mind mapping and flowcharting techniques, and students were encouraged to use these techniques in their independent and group study. The techniques were also modelled in lectures. The results showed an improvement in the post-test scores, with all students achieving passing scores. These findings imply that incorporating mind mapping and flowcharting is effective for undergraduate learning.

Keywords: Mind mapping, Flow chart, Teaching Technology, Undergraduate Students

Introduction

One of the critical problems of computer science education is that despite the very high demand for programmers and other CS professionals, there is a very high dropout rate from undergraduate programs (Giannakos, Pappas, Jaccheri, & Sampson, 2017). There are a lot of reasons for this high dropout rate, including perceived challenge of the program and potential deficits in teaching quality as well as personal values and intellectual challenge among others (Giannakos, et al., 2017). One of the potential factors that leads to a high dropout rate for CS students is study skills that are inadequate or poorly suited to the learning demands of the program (Howles, 2009). This problem can become apparent in the early stages of CS education, as students encounter materials and learning demands that are unlike the learning challenges they faced in their secondary education. For example, students may not be familiar with the visual learning techniques and collective learning approaches that facilitate technology learning (Howles, 2009). Thus, one of the key challenges for a CS educator is to provide students with the learning tools required to facilitate and enhance their learning. Furthermore, undergraduate CS students in some disciplines face special learning challenges. Human–computer interaction (HCI) is one of these fields. Undergraduate students do not have as much real-world experience as postgraduate students and may not understand the importance of HCI in usability (Calderón, 2009). They also may not understand how HCI works with system design (Pastel, Brown, Woller-Carter, & Kumar, 2012). Therefore, undergraduate students may require different teaching approaches and scope than postgraduate students when learning HCI (Pastel, et al., 2012).

This research investigated the integration of two visual learning techniques into an upper-level HCI course at a Thai university. Visual learning techniques have long been promoted as effective for science and engineering disciplines because they help students improve communication and help them connect concepts and theories, increasing interest and working with natural learning styles of many of the students (McGrath & Brown, 2005). This study extends an earlier research project, incorporating two visual learning tools (mind mapping and flowcharting) to improve the learning environment.
Visual Learning Techniques: Mind Mapping and Flowcharting

This research used two visual learning techniques: mind mapping and flowcharting. These techniques are similar in nature but have different levels of representational rigor and different symbolic approaches.

Mind mapping is a visual technique in which students or teachers create diagrams that represent key concepts and the connections between them (Davies, 2010). The mind mapping technique is a flexible technique, which can utilise either technological tools or pen and paper. The approach used is dependent on the student, since the main goal of using mind mapping is to help students remember and connect concepts and theories (Davies, 2010). Different symbols, colours and connections can be used depending on the student’s needs to create a network of concepts and their connections (Davies, 2010). Mind mapping is not just a useful classroom learning tool, as it is also used in professional software engineering applications such as requirements engineering (Mahmud & Veneziano, 2011). Therefore, the adoption of mind mapping in the HCI classroom is useful both as a study technique and as a required professional skill. Previous research has shown that mind mapping is an effective tool for science and technology learners. For example, it has been shown to be effective at introducing creativity and facilitating conceptual learning for engineering students (Zampetakis, Tsironis, & Moustakis, 2007). These authors showed that mind mapping allowed engineering students a degree of creativity in learning and maintained flexible learning capabilities, which are critical for engineering skills but often ignored in the curriculum (Davies, 2010). Mind mapping can also be used effectively in conjunction with other learning techniques. For example, a study in computer science students in Malaysia has shown that it is effective at helping students learn analytical skills and logical thinking skills (Ismail, Ngah, & Umar, 2010). These authors showed that mind mapping was an effective tool for facilitating student cooperative learning, with significant improvements in test scores between students taught mind mapping and cooperative learning and those with no additional teaching techniques (the control group) (Ismail, et al., 2010).

Flowcharting is the second technique used in this study. Flowcharts are ordered and structured visual representations of processes, algorithms or other connected concepts, which are some of the earliest tools introduced in CS teaching (Reed, 2011). Unlike mind maps, flowcharts do not typically represent networks of concepts, but may instead represent processes and components (Reed, 2011). The flowchart was one of the earliest tools developed for visual representation in computer science, emerging in the late 1940s and early 1950s and being well-established by the 1960s when they could be represented using computer code (Knuth, 1963). Flowcharts are a common part of instructional design in CS programs, and are often used with pseudocode to represent programs and connect concepts (Ismail, Ngah, & Umar, 2010). They are critically important tools for teaching CS because of their ability to visually represent dynamic processes, although they can also be difficult to understand (Fouh, Akbar, & Shaffer, 2012). They are also commonly integrated into CS instructional technologies, which frequently enable students to construct flowcharts to represent concepts and as a preliminary step for implementation of algorithms and as part of their code design process (Santos, Gomes, & Mendes, 2010). For example, common programming teaching tools use flowcharts as part of their algorithm process and it is common for lecturers to use flowcharts to visually represent concepts (Santos, et al., 2010). However, these tools are often poorly explained and students may not be explicitly instructed in how to construct and use them efficiently (Ismail, et al., 2010). Therefore, flowcharts may not be as strong a teaching tool as they could be, depending on the process used to teach students about them. In fact, a study of student failure and student attrition in computer science points to inadequate instruction on how to use flowcharts, along with other common representational tools such as pseudocode, as one of the reasons why students may not be successful at computer science programs (Sarpong, Arthur, & Amoako, 2013). Therefore, even though the use of flowcharts is a potentially useful tool for CS students both in their classes and in later professional life, they may not be taught how to use the tools effectively. Thus, there is an opportunity to improve teaching effectiveness by offering explicit instruction on flowcharts, how they are constructed and what they mean.

Pedagogy

The study took place during the second semester of the 2017 teaching year, in an undergraduate introductory HCI course aimed at third and fourth year undergraduate students.

The evaluation began with an introductory assessment of knowledge about HCI, including 25 items that measured simple and complex concepts that would
be addressed over the course of the term. This questionnaire also included additional items about previous experience with mind mapping and flowcharts. The same instrument was used during the pre-test period (first week of class) and post-test period (last week of class). Participation in the assessment was optional and it was presented as a self-assessment exercise. It was distributed as an online multiple choice quiz through the course’s content management system (CMS). The quiz did not count toward the student’s grade in the course, but a passing grade of 50% was established as the goal for ensuring the student would pass the course. Data was also collected using observations and informal interviews with students over the period of study.

The mind mapping and flowchart tools were presented and discussed explicitly during the seminar portion of the first week of the class. Following this introduction, a post-intervention questionnaire was distributed, repeating the learning tool questions from the initial assessment. The introduction of the tools was accompanied by a comprehensive guide and tutorial distributed through the CMS system. Students were encouraged, though not required, to use mind mapping and flowcharts as self-guided learning tools and during group exercises throughout the course. Both tools were also used routinely in presentation of information, for example in lecture presentations and notes and in tutorial sessions.

Analysis of the pre-test/post-test assessments was performed using descriptive statistics, including average (mean and standard deviation) and categorical analysis of pass rates. The findings also contain a review of the overall performance of the tools in the teaching process.

Results

The pre-test assessments showed that 100% of students had encountered flowcharts in their coursework previously, but only 48 students (57.8%) were confident in interpreting flowcharts and only 22 students (26.5%) had previously used them in more than one class assignment. Mind mapping was less well-known, with 69 students (83.1%) encountering them previously, 36 students (43.3%) being confident in interpretation, and 17 students (20.5%) using them in more than one previous assignment. In the post-intervention follow-up assessment, 71 students (85.5%) reported feeling confident in interpreting flowcharts and 64 students (77.1%) reporting feeling confident in interpreting mind maps. Throughout the course, 56 students (67.5%) used flowcharts in their submitted work or during in-class exercises at least one time, while 79 students (95.2%) used mind mapping in their submitted work or in-class exercises at least one time. Therefore, it can be stated that in terms of teaching the mind mapping and flowchart techniques, the deliberate introduction of the material was successful.

The results of the pre-test/post-test assessments of HCI knowledge are shown in Table 1. As this table shows, the initial scores were relatively low, with 18 students (21.7%) scoring less than a 50% mark. During the post-test period, all 83 students passed the exam, with only one scoring below 65%. This performance was higher than the previous year’s performance, where two students scored below 65%. Thus, there was a noticeable improvement in HCI general knowledge over the course of the semester for all students.

Table 1 Summary of pre-test/post-test outcomes for HCI knowledge assessment

<table>
<thead>
<tr>
<th>HCI class in 2017</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fail*</td>
<td>Pass</td>
</tr>
<tr>
<td>Number of students</td>
<td>18</td>
<td>65</td>
</tr>
<tr>
<td>Percentage</td>
<td>21.6%</td>
<td>78.4%</td>
</tr>
<tr>
<td>Remarks</td>
<td>#Score lower than 50% means fail</td>
<td>**Only 1 students achieved less than 65%</td>
</tr>
</tbody>
</table>

Discussion

The findings showed that students became more confident and knowledgeable about flowcharts and mind mapping over the course of the semester and began to use the techniques more frequently as the term went on. The findings also showed that the students’ general knowledge of HCI increased. These two factors cannot be directly correlated, since students were also absorbing knowledge from the lectures, coursework, and independent research and reading that was part of the course. However, the increase in knowledge and confidence about the two techniques suggests that there
is a significant benefit to explicitly teaching students to use these techniques.

The success of introducing these techniques into an upper level class raises the possibility that it would be better to introduce these tools even earlier in the undergraduate curriculum. Lack of appropriate study skills and knowledge is known to be one of the main factors in student dropout from CS programs (Giannakos, et al., 2017; Howles, 2009). These problems become evident early, as students begin to struggle in their lower level courses (Howles, 2009). Therefore, it would be appropriate to teach the techniques at an even earlier stage, rather than to the third and fourth year undergraduates enrolled in the study course. This would help improve student performance and increase retention rates. It could also help students begin to develop visual understanding and help them identify the connections between concepts of HCI (Calderón, 2009). Furthermore, these techniques may be useful for students outside the CS program. Mind mapping is a general technique that can be used to visually explain connections between any complex network of concepts (Davies, 2010), making it an appropriate tool not just for science learning but also for other concepts. While flowcharts are perceived as a STEM tool (Reed, 2011), in fact they are ideal for representing complex dynamic processes (Fouk, et al., 2012). Therefore, they could also be useful in other disciplines as well. Therefore, this research provides continuing evidence that the use of such visual teaching tools could be more widely helpful in Thai undergraduate teaching.

**Conclusion**

The reason for conducting this research was to examine how undergraduate teaching for CS students could be improved by integrating two visual learning techniques – mind mapping and flowcharts. The outcomes of the semester-long intervention showed that when these techniques were specifically explained to students, they gained confidence in interpreting the representations and in using them to represent their own concepts and processes. The study also showed that student learning may have been enhanced, although as with any other classroom interventions there are multiple conflicting factors. However, the increase in use of the tools over the course of the semester does indicate that the tools are effective at improving learning.

This study provides some recommendations for CS teaching practice. Given the importance of both mind mapping and flowcharts in the professional life of CS graduates and the role of appropriate study techniques in preventing CS program attrition, it would be well worth introducing these tools during formal CS classes. This introduction should occur even earlier than the upper-level undergraduate course. The study was conducted within, potentially within the first few courses in CS that undergraduates take. This is necessary because students may not gain confidence with these tools, meaning that they may lose a lot of learning resources that could be better used if they understood the teaching tools. It also implies that the integration of visual learning tools like mind mapping and flowcharts into course materials, lecture notes, and assignments can help students gain confidence in their use of the tools and increase the likelihood that they will be able to use these tools effectively, which would improve the student experience and learning.

**References**


A PILOT STUDY OF MEASURING THE EFFECTIVENESS OF BLENDED LEARNING

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Abstract

This study examined four factors of students’ perceptions towards a blended learning environment of a module. Two surveys measuring e-learning experience and study process were administered to seventy-four second-year engineering students at a polytechnic in Singapore. Final module grades were examined for correlation analysis. It was found that students generally agreed that this module provided a good on-line environment for learning as well as sufficient on-line resources to enable students to learn effectively. Their online interactions with the lecturer and peers have aided them to delve further into their learning. Furthermore, all four factors, blended learning approach of the module and deep approach to learning were significantly correlated with each other. The findings of this study can provide valuable insights for the development of similar modules in a blended learning environment.

Keywords: e-learning, online learning, blended learning, life-long learning, information and communication technologies

Introduction

In Singapore, the Ministry of Manpower launched a Continuing Education and Training (CET) masterplan, which aimed to prepare the Singapore workforce for the future and to ensure a competitive and career resilient workforce (Tan, 2014). At the same time, “Singapore envisaged to be a Smart Nation, where people lived meaningful and fulfilled lives, enabled seamlessly by technology, offering exciting opportunities for all.” (Lee, 2014) As such, together with the rapid development of information and communication technology (ICT), e-learning has been envisioned as a staple learning system that underpins the future CET framework (Tan, 2014).

Benefits of e-learning

There were several benefits of e-learning and thus explained the wide acceptance in education, especially for institution of higher learning and in the realm of adult learning. The predominant benefit is the flexibility of learning in terms of time and place (Lee & Lee, 2009; Mahdizadeh, Biemans, & Mulder, 2008; Sun, Tsai, Finger, Chen, & Yeh, 2008). Learners have the freedom and the discretion to learn wherever they were, at any time of the day. As learning materials are normally available online or given in digital format, learners do not need to be in school premises to access learning content (Lee & Lee, 2008; Liaw et al., 2007; Liaw, 2008; Ozkan & Koseler, 2009; Sun et al., 2008). This helps to save travelling time, giving the learners opportunity to learn more. E-learning could be conducted in two modes: synchronous and asynchronous. In synchronous mode, the lecturer with learners or learners with learners need to participate in the learning process at the same time through the internet space. This helps to alleviate space limitation. As long as the learners have internet access, they can learn wherever they are. After the synchronous session, if learners have any learning issue, they could make use of an asynchronous platform to seek help from their lecturer or peers. Asynchronous platform could take several forms, such as email, chat group, social media or discussion forum. In the asynchronous mode, the use of e-learning allows learners to learn at their own pace. This, therefore, increased learning satisfaction and reduced stress (Arkorful & Abaidoo, 2015; Liaw, 2008; Mahdizadeh et al., 2008; Sun et al., 2008). Learners, who are introvert or shy in expressing themselves, often, have difficulty interacting and communicating in class. E-learning could enhance group discussion and collaboration, where it creates a platform liberating interaction between lecturer with learners or learners with learners, without seeing the person physically. This helps to eliminate barriers, give learners the freedom to express their thoughts and ask questions without much limitation. E-learning allows learners to choose from the variety of learning materials that best suit their learning needs (Arkorful & Abaidoo, 2015). For example, some learners may focus on certain sections of the course materials, while others are prepared to review the entire course. Therefore, this way of customizing content for learners’ need could enhance educational values (Engelbrecht, 2003). Lastly, from the lecturers’ perspective, e-learning could be a cost-effective way to offer opportunities to maximise the number of learners without the need for additional infrastructure resources (Arkorful & Abaidoo, 2015). Furthermore, this could help to compensate for lack of academic staff, including instructors, lab technician, etc. Through e-learning,
learners were encouraged to depend on themselves as lecturers were no longer the solitary source of knowledge, instead, they became advisors and guides (Alsalem, 2004).

Pitfalls of e-learning

In spite of the benefits, researchers argued that e-learning still has its weaknesses. As compared to an environment where learners were surrounded by lecturer and peers, during the course of e-learning, learners, most of the time, might be alone trying to make sense from the given learning material. Thus, they might suffer from isolation or remoteness going through the e-learning content (Al-Qahtani & Higgins, 2013; Arkorful & Abaidoo, 2015). Furthermore, this could cause issues of clarification and interpretation as learners may not have anyone to talk to at that instant when they had learning issues. Another situation could be that the lesson designer might assume the learners to have a certain level of understanding about a particular concept. However, there might have a gap where the learners’ understanding was different from what the lesson designer has assumed. Typically, this situation does happen even in normal face-to-face classroom teaching. However, it can be mitigated on the spot in class because once the lecturer sensed that there was any misconception through their interaction with the learners or from their behavior in class, the lecturer could rectify instantly by addressing the learning issues. On the other hand, in the e-learning environment, the lecturer has limited control over the situation. Lastly, although e-learning can help to avert the situation of learners having interaction or communication issue, this might pose a negative effect on learners’ socializing skills because, for full e-learning courses, they were often not required to meet face-to-face and had to complete all learning assignments through computers and internet. This would result in learners acquiring excellent academic knowledge but they might not possess the needed skills to deliver their acquired knowledge to others.

Blended Learning

Since pure e-learning and traditional face-to-face learning hold some weaknesses and strengths, mixing the strengths of both learning environments could enhance students’ learning experience (Azizan, 2010). This new environment is commonly called blended, hybrid or mixed learning. This new strategy capitalizes on the positive aspects of e-learning and to mitigate the negative aspects of face-to-face learning. As such, blended learning has gained its popularity over the years because lecturers believed that varied delivery methods can increase students’ satisfaction from the learning experience as well as their learning outcomes (Lim & Morris, 2009).

There are numerous research articles on evaluating various aspects of blended learning. One of the most important aspects would be to look into the coherence of e-learning with face-to-face learning as “the overall goal of a blended learning experience is to provide a mix of both on-line and face-to-face experiences which support each other in achieving desired learning outcomes” (Ginns & Ellis, 2007, p. 55). Thus, this study intends to extend the work from previous research done by Ginns and Ellis. Ginns and Ellis administered an instrument to a group of undergraduate degree students in an Australian university. This study aims to extend the use of this instrument to a younger cohort of students in a Singapore educational institution. As such, the guiding research questions are as follows:

- What are the factors of student’s perception towards effective blended learning environment?
- How these factors are correlate to student’s approach to learning and their academic grades?

The Participants

Seventy-four Year 2 students from a polytechnic in Singapore, who were enrolled in a module, Green Building Technology and Design, were invited to participate in the survey during the twelfth week of Academic Year 2017 Semester 2. They were briefed about the purpose of the study and how the study will be conducted. Students were informed that their participation will be kept anonymous and that they can refuse or discontinue participation at any time without penalty. After cleaning the data, sixty students’ responses were valid and fourteen students’ responses were incomplete.

Instruments

This study adopts a quantitative methodology where students, filled out two paper-based survey questionnaires, namely, a 31-item E-learning Experience Questionnaire, and a 20-item Study Process Questionnaire-Revised (R-SPQ-2F). The e-learning experience questionnaire was adapted from Ginns and Ellis (2007). To suit local context, word like “teacher” was substituted to “lecturer”. Some questions were rephrased to suit the way blended learning is conducted for the module under research. For example, the original question was, “The relationships between the on-line resources and the whole unit of study was clarified on the unit’s website” and it was changed to, “The relationships between the on-line activities and the whole module motivated me to learn more deeply”. One question was removed, as it was not applicable to the module under research. The study process questionnaire was adopted from Biggs, Kember, and Leung (2001). The original version of this questionnaire (Study Process Questionnaire SPQ) was developed in 1987 and it has been widely used by education researchers assessing approaches to learning. Choy, O’Grady and Rotgans (2011) validated the SPQ with 1,608 Republic Polytechnic (RP) students and results shown that the construct validity and reliability was deemed adequate. Biggs and his team revised the questionnaire in 2001 to a two-factor version. The new version has fewer items and is found to be suitable for use by teachers in evaluating the learning approaches of their students. For
Procedures

This study takes a semi-exploratory approach to the data collected, as the e-learning experience questionnaire was not validated in Singapore while the study process questionnaire was partially validated. The goal of the analysis should be guided as far as possible by prior research while being flexible enough to allow possibilities for future research to emerge. The analysis was based on the data collected from the two questionnaires. Correlations between factors, the R-SPQ-2F, the overall satisfaction with blended learning module and students’ final module grade were examined.

Exploratory factor analysis was carried out to assess the dimensionality of students’ responses on the thirty-one items of the e-learning experience questionnaire. The analysis involved principal component analysis as the factor extraction method with equamax rotation to extract four factors. Items with loadings less than 0.4 were eliminated. The items and factor loadings are shown in Table 1. The Keiser-Meyer-Olkin value of sampling adequacy was .754, which exceeded the recommended value of 0.6 and Bartlett’s Test of Sphericity showed statistical significance. The analysis revealed that the four factors have eigenvalues greater than 0.7 is considered good.

Results and Discussions

The pattern matrix in Table 1 showed the grouping of the items based on the loadings. There were some differences in the groupings of the items as compared to the research done by Ginns and Ellis. Nonetheless, based on the description of the items, it was appropriate to use the same label descriptions as the prior research. The factors were labelled as Good e-Teaching, Good e-Resources, Appropriate Workload, and Students’ Interaction. With these grouping, the measure of reliability was examined for all four factors and the results are shown in Table 2. Generally, Cronbach’s Alpha of more than 0.7 is deemed acceptable and more than 0.8 is considered good.

Next step is to analyse the students’ responses to the four factors that were identified earlier. Table 3 showed the descriptive statistics on the issues of online teaching. The module under research has two on-line environments that the students used. First, there is an on-line platform where students used to access learning material for their daily lesson. The other on-line environment was more specific to the module itself. It is a free voice and text chat app, where students used the app to discuss learning issues among their classmates or with their lecturer. As the results have shown, majority of the students agreed that the lecturers made good use of the on-line environment to facilitate their learning by providing prompt guidance. Table 4 showed the descriptive statistics on the issue of online resources.

<table>
<thead>
<tr>
<th>Items</th>
<th>Good e-Teaching</th>
<th>Good e-Resources</th>
<th>Appropriate Workload</th>
<th>Students’ Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL5</td>
<td>.709</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL30</td>
<td>.707</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL26</td>
<td>.639</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL19</td>
<td>.627</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL6</td>
<td>.615</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL7</td>
<td>.560</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL3</td>
<td>.678</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL21</td>
<td>.650</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL25</td>
<td>.627</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL9</td>
<td>.447</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL13</td>
<td>.436</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items</th>
<th>Good e-Teaching</th>
<th>Good e-Resources</th>
<th>Appropriate Workload</th>
<th>Students’ Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL14</td>
<td>.669</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>EL11</td>
<td>.638</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL23</td>
<td>.581</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL20</td>
<td>.545</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL22</td>
<td>.454</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL4</td>
<td>.436</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2

Reliability Statistics

<table>
<thead>
<tr>
<th>Factors</th>
<th>No. of Items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good e-Teaching</td>
<td>10</td>
<td>.843</td>
</tr>
<tr>
<td>Good e-Resources</td>
<td>8</td>
<td>.799</td>
</tr>
<tr>
<td>Appropriate Workload</td>
<td>6</td>
<td>.702</td>
</tr>
<tr>
<td>Students’ Interaction</td>
<td>5</td>
<td>.700</td>
</tr>
</tbody>
</table>

Most of the module resources were provided through an on-line platform. Based on the results, majority of the students agreed that the online resources allow them to learn effectively and motivated them to learn more deeply. Table 5 showed the descriptive statistics on the issue of workload. The results showed that students have mixed views on the amount of workload given to them. This may be due to the diverse academic abilities in the cohort. Academically stronger students may find that the assignment given was appropriate while academically weaker students may find it challenging to complete the assignment. Table 6 showed the descriptive statistics on the issue of students’ interaction. As the results have shown, majority of the students agreed that lecturers’ interaction with them have encouraged them to learn more and that other
students’ online posting has encouraged them to delve further in their learning.

Finally, this study investigates the correlation of the four factors with the overall perception of the blended learning approach, the approaches to learning and students’ final grades for the course. Table 7 summarises the result. The four factors were significantly correlated to each other, which implies that students’ having a positive perception on one factor will have a similar positive perception on the other three factors. Furthermore, these four factors were shown to be significantly correlated to students’ overall perception to the blended learning approach of the module (EL31). This implies that there were reliable association between indicators of the online teaching components, online resource components, students’ interaction and workload and the indicator of the quality of the whole blended learning course. In the correlation analysis between grades and the rest of the construct, the results showed that there is a significant positive correlation between indicators of on-line teaching components and deep approach to learning. In addition, there is a negative significant correlation between grades and surface approach to learning. These imply that students’ having positive perception to on-line teaching generally will have intrinsic motivation to learn more in-depth about the module as well as scoring well for the final grades and not merely carrying out the tasks. Lastly, all the four factors and overall perception of the blended learning approach of the module were significantly correlated to deep approach to study. At the same time, it is intriguing to note that these four factors and overall perception of the blended learning approach in the module were not significantly correlated to surface approach to study. The results imply that students’ perception to learning in such a blended learning approach has allowed them to have internal motivation or curiosity to learn more in the module.

Limitations and recommendations

There are a few limitations in this study. Firstly, the small sample size in this study might have affected the groupings of the items into the four factors, as there were some differences as compared to the research done by Ginns and Ellis. Secondly, although the reliability scores for three factors were in the acceptable range, a
further refinement on the wordings and phrases might help to improve the reliability scores. Lastly, the study was limited only to students from a particular diploma who were taking the module under research, thus, it cannot be generalized and results may differ in other fields of engineering. As such, the present study raises some issues for future research. Firstly, it may be worthwhile to investigate further the reason to improve the reliability of the two factors, namely, Appropriate Workload and Students’ Interaction. This may help to improve the reliability results. Secondly, it would be useful to replicate and extend these findings to different student populations and domains. This could help to further strengthen and generalize the theory that was presented in this study. Lastly, it may be beneficial to explore cluster analysis where it identifies subgroups of students who varied systematically according to their perceptions of the e-learning environment, their approaches to study, and overall grade.

Conclusion

This study determined the four factors on students’ perception towards blended learning environment in the module, Green Building Technology and Design. Students generally agreed that the module had a good on-line environment for learning, provided good on-line resources for the students to learn effectively, and their interactions with the lecturer and their peers have encouraged them to delve further in their learning. Furthermore, results showed that all four factors were significantly correlated with each other as well as with the blended learning approach of the module and deep approach to learning. Specifically, on-line teaching components had a positive significant correlation with grades, which suggested that students with good perception to on-line teaching would also score well for their final grades. Although the findings in this study cannot be generalized and a lot of work still needs to be done, they can be used to provide valuable insight for the development of similar study in future.

References


**Appendix**

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL1</td>
<td>To do well in on-line quizzes all you really need is a good memory.</td>
</tr>
<tr>
<td>EL2</td>
<td>My lecturer used the on-line environment when appropriate to keep students informed about their learning progress.</td>
</tr>
<tr>
<td>EL3</td>
<td>I received too much feedback on-line from my lecturer.</td>
</tr>
<tr>
<td>EL4</td>
<td>My lecturer’s responses on-line motivated me to learn more deeply.</td>
</tr>
<tr>
<td>EL5</td>
<td>My lecturer helped to guide on-line discussions between students.</td>
</tr>
<tr>
<td>EL6</td>
<td>My lecturer used the on-line environment to regularly update students about relevant unit of study information.</td>
</tr>
<tr>
<td>EL7</td>
<td>Reading on-line team’s comments clarified some of my own ideas.</td>
</tr>
<tr>
<td>EL8</td>
<td>The on-line learning materials in LEO 2.0 are extremely good at explaining things.</td>
</tr>
<tr>
<td>EL9</td>
<td>My lecturer’s interaction with me on-line encouraged me to get the most out of my learning.</td>
</tr>
<tr>
<td>EL10</td>
<td>On-line quizzes helped me to learn effectively.</td>
</tr>
<tr>
<td>EL11</td>
<td>The workload for the on-line component of this module is too heavy.</td>
</tr>
<tr>
<td>EL12</td>
<td>My lecturer’s on-line responses motivated me to do more on-line learning than I would have done otherwise.</td>
</tr>
<tr>
<td>EL13</td>
<td>Information needed to understand the purpose and contents of the module was integrated in one place on-line.</td>
</tr>
<tr>
<td>EL14</td>
<td>I generally had enough time to understand the things I had to learn on-line.</td>
</tr>
<tr>
<td>EL15</td>
<td>I did not receive enough helpful on-line feedback from my lecturer.</td>
</tr>
<tr>
<td>EL16</td>
<td>I interacted with classmates’ on-line postings even if they were not assessed.</td>
</tr>
<tr>
<td>EL17</td>
<td>The on-line activities are designed to get the best out of students.</td>
</tr>
<tr>
<td>EL18</td>
<td>Other students’ on-line postings helped me understand my ideas from a new perspective.</td>
</tr>
<tr>
<td>EL19</td>
<td>I am clear about the requirements of using on-line discussions.</td>
</tr>
<tr>
<td>EL20</td>
<td>The on-line learning materials in LEO 2.0 are designed to really try to make topics interesting to students.</td>
</tr>
<tr>
<td>EL21</td>
<td>Other students’ on-line postings encouraged me to investigate further sources of knowledge.</td>
</tr>
<tr>
<td>EL22</td>
<td>The sheer volume of work for the on-line component of this module means it cannot all be thoroughly comprehended.</td>
</tr>
<tr>
<td>EL23</td>
<td>The on-line learning materials in LEO 2.0 helped me to learn during the face-to-face situations in this module.</td>
</tr>
<tr>
<td>EL24</td>
<td>It was clear if on-line resources were related to assessment.</td>
</tr>
<tr>
<td>EL25</td>
<td>The on-line activities helped me to reflect and understand the face-to-face activities in this module.</td>
</tr>
<tr>
<td>EL26</td>
<td>The on-line learning materials in LEO 2.0 supported some key assessment items in this module.</td>
</tr>
<tr>
<td>EL27</td>
<td>The relationships between the on-line activities and the whole module motivated me to learn more deeply.</td>
</tr>
<tr>
<td>EL28</td>
<td>My lecturer helped to focus on-line discussions between students.</td>
</tr>
<tr>
<td>EL29</td>
<td>Information needed for assignments was integrated in one place on-line.</td>
</tr>
<tr>
<td>EL30</td>
<td>I was able to learn more during classroom session as compared to during e-learning session.</td>
</tr>
<tr>
<td>EL31</td>
<td>Overall, I was satisfied with the quality of the on-line activities for this module.</td>
</tr>
</tbody>
</table>
SELF-MONITORING TRAINING PRACTICES FOR READING ENGLISH ALOUD AND THE EDUCATIONAL EFFECTS

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Abstract

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

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

1. Do the two different self-monitoring training practices result in differences in reading error rate and reading speed?
2. Does students’ learning aptitude change after participation in self-monitoring training practices?

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

Introduction

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

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

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

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

Self-monitoring with GVC2

In the first semester of 2017, students used GVC2 to prepare for oral reading tests by self-monitoring their
English showing the GVC2 program. After listening to a model English example, a student records himself or herself reading through the microphone attached to the headset. The performance displayed as a speech waveform, and its similarities to the pronunciations, accents, intonations, timings, and overall performance of the model English examples are shown with graphs and scored out of 100. Each student can self-monitor his or her oral reading objectively and precisely using GVC2. We expected that students would be able to reduce their reading errors using GVC2.

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

**Practical Oral Reading Test**

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

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

**Table 2 : Oral Reading Materials of Departure English**

<table>
<thead>
<tr>
<th>Expression II Part2</th>
<th>Text Conducting Time</th>
<th>Contents</th>
<th>Text Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>The first mid-term May</td>
<td>1</td>
<td>Computerized Society</td>
<td>98</td>
</tr>
<tr>
<td>2</td>
<td>Impression on Japanese</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Team Hoyt</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>The first final July</td>
<td>4</td>
<td>Kazuo Ishiguro</td>
<td>114</td>
</tr>
<tr>
<td>5</td>
<td>Language Features on Japanese</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>The second mid-term November</td>
<td>6</td>
<td>Pictograms</td>
<td>104</td>
</tr>
<tr>
<td>7</td>
<td>Heart diseases</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Japanese cultures</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>The second final January</td>
<td>9</td>
<td>Japanese Voting Rights</td>
<td>119</td>
</tr>
<tr>
<td>10</td>
<td>“Silver seats” as Privileged Seats</td>
<td>127</td>
<td></td>
</tr>
</tbody>
</table>

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

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

Results and Discussions

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

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

<table>
<thead>
<tr>
<th>Oral Reading Test Error variations</th>
<th>The first mid-term</th>
<th>The first final</th>
<th>The second mid-term</th>
<th>The second final</th>
</tr>
</thead>
<tbody>
<tr>
<td>phoneme errors</td>
<td>107</td>
<td>223</td>
<td>129</td>
<td>150</td>
</tr>
<tr>
<td>ex. our[əʊər], see[si:] fi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>word’s accent errors</td>
<td>23</td>
<td>76</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>ex. influence[ɪnˈflaʊəs]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intonation errors</td>
<td>42</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>ex. [Aʌ, Bʌ, or Cʌ]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaning chunk errors</td>
<td>12</td>
<td>2</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>ex. there/ are indirect expressions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-error-observed performances</td>
<td>48</td>
<td>39</td>
<td>69</td>
<td>54</td>
</tr>
<tr>
<td>Individual monitoring with GVC2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer Monitoring of Three with Rubric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

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

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

There were fewer scores of 4 and 5 in meta-cognition (Figure 3) and self-efficacy (Figure 4) in January than in April; however, high scored for self-control (Figure 5) slightly increased in January. AAI defines self-efficacy...
Next Steps

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

Onodera (2015) argued that Japanese students need to practice English articulation mechanisms regularly by training themselves in the correct tongue and tooth positions, lip movements, and breath control skills to pronounce the seven vowels and 25 consonants accurately. However, while it is difficult to practice all pronunciation, we should limit the chorus reading speed to less than 2 s per chunk.

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

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

Summary

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

Notes*

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

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Additional Statement

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

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

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Abstract

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

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

Introduction

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

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

Method

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

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

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

Fig.1.

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

This diagramming technique was used to teach 4 of the 5 engineering classes while the 5th class was taught using a more “standard” grammar translation technique. The students were taught in groups of roughly 40 by a single teacher in 90min blocks once a week for 32 weeks with each class focusing on a particular grammar fea-
ture. The diagramming classes generally followed a regular procedure: A short review of the previous weeks work conducted mostly in English (usually in the form of interactive Q&A). Then several example sentences are presented that feature the grammar point being explored that day with students encouraged to discover the patterns and relevant details and to build on what they already know by labeling the parts of the sentence. Then the remaining “new” forms or ideas are explored and taught including any new labels and diagramming techniques required. After this has been presented thoroughly, the relevant grammar vocabulary is reviewed. Finally, the students are broken into small groups (4-6 students) to work on diagramming more example sentences. When they are finished, groups are called to the board to present their diagrams which are then examined as a class for accuracy. A short review of the important points follows and finally a quick Q&A to check for understanding. Tests were given quarterly to both the control and experimental groups. Clauses are among the last grammatical forms to be examined and are given 5 weeks of time, roughly one week per clause type. Students who enrolled in the advanced course the next year semester were later given a survey that contained 5 questions about their attitudes towards the English class and 10 questions about subordinators. This survey and quiz were given about 8 weeks after their last English class.

Results and Discussion

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

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

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

The survey can be found in the appendix.

Conclusions

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

Acknowledgements

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APPENDIX A

Parts of speech

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

Verb Details

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

Noun Details

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

Conjunction Details
Appendix B

Survey as presented to the students:

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

Part I

Using a scale of 1 through 7 how much do you agree or disagree with the following sentences (1= completely agree and 7 = totally disagree):

1. I found my English class last year to be more interesting than my usual English classes.

2. I felt my English class last year was more helpful than my usual English classes.

3. I found my English class last year to be more enjoyable than my usual English classes.

4. I feel that my English class last year will help me with my future English studies.

5. I preferred my English class last year to other English classes.

Part II

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

6). __________I ate curry for breakfast was a mistake.

1. Because;  2. And;  3. So;  4. That
7). Tell me ________ you like about English.
   1. what;  2. because;  3. if;  4. and
8). The man of ________ you speak is not here.
   1. but;  2. what;  3. whom;  4. so
9). I will go to the movies with you ________ you pay.
   1. while;  2. that;  3. if;  4. whom
10). ________ you bought the drinks, I will pay for dinner.
    1. While;  2. Because;  3. So;  4. That
11). I took a shower ________ she studied.
    1. while;  2. whom;  3. however;  4. only
12). The woman ________ came to dinner was my sister.
    1. while;  2. moreover;  3. who;  4. when
13). I couldn’t start the car ________ is in the garage.
    1. when;  2. while;  3. that;  4. but
14). Bob made dinner ________ Sally made dessert.
    1. and;  2. that;  3. whom;  4. really
15). That is the place ________ I broke my leg.
    1. so;  2. where;  3. when;  4. what

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Abstract

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

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

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

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

Introduction

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

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

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

Considerations for Curriculum Design

a. Importance of Business Communication for work

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

However, possessing excellent communication skills is not an innate ability (Wilczynski, 2009). Like any other skill, communication skills need to be practised over time for the learner to deepen his knowledge and skills, preferably with a facilitator who can connect real-
world situations to key learning points. Wilhelm, Logan, Smith, & Szul (2002, p.45) recommends multiple practices with an experienced practitioner under realistic working conditions as repeated practice helps the learner get the “feel of doing it proficiently.”

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

b. Learning Needs of BCOMM Students

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

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

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

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

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

Overview of BCOMM

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

a. Scaffolding the Learning

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

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

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

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

By the time students reach BCOMM 3, they would have sufficient practice in both the written and oral communication skill sets through their three years in the various modules of their diploma. Hence, in BCOMM 3, students are given more opportunities to work on their interpersonal skills. They learn to interact professionally in a networking situation and also how to manage different personality types in a business meeting. Through these, students hone their situational awareness in order to respond appropriately. In their final presentation to a group of “board members” (usually consisting of fellow classmates and the tutor), students use all the communication tools and strategies they have learnt to convince and convert the “board members” to their business propositions. Figure 1 highlights how the scaffolding process is applied specifically in the Oral Communication skill set. This intentional scaffolding process, woven into all four skill sets, provides students with a logical learning progression, which in turn produces more confident and skilful student communicators (Popham, 2007).
In the Director's Course Experience Dialogue (conducted in April 2017 semester), students were positive about the intentional scaffolding of the modules across all three years and they could see that BCOMM 1 topics were more generic whereas BCOMM 2 and 3 topics were more specific, which required greater depth and difficulty. This dialogue is organised for the Director of the school to meet students from the different diplomas to garner feedback on their experience in their respective courses.

Teaching and Learning Innovation

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

Scenario-Based Learning

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

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

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

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

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

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

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

Actual scenarios have included:

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

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

Scenario-based learning has helped students experience Krathwohl’s (2002) Six Levels of Learning.
uses and benefits of the activities.

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

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

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

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

“I find that these online practices are quite useful and it allows us to know English standards.”

“I feel that these online practices help me to identify the mistakes that I make in normal writing.”

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

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

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

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

In April 2018, the BCOMM 2 team launched “Report Writing Made Simple” – a report writing e-course hosted on Blackboard Learn. Previously, the BCOMM 2 team taught report writing in class as the
assessments was worth 30% of the students’ total grade, the largest assessment component of BCOMM 2. With the introduction of the e-course, in-class teaching time was reduced by 75%. Students accessed all other material online and more teaching sessions were converted into project consultations.

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

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

Assessments in BCOMM

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

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

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

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

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

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

Effectiveness of Curriculum Transformation

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

<table>
<thead>
<tr>
<th>Section</th>
<th>AY 14/15</th>
<th>AY 15/16</th>
<th>AY 16/17</th>
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<tr>
<td>BCOMM 1</td>
<td>4.84 (Sem 1)</td>
<td>5.26 (Sem 2)</td>
<td>5.17 (Sem 1)</td>
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<tr>
<td>BCOMM 2</td>
<td>5.10 (Sem 1)</td>
<td>5.24 (Sem 2)</td>
<td>5.28 (Sem 2)</td>
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<tr>
<td>BCOMM 3</td>
<td>5.17 (Sem 1)</td>
<td>5.28 (Sem 2)</td>
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Table 1. An overview of BCOMM’s MES Score

This upward trend shows that students are getting an overall classroom experience and they are also seeing how the modules support their future aspirations. This is due to BCOMM’s innovative teaching method which include the use of feedback for learning, a strong communication transformation focus and relevance to the 21st century workplace.
The success of BCOMM is best experienced by students who have completed their six-month internship. Applicable to job roles and industries, communication skills learned in BCOMM have become extremely useful in actual work situations. Reflecting in her internship report, Ong Jing Ting, an International Business student and intern at Bake-It-Yourself wrote how BCOMM built the foundation for her to succeed at work:

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

Conclusion

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

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

References


AN OUTLINE AND OVERVIEW ON EXPERIENTIAL LEARNING ACTIVITIES FOR ENHANCING STUDENTS’ ENGLISH FOR LEARNING STEM

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Abstract

Upon the robust and rapid development of various technologies, the global demand for talents with high-quality STEM (Science, Technology, Engineering and Mathematics) knowledge and skill is increasing in the industry. STEM education has become a focus of global education over the past two decades since its firstly promoted in the United States in the 1990s. In STEM education, students are educated with interdisciplinary knowledge, problem-solving and innovative skills. However, there are many different factors to hinder the students from learning STEM knowledge. Language used in learning STEM is one of the barriers to students, especially for the students whose first language is not English whereas English is a typical language traditionally used for interpreting STEM knowledge. In many cases, learning STEM in English is unavoidable as most of the latest STEM knowledge is published in English. Therefore, it is important to address this issue.

Recently, an attempt was made to design and implement a series of strategic and experiential teaching and learning activities for enhancing students’ English for learning STEM, and hence to improve various skills of students in acquiring and applying their knowledge. Apart from enhancing English for learning STEM, by adopting a mixed traditional and non-traditional way of teaching and learning, the students’ interest to STEM could be substantially increased. Students are inspired to learn STEM and to apply their STEM knowledge in solving problems. In terms of learning English for STEM, this paper aims to present and discuss the methods and activities designed and implemented for English learning for STEM education. The feedbacks from students are also evaluated. Recommendations for improvement are suggested at the end.

Keywords: English for STEM, experiential learning, Interactive learning, learning and teaching tools, STEM education, student competition, student workshop, teaching strategies

Introduction

Over the past two decades, STEM education has become a focus of global education because of the strong demand of talents for driving the development of various technologies. In STEM education, students are educated with interdisciplinary knowledge, problem-solving and innovative skills that are crucial to their personal development. However, there are many different factors to hinder the students from learning STEM knowledge effectively. Language used in learning STEM is one of the barriers to students, especially for the students who first language is not English, like most of the students in Hong Kong. In Hong Kong, most of the sub-degree or above levels of students who are studying STEM related programmes are required to use English as a medium of instruction in classes. Whereas English is a typical language traditionally used for interpreting STEM knowledge. In many cases, learning STEM in English is unavoidable as most of the latest STEM knowledge is published in English. Therefore, it is important to address this issue. In order to help students to tackle the language barriers and to raise their interests in learning STEM knowledge, a series of strategic and experiential teaching and learning activities were proposed to enhance students’ English for learning STEM at higher diploma level.

This paper will describe the designed strategic and experiential teaching and learning activities, elaborate on the impact of the activities to the students, evaluate feedbacks from students in some of the activities, and suggest some recommendations for improvement of the activities.

Experiential learning

In simple definition of experiential learning, it is interpreted as learning from experience or learning by doing (Schwartz, 2012). Upon “learn by doing”, students would apply knowledge to experience and develop skills or new ways of thinking (Lewis & Williams, 1994). For an extended definition, experiential learning is a process through which learners develop knowledge, skills and values from direct experiences outside a traditional academic setting (University of Colorado Denver, 2018). Experiential learning encompasses different activities including internships, service learning, undergraduate research, study abroad, and other creative and professional work experiences.

Experiential learning can be described as a four-stage cyclic process that an individual can start from any stage but the sequence of the stages remains the same as shown
Four stages of the experiential learning cycle include:

- **Concrete experience (Doing):** Students obtain hands-on experience on problem-solving tasks through engagement of learning activities.

- **Reflection (Observing):** Students review and reflect on their process either individually or in group by recalling their memory or looking at records of the learning activities.

- **Abstract conceptualization (Thinking):** Students generalize knowledge and theory from the previous experience based on the reflection.

- **Active experiment (Planning):** Students modify existing concepts and knowledge with the new knowledge and theory they obtain and apply in later occasions.

This cycle can enable students to develop various skills in problem solving, for example, analyzing, synthesizing and evaluating (Ministry of Education, 2018).

![Experiential Learning Cycle](image)

**Figure 1: Experiential learning cycle**

### Designed experiential teaching and learning activities

In the curriculum of the group of higher diploma students under the study, the students have to complete an industrial attachment, which the students are required to attach to a company or organization of relevant field of study for a period to obtain work experience. At the same time, the students have to identify industry-related topics for their final-year projects – industrial-based student projects (IBSPs). Through the industrial attachment and the IBSP, students can obtain valuable experiential opportunities to apply their STEM knowledge from classroom and acquire new knowledge and skills by going through the experiential learning cycle. During the industrial attachment, students can obtain hands-on experience on various tasks that given by their employers (Doing). Throughout the attachment period, students have to log down the tasks that they work on, as well as review and reflect what they have learnt in the process (Observing). The students have to generalize the knowledge and theory learnt from the experience based on the reflection (Thinking). The above process can simulate their thinking to identify the topics for their final-year projects that allows an opportunity for them to modify their existing concepts and knowledge with new knowledge and theory they obtained, and apply the new concepts and knowledge in the project or later occasions (Planning).

The industrial attachment and the IBSP combined as a main stem of the experiential teaching and learning activities for learning STEM knowledge. The students have to complete their IBSP reports and presentations of their identified industry-related topics. According to previous experience and general observation, the students often find difficulties in writing a formal report and giving a presentation of STEM related topics. There are difficulties for the students to organize, collocate and express their ideas and findings. Besides, some students under-performed may because of their weaknesses in understanding STEM knowledge in formal classes. It is observed that English proficiency is one crucial hurdle for the students to understand STEM knowledge.

To enhance students’ English in learning STEM, the experiential teaching and learning activities are extended (see Figure 2). Along the main stem of the experiential teaching and learning activities, a STEM project presentation competition was held. The students were invited to join the competition. In the competition, the students were required to give a ten-minute English presentation on a STEM project which could be developed from their IBSP. Through competition, it was aimed to boost the performance of students in the use of English and presentation skills on one hand. On the other hand, it was aimed to increase the interest and incentive of students in learning STEM.

Before the competition, as a base to improve students’ English, lectures on writing and presentation were organized. A native English-speaking lecturer with STEM background was employed to give the lectures to the students with the aim to allow the students more opportunities to practice and communicate with a native English speaker. In the delivery of lectures, the lecturer tried to keep it informal to create a relax and comfortable atmosphere for students to practice English. Different interactive activities were conducted in the lectures. Some mini games that incorporated with the use of technology and online education tools were carried out. For example, in the recap of the concepts delivered in previous lectures, a mini game that worked with an online education tool, called “Kahoot!”, was applied. “Kahoot!” is a game-based learning platform that enable teachers to set up multiple-choice quizzes that allow students to access via web browsers by using mobile devices. Students can access the quiz and compete with others by determining the one who can answer all the questions correctly with the least time. “Kahoot!” is an interesting tool to reinforce students’ learning. It can be used to review students’ knowledge and especially it can log the quiz results of students for reference (Kahoot, 2018). However, it cannot be overused because students may lost the interest. Sometimes, the students may not get down to the quiz.

On top of the lectures delivered to the students, other experiential teaching and learning activities or supports are provided to the students. STEM English help desk by native English-speaking lecturer was organized to
provide STEM English enhancement support to the students. This could further extend the opportunity for students to practice English outside the class. Besides, students could also join the interactive group activities organized by the STEM center of the institute. The activities were conducted in English. The activities could facilitate the students to learn from experience and allow peer learning.

Furthermore, student exchange programmes with overseas institutions were organized to allow students to experience the STEM education in an English-speaking environment. Through the interactions with foreign students, language acquisition could be achieved through practical immersion. The international learning and knowledge could propel students towards acceptance and understanding of different cultural and community perspectives. Valuable experience leading to the enhancement of global vision, self-confidence and self-esteem could be gained by the students in the exchange programmes.

Pilot questionnaire survey for feedbacks from students

As a pilot study on the effectiveness of the designed experiential teaching and learning activities, a questionnaire survey was conducted to obtain some feedbacks from the students who have participated in the activities, mainly focused on IBSP and STEM project presentation competition.

The questionnaire survey was divided into two parts, A and B. Part A of the survey asked students to conduct a self-evaluation on their various aspects of improvement in learning STEM and English for STEM after the IBSP and the STEM project presentation competition. The students were requested to rate their improvements on a 10-point scale: from “1” for “unsatisfactory” to “10” for “excellent”. The following nine aspects of improvement were asked:

A1. Improvement on students’ learning
A2. Improvement on trade knowledge
A3. Improvement on problem solving skills
A4. Improvement on communication skills
A5. Improvement on presentation skills
A6. Improvement on written English
A7. Improvement on oral English
A8. Improvement on self-learning ability
A9. Interest in STEM

Part B of the survey asked for the students’ perceptions on the effectiveness of experiential learning (B1). The students are requested to rate their perceptions on a 10-point scale: from “1” for “unsatisfactory” to “10” for “excellent”.

Results and discussions

A total of 12 students completed the pilot questionnaire survey. The average rating on each of the aspects in Part A and the average rating on the effectiveness of experiential learning in Part B were calculated. The results are shown in Figure 3. Horizontal axis of the figure refers to the questions/aspects asked in the two parts of the questionnaire, while vertical axis of the figure refers to the average rating calculated. Satisfactory improvements were found in the nine aspects concerned according to the self-evaluations of the students. All the nine aspects of improvement under the study obtained average ratings of higher than 7. Among the nine aspects, relative larger improvement on self-learning ability was perceived by the students. The students found they have well improvements in problem solving skills and communication skills after the activities. Focusing on the improvements in language abilities and presentation skills, similar results were found in students’ written English, oral English and presentation skills with average ratings of 7.8, 7.9 and 7.8 respectively. Besides, the students’ interests in learning STEM was greatly increased (average rating = 8.3). It seems that the experiential teaching and learning activities could effectively increase students’ interests in learning and stimulate development of students in different aspects. Overall, the students found the experiential learning approach was effective (average rating = 7.5).
Limitation and recommendations for improvement

Though satisfactory results on the self-evaluation of the students were obtained in the pilot questionnaire survey, further verification on the improvements and performance of the students should be conducted to provide a stronger support on the effectiveness of the designed experiential teaching and learning activities for enhancing students’ English for learning STEM or even enhancing different skills of students applicable in learning or working.

As far as the effectiveness of the designed experiential teaching and learning activities is concerned, the effectiveness can be further increased by the application of technology. Online forum or chatroom support, or even instant messaging tools, for example telegram, can be used for creating a space for learning and communication in a large class setting with the intention to create an informal learning community for peer learning.

Conclusions

This paper presented an outline and overview on the application of experiential teaching and learning activities to enhance students’ English for learning STEM.

According to a pilot questionnaire survey on the students’ who participated the designed experiential teaching and learning activities - IBSP and STEM project presentation competition, positive results were obtained to demonstrate the effectiveness of the activities. The positive impact on students was not just limited to English improvement but also improvement in learning STEM knowledge and personal development of the students. Further investigation on the effectiveness of the whole package of the strategically designed experiential teaching and learning activities for enhancing students’ English for learning STEM can be conducted in the future.

References


STEM CO-LEARNING BRINGS CROSS-GENERATION LEARNING

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Abstract

This study explores collaborative synergistic learning on elderlies and kids and provides empirical insights for STEM (Science, Technology, Engineering and Mathematics) education in Hong Kong. Experiment on elderly and kid to complete a STEM challenge for measurement. The result shows elderly performs well in STEM areas. Elderlies and kids learning together is significantly more effective, also benefit on both sides.

Keywords: cross generation, collaborative learning, elderly and kid, STEM education

Introduction

The promotion of STEM education in Hong Kong was first proposed in the 2015 Policy Address and further supported in the Policy Address (2016), aim to nurture a versatile pool of talents with different sets and levels of skills to enhance the competitiveness of Hong Kong. Technology is growing rapidly, cause to increasing the gap of digital divide between older and younger generations.

Digital Divide

Technology is growing rapidly, cause to increasing the gap of digital divide between older and younger generations (Holmes, 2012). The baby boomers generation, born between the years of 1946 and 1964, they are not big fans of technology and hard to catch up the latest technological trend, due to resist to learn (Loges, W. & Jung, J., 2001). Therefore, the generations divide is formed.

According to Table 1, in 2064, the elder population will be increased to 33% of the entire population in Hong Kong. It will cause a serious impact to the society because of this digital divide.

Table 1. Characteristics of the HK population (Projections).

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Percentage of population</th>
</tr>
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<tbody>
<tr>
<td>Aged 0 – 14</td>
<td>11%</td>
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<tr>
<td>Aged 15–64</td>
<td>74%</td>
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<tr>
<td>Aged 65 &amp; over</td>
<td>15%</td>
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(Source: Census and Statistics Department, Hong Kong Population Projections 2015–2064)

Leisure Time

Ibrahimov (2015) finds the leisure activities and spending time are in similar pattern between teens and elderlies, watching Television or Video time is 1100-1200 hour per year, shown in Table 2. That implies they have plenty of leisure time to spend.

Table 2. Hour of leisure time per year.

<table>
<thead>
<tr>
<th>Leisure Activity</th>
<th>Teens</th>
<th>30s/40s</th>
<th>70s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watching TV/Videos</td>
<td>1200</td>
<td>450</td>
<td>1100</td>
</tr>
<tr>
<td>Socializing with 3 or less people</td>
<td>150</td>
<td>275</td>
<td>200</td>
</tr>
<tr>
<td>Socializing with 4 or more people</td>
<td>350</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Individual exercise (Sport)</td>
<td>150</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>Group exercise (Sport)</td>
<td>450</td>
<td>175</td>
<td>0</td>
</tr>
<tr>
<td>Cinema</td>
<td>100</td>
<td>37</td>
<td>75</td>
</tr>
</tbody>
</table>

(Source: Ibrahimov, 2015)

The Experiment

This study explores collaborative synergistic insights on elderly and kid to learn in STEM areas. Experiment on assess STEM aptitude test for solving the types of problems that arise in science, technology, engineering and mathematics. The participants were grouping in pair into 3 categories: 1. Elderly-elderly, 2. Kid-kid and 3. Elderly-kid. Arranged as Table 3. The selected elderly aged from 66 to 73 and kid aged from 4 to 8, total 20
persons (10 pair group). The test required the participants to complete 10 problems in 20 minutes.

Table 3. Groupings

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Notations: Elderly Male – EM Elderly Female – EF Kid Male – KM Kid Female – KF

Result and Discussion

The experiment result was measured by the answer accuracy and finishing time as shown as Table 4.

Table 4. Result

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</table>

| Time | F | F | F | M | M | F | F | S | M | M |

Notations: F – Fast M – Moderate S – Slow

Finding1: The elderly and kid pairing groups were significantly more effective than the others.

Finding2: The elderly pairing groups were also performing well in STEM area.

Finding3: Indicating elderlies enjoyed more to learn and play with kids in observations.

Conclusions

Bring the cross generation collaborative learning (co-learning) is significantly benefit for both generations, not only the acquire for knowledge but also to build emotional attachment for active living. However, the motive for learning of elderlies is still in low, collaboration with the kids may be one of the motives to commence. The findings also reveal STEM knowledge of elderlies is high, through co-learning with kids can effectively transfer to kids.

Acknowledgements

We thank Dr. Raymond Pang, Associate Professor and Dr. Jeff Tang, Assistant professor at Caritas Institute of Higher Education for their kind supports and useful suggestions.

References


TEACHING ETHICAL REASONING TO ENGINEERING STUDENTS

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Abstract

Engineering ethics is an important component of engineering education. Yet the topic is seldom covered in mainstream engineering education, partly due to the wide-ranging nature of ethical issues. Especially of concern is the rapid advancement of technology, in particular in the advent of Internet of Things, while bringing about greater convenience and availability of information, also threatens personal and data privacy. This paper presents an initial effort by a team of lecturers from the Diploma in Chemical Engineering to teach ethical reasoning to its students. While not directly related to addressing the ethical issues related to technologies per se, we believe this is an important first step towards greater coverage of engineering ethics in education. Due to an already packed curriculum, the topic is introduced as part of the study of chemical process plant safety, a 60-hour core module in Year 3 titled Plant Safety and Loss Prevention. The paper starts with a brief introduction to engineering ethics, and shares various ways – based on a survey of the literature – how engineering ethics can be integrated into the curriculum. Then, after a brief introduction to the module, the paper presents the work done by the team, which involved the use of the DVD Incident at Morales, a professionally-produced teaching aid, as an assessable assignment. The objectives are to introduce our students to potential ethical issues related to engineering work, heighten their awareness in recognizing them, and how they can reason through possible resolutions using the engineering profession’s code of practice. Essentially the work done is via facilitated classroom discussion, where scenes from the DVD are identified as posing potential ethical issues, and how these can be addressed, with students putting themselves in the shoes of the main actors. Students are assessed through a presentation in MP4 format. The paper concludes with some ideas to further improve the teaching of engineering ethics.

Keywords: CDIO, Chemical Engineering, Ethical Reasoning, Code of Ethics

Introduction: Importance of Engineering Ethics

Being able to practice is an ethical manner is expected of engineers. Therefore, the teaching of ethics should be an important component of all engineering education. Colby & Sullivan (2008) suggested that training of professionals in all fields can be designated as 3 formative apprenticeships as follows:

- Intellectual training to learn academic knowledge base and the capacity to think in ways that are important to the profession
- A skill-based apprenticeship of practice: the craft know-how that marks expert practitioners of the domain
- An apprenticeship to the ethical standards, social roles, and responsibilities of the profession, grounded in the profession’s fundamental purposes

Figure 1. Apprenticeship of Professional Training

However, the teaching of ethics in engineering profession as currently practiced is still inadequate (Herkert, 2010; Colby & Sullivan, 2008). The rapid progress in technology development, in particular Internet of Things, had raised concerns (Waddell, 2017). For example, Stahl et al (2017) probed the social and ethical implications of research and innovations in emerging technologies such as artificial intelligence, cloud computing and robotics. Wadhwa (2014) went further and noted that technological progress is moving further ahead than the legal and moral frameworks needed to manage it. From a different perspective, several authors had also argued that teaching of ethics is important for the development of professional identity in one’s chosen field (e.g. Stappenbelt, 2012; Loui, 2005)

Sternberg (2012) argued that ethical reasoning can be taught, and best with the case study approach. Ethical reason is distinct from ethics – the former is how to think about issues of right or wrong, whereas the latter comprises a set of principles for what constitute right and wrong behaviour (Sternberg, 2012). Also, as noted by
Adamson (2017), while ethical behaviour is about doing the right thing, it doesn’t follow that the right thing is intuitively obvious. Just as engineers and technologists learn to assess risks in their work, they need to learn how to identify ethically challenging circumstances.

Integrate Engineering Ethics into Curriculum

There is clearly an increasing need for educational institutions to teach ethics to better prepare students for today's workplace (Frisque et al., 2004). However, there is no one consistent, widely agreed-upon method of teaching ethics to undergraduates, and literature indicates disagreement about approaches to teaching ethical practice (Baker, et al., 2012). Various approaches had been suggested to integrate engineering ethics into a curriculum. Some of these are ‘standalone’ approaches (e.g. Hornsby, 2007), where a separate module is introduced, and the teaching may not be directly related to any core modules and often taught by faculty not belonging to the engineering profession. Others tend to link teaching of engineering ethics with the execution of capstone projects (e.g. Jiménez, et al, 2006; Leone & Isaacs, 2001). Our approach in the Diploma in Chemical Engineering (DCHE) is based on what Davis & Riley (2008) termed “insertion”, which involved the inclusion of ethics instruction into technical modules resulting in a dozen or so “ethics mini-lessons”. A micro-insertion is one that is small-scale, each lasting only a few minutes. The work described here is one that is significantly longer, as presented next. In this case, we use the video Incident at Morales and integrate it into the module Plant Safety and Loss Prevention.

The video is a product of the combined efforts of a team with representation from several universities and individuals with experience in various engineering disciplines and philosophy. It was developed by The National Institute for Engineering Ethics (NIEE), Murdough Centre for Engineering Professionalism, Texas Tech University, with a grant from the National Science Foundation.

This video is chosen because it provides the suitable context for the chemical engineering discipline. It involves a variety of ethical issues faced by a company that wants to quickly build a chemical plant in order to develop a new chemical product to gain a competitive edge over the competition. Potential technical and ethical issues arise from choices of designs, including valves, piping, chemicals, etc. The process involves high temperatures and pressures and requires the use of chemicals that need special handling. The plant is designed to be automated and controlled using computer software. Because of cost factors, the company decides to construct their plant in Mexico and uses cheaper parts and components (Smith & Nichols, 2004). Various problems of different nature (technical, environmental, financial, and safety) arise that involve ethical issues. The movie emphasized 3 aspects:

- Ethical considerations are an integral part of making engineering decisions.
- Although legal requirements may vary among states and nations, ethical obligations do not stop at state or national borders.
- Wherever engineer practice, they should strive to protect the health, safety, and welfare of the public.

Description of Work Done

Plant Safety and Loss Prevention is a core module taught to all 120 DCHE students in Year 3. It is non-examinable, i.e. it is 100% based on in-course assessment, as shown in Table 1.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA1</td>
<td>Assignment: HAZOP Report</td>
<td>Group</td>
<td>20</td>
</tr>
<tr>
<td>MST</td>
<td>Mid-Semester Test</td>
<td>Individual</td>
<td>20</td>
</tr>
<tr>
<td>CA2</td>
<td>Case Study: Singapore Standards</td>
<td>Group</td>
<td>15</td>
</tr>
<tr>
<td>Assignment: Incident at Morales</td>
<td>Group</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>EST</td>
<td>End-Of-Semester Test</td>
<td>Individual</td>
<td>30</td>
</tr>
</tbody>
</table>

The module was taught in semester 1, with 4 hours contact time per week, over 2 terms for a total of 15 weeks, not including the 3-week term break in-between. The lesson on teaching ethical reasoning was conducted over Weeks 16 and 17 (total 8 hours) as follows. Students are first reminded (i.e. to activate their prior knowledge) of their Year 1 study in the module Introduction to Chemical Engineering where the Bhopal Gas Disaster and ethical issues were first introduced. The class then goes on with more in-depth discussion such as identifying key stakeholders and their perspectives. This sets the stage for exploring potential ethical issues and ethical reasoning using the Incident at Morales video.

The video is about 35 minutes long. It was played in class and paused at appropriate intervals whereby he lecturer then initiated classroom discussion to clarify scenes in the video, and to engage students in identifying potential ethical issues. Collectively, the class (comprising 20-24 students, working in groups of 4-5 students per group) record the discussions into Google Doc (see Table 2). At this point, any group can help with the recording. The purpose is to capture the key points of the discussion. Later, students were given time to watch the video again to better understand the entire storyline. Students were then informed that each group is to select one ethical issue of technical nature and another ethical issue of non-technical nature for their assignment; and no groups can work on the same issues. Each group recorded its choice with an “X” in Table 2 for all to see. Selection is on a first-come-first serve basis.

Students are also briefed on the assessment requirement of the assignment, which is worth 15% of the overall assessment (see Table 1). It requires students to prepare a presentation in-class or via a video. Specific details of this assessment are shown in Table 3. Lesson then continues with the lecturer facilitating the discussion on ethical reasoning. Students were given up to one week to complete the assignment.

Table 1. Module Assessment Plan

- Assignment: HAZOP Report
- Mid-Semester Test
- Case Study: Singapore Standards
- Incident at Morales
- End-Of-Semester Test
Table 2. Google Doc for Recording Discussion Outcome

<table>
<thead>
<tr>
<th>S/N</th>
<th>Brief Description of Issues</th>
<th>Class:</th>
<th>Group:</th>
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<td>T2</td>
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<td>T5</td>
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<tr>
<td>T6</td>
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<td>N6</td>
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Table 3. Assessment for Incident at Morales

<table>
<thead>
<tr>
<th>Assessment Component (Group)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Analysis of Ethical Issues: 1 Technical, 1 Non-Tech</td>
<td>40</td>
</tr>
<tr>
<td>• “If You Were In-Charge”</td>
<td>20</td>
</tr>
<tr>
<td>• Creativity / Presentation Skills</td>
<td>20</td>
</tr>
<tr>
<td>Assessment Component (Individual)</td>
<td>Percentage</td>
</tr>
<tr>
<td>• Class Participation, Completion of Surveys</td>
<td>20</td>
</tr>
</tbody>
</table>

A total of 3 surveys were carried out. The first two surveys use the same set of 5 questions devised by Loui (2006), who used the video to investigate students’ learning of engineering ethics; but adapted them to Singapore’s context for one of the questions. His study showed that the video is an effective approach to teach engineering ethics. One survey was administered before students watch the video, and another survey after they watched the video and classroom discussion. The 5 questions are:

S1. The first obligation of an engineer is to fulfil an assignment from the employer, or a contract of a client
S2. When working in a foreign country, a Singaporean engineer should comply with local regulations and should avoid imposing more stringent Singapore standards for safety
S3. Ethics consideration are an integral part of making engineering decisions
S4. A code of ethics can provide guidance in making engineering decisions
S5. Many ethical problems encountered by engineers have technical solutions

For each question, students are to indicate on a Likert Scale their responses: from 1 for “Strongly Disagree” to 5 for “Strongly Agree”. The third survey is prepared by the author to learn about the students’ learning experience in engineering ethics based on an active learning approach used in classroom. There are 10 question with a Likert Scale ranging from 1 “Strong Disagree” to 5 “Strongly Agree”:

Q1. I find that the lessons from “Incident at Morales” had provided me with new understanding of the role and responsibilities (i.e. that of ethics) of a chemical engineer.
Q2. I have developed greater awareness of potential ethical issues that may arise from the conduct of a chemical engineer in the workplace.
Q3. I believe that having a good understanding of ethical principles is important for the professional identity of a chemical engineer.
Q4. I find the approach used in class (use of probing questions, reminder of selected scenes, or words spoken) useful in helping me identifying potential ethical issues in “Incident at Morales”.
Q5. I enjoy participating in my group discussion analyzing ethical issues in “Incident at Morales”.
Q6. I have learnt to analyze a technical issue for its potential ethical implications.
Q7. I have learnt where to obtain more resources and some tools needed to help me resolve an ethical dilemma that I may face.
Q8. I find that including learning of ethics in the chemical engineering curriculum is beneficial to me.
Q9. I find that working collaboratively in Google Doc is a useful way to identify as many ethical issues as possible in “Incident at Morales”.
Q10. Overall, I benefitted from the lessons in analyzing ethical issues covered in “Incident at Morales”.

Results and Discussions

We will first discuss the results from the 5-question Pre- and Post-video surveys, shown in Figures 1 to 5 as obtained from 2 cohorts of students in 2 semesters. The results in Figure 1 is encouraging, as it showed that there is an increased awareness that the obligation of an engineer went beyond that of employers or clients. There is a shift in the numbers of responses that indicated “Agree” or “Strongly agree” towards “Strongly disagree”. This showed that the broad intended learning outcome had been achieved, i.e. the commitment that an engineer should have is towards health society and welfare of the public.

Likewise, Figures 3 to 5 represented changes in students perceptions that were not unexpected. Students recognized that ethical considerations is part of engineering decision-making; and felt that having a code of ethics is useful. In Figure 3 there is a significant increase in responses towards “Strongly agree” that ethics consideration are an integral part of engineering decision-making, confirming the shift noted in Figure 1. There is minimal change seen in Figure 4: we take it that all along students opined that a code of ethics is useful in guiding their decision-making. As for Figure 5, it showed a shift in students’ belief that many ethical problems can have engineering solutions.

An interesting situation came from Figure 2, which suggests that when in a foreign country, an engineer should comply with local regulations and should avoid imposing more-stringent Singapore standards for safety. Here there is negligible change overall, due to ‘cancellation’ effect as shown in Table 4.
The pattern of the shift indicates that there seem to be confusion among students on which country takes precedence on ethical matters – his/her home country or the country he/she is working in. This means that we
should spend a bit more time during the lesson debrief to address the issue. Timing-wise this can be challenging because the post-survey can only be done after students watched the video and class discussions completed. At this point students tend to be more interested in continuing with the assignment than completing this post-video survey, even if we stop conducting the third survey.

Next, we look at the students’ learning experiences in the topic by examining the results from the third survey. Responses to Questions 1, 2 and 3 as captured in Figure 6 showed that students can readily identify with the need for chemical engineers to conduct themselves in an ethical manner. Most students also reported that they felt engaged by the approach used in teaching the subject, as shown by responses to Questions 4 and 5 in Figure 6. This is again reaffirmed by the students in their response to Question 9 in Figure 7, on the use of Google Doc. Based on the authors’ experience, students often came up with more numbers of ethical issues (both of technical and non-technical nature) than required. As mentioned in an earlier paragraph, the requirement is that no group should work on the same issues; i.e. if there are 5 groups, then there should be 5 different technical and 5 different non-technical ethical issues identified. However, in all instances, the students usually came up with 6 or 7 different issues for each category.

On their skills development, students generally reported that they had improved in the ability to analyse a potential ethical issue (Question 6), and be more resourceful when seeking more information (Question 7). Overall, they believed that learning about ethics is a useful endeavour (Questions 8 and 10).

Due to time constraint, we are not able to allocate as much time needed for classroom discussion using the approach suggested in the training guide. Another challenge faced is the need to invest some time to explain some of the scenes, for example, how a multi-national corporation operates (for example as in the Incident at Morales case, which involve a parent company in France, with the subsidiary in the U.S., building a new plant in Mexico), or the terminologies used in the dialogues among the actors due to the students’s lack of real-world working experience.

An interesting finding though, was the preference shown by students for sharing their work, which contributed to 15% of total module assessment. This was in fact a chance encounter: for Academic Year 2017, due to clashing of class schedule with national public holiday, students were given options to either send in a video submission of Week 17, or do a classroom presentation to the lecturer on Week 18. The latter had been the traditional approach of assessment used in previous years. All except one group opted for the video presentation. As can be seen from Table 3, use of creativity in presenting the materials is one of the assessment criteria.

As things turned out, students handed in more interesting work based on their video submissions. There were much creativity displayed in presenting the assignment, in terms of analysis of ethical issues, and the segment on “If You Were In-Charge” (Table 3) using a wide range of media such as PowToon, VideoScribe, or they simply just film themselves in role play. For the author, this outcome is much more desirable than sitting in class going through one PowerPoint presentation after another.

Ideas for Future Work

The survey results are very encouraging to the team, which prompted us to think of ways to build on what we had done thus far, to further deepen the students’ engagement in learning about engineering ethics. We come up some ideas for future work:

(a) We can consider consolidating the separate cases of ethical issues currently integrated in various core chemical modules under a common theme, such as using a spiral curriculum (Whysong, et al, 2007). An opportunity to do so now available, as the course is now undergoing a revamp to align itself with the requirement of a national-level initiative (Cheah & Yang, 2018).

(b) Introduce a systematic process for ethical reasoning, to help students analyse ethical issues. An example is the Sternberg’s 8-step process (Sternberg, 2012):

1. Recognize that there is an event to which to react
2. Define the event as having an ethical dimension
3. Decide that the ethical dimension is significant.
4. Take personal responsibility for generating an ethical solution to the problem.
5. Figure out what abstract ethical rule(s) might apply to the problem.
6. Decide how these abstract ethical rules actually apply to the problem so as to suggest a concrete solution.
7. Prepare to counteract contextual forces that might lead one not to act in an ethical manner.
8. Act

(c) The logical next step after students had acquired the ethical reasoning skills is for us to assess how well they are able to use it in various situations. In this case, we can refer to the works of Self & Ellison (1998) who investigated the use of Defining Issues Test (DIT), which is based on cognitive moral development theory, as the instrument of assessment of moral reasoning skills. They found that the teaching of ethics in engineering can be rigorously measured, tested and analysed and can have a significant positive influence on the moral reasoning skills of the students.

Strategy (a) can and should rightfully be implemented within the DCHE curriculum itself, as this can best provide the right context of learning about ethical issues in chemical engineering setting. This approach can also support a longitudinal study to track students’ skills in handling ethical issues over the duration of their study. Students can be taught to recognize potential ethical issues early in their study, right in Year 1. They can then learn the systematic way to deal with such issues via Strategy (b) for example in Year 2. Evaluation of their competency in ethical reasoning can be carried out in Year 3 using Strategy (c).
The challenge here is for the team to figure out how best to do this in a curriculum that is already packed. Where can Strategies (b) and (c) best incorporated is not immediately clear at this point. The Year 2 curriculum is particularly congested. An alternative may be to explore this as an elective module offered in Year 3, combining both Strategies (b) and (c). The on-going revamp effort may help to inspire some new creative ways.

Conclusions

This paper shared the work done to develop in students skills in ethical reasoning. From the results obtained, we can conclude that students had gained greater awareness of potential ethical issues in engineering, but still need practices to hone the skills required. We had acquired new understanding from this effort, and come up with new ideas of improving the teaching. Although we are still far away from addressing the concerns of technology as mentioned in the beginning of the paper, the author believed the effort made thus far is one that is pointing in the right direction.

References


Abstract

Common problems faced by ICT students are difficulties in understanding programming concepts and applying these concepts in programming. This research explores how Team-Based Learning (TBL) supported by Online Collaborative Learning (OCL) before class promote active learning among students and enhance their programming competencies.

Both TBL and OCL promote teamwork and collaboration. They align with Vygotsky’s sociocultural theory’s “Zone of Proximal Development” which states that help and feedback of instructors and peers are necessary in picking up new ideas and concepts (Vygotsky, 1980).

The Experimental Group comprised 60 Year 1 students from the Diploma in Cyber Security & Forensics while the Control Group comprised 194 Year 1 students from the Diploma in Information Technology and the Diploma in Financial Informatics. The research was conducted for the “Web Applications Development & Project” module. The Control Group learnt under the traditional classroom approach while the Experimental Group underwent OCL before class and TBL in class.

For OCL, virtual rooms were created on the online platform Mural.ly where questions were posted for students to discuss, collaborate and attempt in Teams of 4-5 students. Meanwhile the instructor identified gaps in students’ learning for clarification.

During classroom TBL, each student was required to solve a programming problem individually (termed as “Individual Readiness Assurance Test”) before resolving the same problem as a Team (termed as “Team Readiness Assurance Test”). The students could negotiate and appeal for their answers should their solution differ from the instructor’s model solution. Finally, each Team is given a more challenging problem to solve to reinforce programming concepts taught.

This research indicates that the Experimental Group grasp programming concepts better and outperformed the Control group in their common test. Instructor’s feedback, students’ surveys and classroom observation also showed a higher level of student engagement.

OCL brings collaboration and problem solving beyond the classroom while TBL encourages students to think critically, collaborate, negotiate and solve problems as a Team during the face-to-face sessions. The author recommends tapping on the benefits of both teaching pedagogies as a form of blended learning to help students understand programming concepts better and prepare them for the future workforce.

Keywords: Team-based learning, online collaborative learning, technology enhanced learning, blended learning, active learning, programming, pedagogy

Introduction

A common observation made by lecturers is that students who face difficulties in programming often grapple with the understanding of the underlying programming concepts. This in turn leads to the students not being able to apply programming concepts into solving programming problems which result in a dip in their confidence towards programming as well as a drop in their programming competency.

To address the above challenges, this research explored the adoption of Team-Based Learning in a programming class with the support of Online Collaborative Learning as the teaching technique for the pre-classroom segment of the Team-Based Learning approach. Both Team-Based Learning & Online Collaborative Learning are teaching pedagogies that have been researched extensively. By tapping on the benefits of both strategies, the author aims to help instructors identify and address learning gaps in their students earlier. Meanwhile students, besides having their doubts clarified before attending class, can also have ample opportunities to apply programming concepts to solve programming tasks through their individual and team readiness assurance tests as well as the programming challenges posed to them in class.

Through active engagement of students both online and face-to-face, the author hopes to strengthen students’
understanding of programming concepts, increase their confidence towards programming and thus enhance their programming competencies.

**Literature Review & Pedagogy**

Team-based Learning is an instructional strategy that promotes active learning and participation through small group interactions (Michaelsen et al., 2002). In Team-based learning, students go through pre-assigned materials before coming to class where each student is required to take an Individual Readiness Assurance Test (iRAT) before re-attempting the same test, termed as the Team Readiness Assurance Test (TRAT) (Michaelsen & Sweet, 2008) as a team. The TRAT encourages team discussion and collaboration among members. Finally, the team is given a group challenge to reinforce concepts and deepen their understanding. Both the TRAT and the group challenge encourage active group discussion and facilitate learning.

Though well-backed by research as an effective strategy, Team-Based Learning is conducted predominantly in the medicine field to help students apply concepts taught in an engaging manner (Parmelee, 2012).

Whittington (2007) implemented Team-Based Learning in a programming class and observed a higher level of engagement and enthusiasm in the students during class participation as compared with traditional classroom teaching. However, the results he collected from his study was not significant to conclude if Team-Based Learning is an effective strategy to adopt for use in programming. Whittington noted that programming tends to be individualistic in nature and might not be as suitable for Team-Based Learning (Whittington, 2007).

Lasserre (2009) also researched on Team-Based Learning in a programming class and reported that there was a drop in the attrition rate for the students exposed to this form of instructional approach in class. She observed that class time management and the provision of immediate feedback by instructors were important factors for success for this teaching approach (Lasserre, 2009).

Team-Based Learning has been known to pose practical challenges such as having to set aside substantial time for the iRAT and TRAT in the classroom segment, leaving limited time for instructors to clarify content and learning material in class (Kolar & Sabatini, 1997).

To address these challenges, in this research, the author explored the use of Online Collaborative Learning to support the pre-classroom segment of the Team-Based Learning instructional strategy. Online Collaborative Learning allows students to keep up with their lessons in a self-paced, asynchronous manner while supporting team collaboration and interactions among students and instructors in-between their face-to-face sessions (Gomez et al., 2010). With Online Collaborative Learning, students can clarify their doubts and misconceptions with peers and instructors before coming to class. This helps them to perform programming tasks in class better. Through Online Collaborative Learning, instructors can also identify the learning gaps in their students as well as pinpoint challenging concepts that the students may have difficulties understanding even before class. This in turn helps the instructors to be more focused in class, enabling them to allocate more time to explain concepts that students deem as challenging. Over the years, collaborative learning has proven to be effective in helping learners pick up new ideas and concepts (Ku et. al, 2013).

Both Team-based Learning and Online Collaborative Learning promotes teamwork & collaboration, and align with Vygotsky’s socio-cultural theory’s “Zone of Proximal Development” that states that help and feedback of instructors and peers are necessary for a learner to pick up a new idea and concept (Vygotsky, 1980). According to Vygotsky, interaction between social, affective and cognitive states in a student’s development is important for learning to take place (Vygotsky, 1980). Team-based Learning and Online Collaborative Learning support this interaction.

Tapping on the benefits of both instructional strategies, this research aims to increase students’ confidence in programming and help students enhance their programming competencies by letting them work in teams to validate and reinforce the programming concepts in an engaging manner before and during class.

**Methods and Measurement**

To investigate the effectiveness of tapping on Team-Based Learning supported with Online Collaborative Learning to enhance programming competencies, 60 Year 1 Diploma in Cyber Security & Forensics students taking the module ITP1911 "Web Application Development & Project" during 2017 Semester 1 were identified as the Experimental Group. The research was carried out for the topic on "JavaScript" which is a programming language that allows dynamic creation of web content. Year 1 students from the Diploma in Financial Informatics and Diploma in Information Technology taking the same module in the same semester were identified as the Control Group. Both Experimental & Control groups consisted of freshmen new to programming. At the end of the research, both groups of students were required to take the same summative Javascript test as part of their in-course assessment.

The research was conducted over a period of 3 weeks. At the start of the research, the students in the Experimental Group were randomly assigned into groups of 4s to 5s. They would remain in this same group throughout the 3 weeks of the research study.

For the Online Collaborative Learning segment, the author used Mural.ly, a cloud-based, online visual workspace that provides shared, digital whiteboards for online team collaboration (Mariano, 2012). Accounts were set up for each student and invitations were sent for them to join virtual rooms created in Mural.ly for their Online Collaborative Learning before class. Exercises were posted on Mural.ly by the instructor for the students to attempt as a team before they attend their face-to-face session in class. To aid the students in these exercises, pre-assigned online reading materials were made
available to them on Blackboard, the learning management system adopted by the institution. The students were also encouraged to raise their queries about Javascript on Mural.ly for peers and instructor to clarify.

Online Collaborative Learning on Mural.ly allowed the instructor to track and participate in students’ discussion as well as clarify doubts that the students might have regarding the Javascript topic before they attend the face-to-face classroom session.

Figure 1 below shows a snapshot of the online exercises posted by the instructor for students to attempt as a Team.

Figure 1: Online Collaborative Learning On Mural.ly

Figure 2 below shows the snapshot of the instructor tracking the progress of a student on Mural.ly and giving feedback to the latter.

Figure 2: Instructor Tracking Student’s Learning Progress On Mural.ly

Following each session of Online Collaborative Learning is the face to-face classroom session which was aligned to the Team-based Learning instructional approach comprising the following segments:

individual Readiness Assurance Test (iRAT)
For the iRAT, each student was required to take a test individually. As this is a programming module, the author intentionally designed the iRAT to be application-based where coding was required. Each student would be required to solve a programming problem within a given time-frame. The iRAT was meant to test the student’s understanding of the topic, how familiar the student was with the programming syntax and how well he had grasped the Javascript concepts.

team Readiness Assurance Test (tRAT)
For the tRAT, the students were required to re-attempt the same programming problem as a team. As they discussed on the best algorithm to adopt to solve the problem, further learning would take place and the students could exchange programming techniques with one another.

Clarification
After the tRAT, the instructor would disclose the model solution to the students and allowed the students to negotiate and appeal for their solution to be accepted in the case where their solution worked but differed from that of the instructor’s solution. Through this, students would be exposed to a variety of programming techniques.

Further Challenge
Finally, a team challenge in the form of a more advanced programming problem was posed to every Team for them to collaborate and work on together to further strengthen their programming concepts. This provided the students with further opportunity to practise their programming skills.

To evaluate the level of success in using Team-based Learning supported with Collaborative Learning to enhance students’ programming competencies, the author used “Learning Effectiveness” and “Students’ Confidence Level Towards Programming” as learning matrices to be analysed against students from the Diploma in Information Technology and the Diploma in Financial Informatics who were taking the same module under the traditional classroom approach.

At the end of the research, both the students in the Experimental and Control Groups took a Javascript test as part of their module in-course assessment. This assessment constituted 10% of the overall module. For Learning Effectiveness, the following facets of measurements were being considered:

- passing rate of the students in the Javascript test
- mean score of the students in the Javascript test

To investigate whether students’ confidence level towards programming had increased, we looked at the qualitative feedback that was collected via various channels:

- survey questionnaires for students at the end of the research study to gather their experience in Online Collaborative Learning and Team-based Learning
- lecturer’s observation on students’ participation

The qualitative data collected would provide additional insights into how students perceive this method of teaching, whether they enjoy this form of
learning and also how this instructional approach can be further improved for future sessions.

Results and Discussion

Improved Learning Effectiveness
The author based the learning effectiveness on students’ passing rate as well as the mean scores in their Javascript assessment. The assessment constituted 10% of their total score for this module. Figure 3 below depicts the passing rate of both Experimental and Control groups.

Figure 3: Passing Rate Of Students In Their Javascript Test

From Figure 3, it was observed that there was a higher percentage (63.30%) of Diploma in Cyber Security & Forensic students passing the Javascript assessment compared to students from the Diploma in Information Technology and Diploma in Financial Informatics (57.50%). The higher percentage of pass in the Experimental group can be attributed to the students having a better grasp of Javascript concepts.

Next, comparison was made to see how each group fared in terms of their mean score.

Figure 4: Students’ Mean Score In Their Javascript Test

Figure 4 shows that the mean score attained was higher for students in the Experimental group (57%) compared to the students in the Control Group (53.32%). The results indicated a positive correlation between this form of instructional approach and students’ learning.

In the survey conducted to gather students’ perception on whether Team-Based Learning supported by Online Collaborative Learning had been helpful, 78.79% of the respondents agreed or strongly agreed that online collaboration before class had helped them grasp concepts better while slightly more than 20% disagreed or strongly disagreed on that. This is shown in Figure 5. The reason for the students’ disagreement could be attributed to them not being able to work well with their team-mates which in turn affected the effectiveness of their online collaborative learning. From the qualitative feedback collected, three respondents specifically requested to form their own groups for future collaborative learning.

Figure 5: Survey Results On Whether Online Collaboration Helped Students Grasp Concepts Better

Figure 6 below shows the students’ response when asked whether their confidence level in programming had increased as a result of this instructional approach. More than 77% of the students agreed or strongly agreed to that. There could be varying factors attributing to the reason why students disagreed or strongly disagreed on this. As observed by the instructors, some students did not accept the online invitation to join Mural.ly for their online collaborative learning. The lack of practice could have affected their programming confidence and competency during class.

Figure 6: Survey Results On Whether Students’ Confidence Level In Programming Has Increased

Overall, the research findings indicated that Team-based Learning supported with Online Collaboration has a positive impact towards students’ grasp of programming concepts and confidence.
From the survey questionnaires done by the students, it was observed that majority of the students enjoyed this teaching approach and indicated that it was better to work in groups than alone. Only 1 respondent requested not to have this form of learning. The qualitative feedback collected was also very positive with a number of similar responses from students such as “I like it”, “It’s fun”, “Good job”, “Engaging”, etc. When asked how they would like the lesson to be further improved upon, students commented that they wish to have more time for the Readiness Assurance Tests.

Classroom observation showed an increase in the level of student engagement. The instructor gave the following positive feedback with regards to this instructional approach:

- Most students participated actively during classroom discussion.
- Students were enthusiastic and continued to code beyond the time limit set for them.
- When the model solution was revealed, the students were very engrossed with the solution, which sparked off many questions for instructor to clarify.
- Instructors were able to gauge the programming ability of each student better.
- Students had learnt more through this instructional teaching approach.

The following challenges were faced by the instructor:

- For the Online Collaboration segment, some students did not accept the invitation sent by the lecturers for them to join the Mural.ly platform to collaborate online before meeting face-to-face.
- Shortage of time to run the various activities in the Team-based Learning segment. Time management is critical for the face-to-face segment. A few students came in late and affected their team’s performance.
- Students displayed a higher level of stress for this form of instructional approach, where marks are allocated for the iRAT and the tRAT, compared to traditional instructional approach.
- Some students continued with their coding challenge despite the time limit for the iRAT and tRAT being up.

Overall, instructors felt that they were able to identify learning gaps, assess the technical competency of each student and help them understand concepts better. Generally, it was observed that Team-based Learning with Online Collaborative Learning led to students being more inclined to take ownership for their learning as they are exposed to course content through preparation before class. Majority of the students enjoyed this form of learning compared to the traditional mode.

Addressing the challenges encountered, improvement can be made to future research studies of similar nature by ensuring all students participating in the study have access to the online collaboration platform before the start of the research. Instructors can also communicate the purpose of the research to the students participating in the research study to help them understand the motivation behind this instructional approach study, to prepare them better and alleviate the stress that they may be facing. More guidance can also be given to the students on how they can better manage their time during the readiness assurance tests.

**Conclusions**

Challenges faced by our students in programming are difficulties in grasping programming concepts and not knowing how to apply these concepts to solve programming problems. This research explored the Michaelsen’s Team-based learning approach supported with Online Collaborative Learning to increase students’ confidence towards programming and enhance their programming competencies. The research results showed that, harnessing the effectiveness of both strategies, there was a positive correlation in students’ confidence levels towards programming and students grasp programming concepts better compared to traditional teaching methods. It was observed that students have turned from passive into more active learners with this approach. Instructors also found this form of blended learning beneficial with students taking more ownership in their learning.

Team-based Learning and Online Collaborative Learning encourage students to think critically, collaborate, negotiate and solve problems as a Team. These are skills listed as among the top 10 future skills required in 2020 by the World Economic Forum Report (World Economic Forum, 2016). The author recommends adopting this pedagogical approach to help students enhance their programming competencies.

**References**


ACTUALIZING AN APPLICATIVE, AUTHENTIC SUMMATIVE ASSESSMENT USING A HYBRID MODEL OF AN INSIGHTS-DRIVEN DATATHON FOR IT STUDENTS

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Abstract

Next generation innovations and increasingly higher expectations for business value and security are rapidly shaping the Information Technology (IT) industry and workforce of today. Against this backdrop, a datathon can address the skill gaps and various constraints of traditional modes of summative assessments which include projects and assignments for computer science students. A datathon is a portmanteau, coined from the words “data” and “marathon”. It is a variant of a hackathon with the focus shifted towards participants from the data science community working with data and predictive models to complete a given challenge. At the School of Informatics & IT, the module Statistics and Analytics (SANA), which is offered to Year 1 students, incorporates learning both statistics and data science skills. This module’s learning objectives include data-driven activities, such as filtering through datasets with multiple variables, handling non-traditional data types, learning essential statistical models, categorizing raw data and collaborative team work. We hoped to elevate students’ achievements to higher levels than traditional projects through an authentic and performance-based datathon. This paper highlights the design, structure and eventual actualization of the assessment metrics of the datathon. It describes how the lecturers prototyped a hybrid model of a datathon to meet the principles of assessment criteria. We also elaborate on how the datathon can gauge students’ underlying skills and the quality of the assessment outcomes. Finally, this paper will indicate the results of the study and propose recommendations for future datathons.

Keywords: Digital innovative learning, datathon model, collaborative learning, learning analytics, data-driven

Introduction

Generally, Warner, J. & Guo. P. J. (2017) has characterized datathon as a data focused computer programming event or a pitching competition to display cases of programmed prototype digital innovations driven by analytical insights. Datathon is a variant of a hackathon with its focus shifted towards data. The purpose of a datathon (Anslow, C, 2016) is for data science community’s participants to practice data science and analytics skills for either work or studies. Organizations have began to provide data to encourage external stakeholders to participate by improving existing services (Hjalmarsson & Rudmark, 2012). In Calgary, datasets are provided by non-profitable organizations for ‘Data for Good’ event in exchange for data-driven insights resulting from the datathon. (S. Seyffarth, 2015). Similarly, in Sweden, Innovation for Sustainable Everyday Travel (ISET), (Hjalmarsson, A., and Lind, M., 2011) provides open data for innovation to enhance sustainable everyday travel.

Briscoe, G. & C. Mulligan (2014) have traced the origins of hackathon back to 1999 when open-source software developers OpenBSD and Sun Microsystems introduced hackathons for developers to create software on their respective platforms. In contrast to the earlier hackathons, hackathons are now prevalent activities for software companies, like Google and Facebook (Alexandra Chang, 2012). This rising popularity is due to the alignment of company culture with hackathons’ rapid-fire prototyping, fusion of expertise, experience, skills and innovation. The hackathon phenomenon is known for its innovativeness and creativity on how a problem is solved (S. Zheng, 2013) at events. The proliferation of hackathons, over 400 hackathons are reported from 2000 to 2012 worldwide (S. Leckert, 2012) across several disciplines forms the culture of digital innovation. Being more collaborative than competitive, the present events contain a spectrum of activities, enabling students to pilot new ideas, synergizing technopreneurs and innovators in context on emerging trends, and serving as de facto hiring arena for tech companies.

Briscoe, G. & C. Mulligan. (2014) explained that hackathons have spiraled into different alternatives. With the burgeoning amounts of data and a growing data science community, datathons assemble data enthusiasts to model data-driven solutions. Typically, datathons are known to be intensive and accelerated competitions which are coordinated in a business environment. It is recommended to assemble datathon participants in interdisciplinary teams (Aboab et al., 2016), although
monodisciplinary teams are fine. So-called datathons transfer the hackathon concept to challenges with regards to data analytics (Aboab et al., 2016). Applying analytics requires a combination of capabilities: analytics, statistical, mathematical, and programming skills (T. H. Davenport & Patil, 2012). The range of tasks can be varied, from data preprocessing and cleansing to data mining and data visualization (Anslow, Brosz, Maurer, & Boyes, 2016).

The purpose of this study is to explore how the synergies and innovations in a hybrid model of datathon can fit into the complex educational system as an alternative, authentic and summative assessment. What are the modifications needed and constraints encountered to introduce it into the intricate educational system to measure learning? Concurrently, we will investigate corresponding assessment metrics and their mapping.

The research questions of this paper are: (1) What are the design parameters for a summative assessment using a hybrid datathon model? (2) How can we design effective assessment criteria and rubrics? (3) What are the perspectives of the participants?

**Implementation and structure of the hybrid datathon**

In the School of Informatics & IT, we propose and implement a hybrid model of datathon in place of a summative assessment. The primary reason is to evaluate students in environment similar to the IT workplace. In the educational context, (Wiggins, G., & McTighe, J.,1998) define summative assessment as a formal measurement of determining if students have sufficiently understood learning goals after a designated time period. Fulfilling such criteria is critical in tests, examinations and final projects.

In a datathon, identifying the right problem usually leads to success because a quick, tangible hack can be demonstrated at the end. Contrary to a datathon, it is imperative for us to concentrate on the design process (Artiles, J. A., & Wallace, D. R., 2013). In the educational context, we are expected to establish the problem, execute brainstorming, prototyping, end user feedback and evaluation. Thus, the design of an educational datathon has to incorporate all these parameters.

In the initial phases of planning, two Year 1 logic and analytics cluster modules: Logic & Mathematics and Statistics & Analytics which were taught over 17 weeks are chosen for the datathon. These are core modules and their learning objectives are analytics acquisition, algorithm thinking, data cleaning and dashboard creation skills.

The datathon was held in the last week (week 17) of the semester. A week before the datathon (week 16), smaller groups of 5 to 6 students are already formed for individual classes. On the actual event, 12 tutors are deployed to 21 participating classes. The tutor’s role is to check the attendance of group members, introduce the dataset, provide directives and a set of general guidelines before its commence. Since it is a scaled down hybrid model, time given for the various groups to brainstorm, acquire data, investigate complex relations and code a dashboard is limited to 6 hours at the learning labs with unlimited access to the internet.

Once the datathon begins, groups work intensely within the time frame from 9am in the morning till 3pm, after which they must cease work and present the dashboard end product with analytical insights to the panel of 3 judges, who are making their rounds to the teams. In the brainstorming session, certain innovative and resourceful groups are seen engaging with online tools which are not taught in the modules for further exploration and processing of given datasets. Some groups tend to be distracted and may take a much longer time to settle in. Many groups quickly work towards their goals and strategize their approach (Figure 1). In a few groups, a visible leader is leading and delegating work to the group in their distributed tasks. Finally, at the end of the 6 hours, teams have to cease work, upload their source codes to a server and give a demonstration. The judges would walk around the venue to assess the insights analysis of the end product using a standardized marking rubric.

**Design parameters for hybrid model of datathon**

In this section, we shall discuss the principles when we design the hybrid model datathon for its suitability as a summative assessment in the educational context.

![Figure 1.0](image)

**Figure 1.0**: (a) Teams brainstorming in a learning space (b) Data analysis using external tools (c) A team exploring the dataset (d) End-product from a team

Firstly, it is essential to evaluate the curriculum of the analytics cluster modules to ensure relevance of knowledge learnt. Analytics or data science addresses the exploration of data sets with different quantitative methods motivated from statistical modelling (James et al., 2015). Cleveland (W. Cleveland, 2001) emphasizes that students should analyze data and it should be a major part required of undergraduate programs in data science. The analytics cluster modules seek to introduce basic data science or knowledge generation from data. The general learning outcome expects students to transform raw datasets and build a dashboard. (Table 1.0). It is fitting to translate a small-scale datathon into several assessment tasks which fulfill the specific learning goals (Boud, D., 1995). The key activities identified in data value chains include data generation, data acquisition, data processing, analytics and visualization. (Miller & Mork., 2013) (Curry, 2016). Since, a data challenge emphasizes on analytics skills such as organizing raw
data, using different data types, sorting through datasets with variables and dashboard creation of insights, it is appropriate to model a summative assessment after a data challenge. As we can see, some key development phases in a data life-cycle are linked to the specific learning outcomes too.

Table 1.0: General and specific learning outcomes.

<table>
<thead>
<tr>
<th>Topic 5</th>
<th>Dashboard Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Learning Outcome</td>
<td>Specific Learning Outcomes</td>
</tr>
<tr>
<td>Students should be able to:</td>
<td>Students should be able to:</td>
</tr>
<tr>
<td>5. transform raw datasets and build a dashboard.</td>
<td>5.1 identify data quality problems in a data source;</td>
</tr>
<tr>
<td></td>
<td>5.2 apply data transformation techniques to clean data;</td>
</tr>
<tr>
<td></td>
<td>5.3 build a dashboard using a visualization tool.</td>
</tr>
</tbody>
</table>

Secondly, the datathon is both focus-centric and tech-centric where the end product will address specific learning outcomes in our educational context. Briscoe & Mulligan, (2014) distinguish between tech-centric and focus-centric. Our datathon is tech-centric datathon as it focuses on software application with a specific visualization software, Microsoft Power BI. We assess our students’ notions of competence with respect to learning and software skills on dashboard building using this application. The assessment is suitably refined to map the datathon’s problem statements to our specific learning outcomes. Being focus-centric, our students have to demonstrate the ability to prepare data, discover insights and charts. In fact, (Boud., D. 1995) deems good assessment as one which closely reflects desired learning outcomes and the process of assessment has a directly beneficial influence on the learning process. We decide to challenge students on a formative approach in our problem statement for deeper cognitive thinking.

For example, a summative approach with specific learning outcomes (Table 1.0) is very structural, such as giving students a dataset, asking for step-by-step computation of variance, mode and inter-quartiles, plotting of data charts and building the final dashboard. Alternatively, a formative approach requires students to explore the same dataset and significant variables. Relying on their cognitive abilities, students have to compute suitable statistics and data charts to discover significant causal variables and their relations within the dataset without pre-identified variables (Table 2.0).

The application of data science is diverse, with focus on areas such as information security (S. Kumar, 2014), healthcare informatics (G. Zheng, C. Zhang, L. Li, 2014) and software engineering (T. Menzies, E. Kocaguneli, F. Peters., B. Turhan, 2013). Additionally, data understanding and domain knowledge are key prerequisites in the analysis process (Waller & Fawcett, 2013). Thus we provided 5 datasets in different contexts consisting information of hospital discharge rates, workers’ salary and age, geographical transport connectivity, industrial employees’ demographics, credit loans with customers’ credit ratings to the participants.

Thirdly, it is an authentic assessment, with what Wiggins, G. (1989) described as “contextualized complex intellectual challenges, not fragmented and static bits or tasks”. Cleveland (W. Cleveland, 2001) highlights that the practicing data analyst faces two critical tasks (1) the building of a model for the data; (2) estimation and distribution of the model. Cleveland (W. Cleveland, 2001) comments that it is vital for data science subject to carry statistical thinking to subject matter in various disciplines. Our fundamental datathon will allow students to deliver tangible products, a report and dashboard where new data insights are discovered from the quantitative charts while building real data analytics practices.

Table 2.0: Problem statement for the datathon.

<table>
<thead>
<tr>
<th>Specific criteria tested</th>
<th>Specific Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deliverables: A report not more than 1000 words</td>
<td>State what you want to investigate in this given dataset. E.g. “Over the years, can we see some trends in the discharge rate of some diseases?” Do not use this question for your project.</td>
</tr>
<tr>
<td></td>
<td>Data preparation or data cleaning steps that you have taken. Take screenshots of the step by step procedure that you have done.</td>
</tr>
<tr>
<td></td>
<td>Different charts that you have created. Take screenshots and do explain your choice of charts.</td>
</tr>
<tr>
<td></td>
<td>The insights or new things that you have discovered while looking at your charts.</td>
</tr>
</tbody>
</table>

In higher education, concerns about learning outcomes oriented perspectives in a discipline have been open to critical scrutiny. Some questions we need to answer are: Can graduates perform in the current “analytics 3.0” environment (Davenport, 2013)? Are current assessments the best performance measurement for related methods of analytics such as text, web and network analytics? (H. Chen, Chiang, & Storey, 2012) As Boud comments that traditional mastery tests are inadequate as the questions are often contrived and the cues are artificial as standard right answers equate to adequacy in achievements. Hence, the preference for a datathon in our case (Boud, D., 1995).

Assessment rubrics and criteria for datathon model

All assessments require evaluation parameters and these can either be explicit or implicit. (Black and William, 1998). The rationale of assessment is to capture complicated learning outcomes, implement realistic tasks, and use good instructional tools to include elements of collaboration and interaction among students. Earlier, we have devised the problem statement and students’ deliverables as criteria to match specific learning outcomes. Sadler (1998) commented that assessment begins with identifying a number of relevant criteria, then we measure the amount present on each criterion and we
combine the various levels or estimates into an overall measure of merit by means of a formula (Sadler, 1998). In an educational context of an assessment, Scriven points out that it is usually necessary to justify (a) the data-gathering instruments or criteria, (b) the weightings and (c) the selection of goals (Scriven, 1967).

In the design of the datathon, there are 2 deliverables, a report and a dashboard. We map the specific criteria of the deliverables to the specific learning outcomes in our modules. (Table 2.0). In the report deliverable, all the specific learning outcomes are translated into essential criteria for measurement of learning competency of data analytics.

To provide clarity in the data challenge’s grading process, we propose a rubric with evaluative criteria. In this paper, assessment rubrics broadly refer to detailed grading with numbers or formulae and they are suggestive of broad quality levels (Sadler, 2009a). The creation of rubrics is in the teachers’ domain and we adopt Bigg’s structure of observed learning outcomes (SOLO, Biggs and Tangs 2007) where there is a transparent alignment between objectives, learning activities and assessment tasks. Likewise, each grade description has embedded within it a number of criteria and descriptors of our learning objectives. The rubrics for the panel of assessors are provided below (Table 3.0).

As an overview, we will discuss the design elements present in the datathon rubrics: specificity, scoring strategy, evaluative criteria and process. The rubrics enable assessors to grade tasks meaningfully and consistently. We have built evaluative criteria into the rubric to break down the grading into several smaller criteria.

Table 3.0: Marking rubrics for end-product dashboard

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solve data quality problems in the dataset</td>
<td>(At least 4) Evidences of cleaning erroneous data values</td>
<td>(3) Evidences of cleaning erroneous data values</td>
<td>(2 or less) Evidence of cleaning erroneous data values</td>
<td>(No) Evidence of cleaning erroneous data values</td>
</tr>
<tr>
<td>Integrate appropriate statistical charts for visualisation purposes</td>
<td>(At least 4) Intuitive charts that are easy to understand</td>
<td>(3) Charts that can be understood</td>
<td>(2 or less) Charts can be improved</td>
<td>(No) Charts are minimal and not intuitive</td>
</tr>
<tr>
<td>Apply suitable data transformation techniques on variables</td>
<td>(At least 4) Show significant relations of quantitative variables</td>
<td>(3) Show relations of quantitative variables</td>
<td>(2 or less) Show important relations of quantitative variables</td>
<td>No relations of quantitative variables</td>
</tr>
</tbody>
</table>

With the rubrics constructed, a scoring strategy can be effectively put in place. For the modules, there is a desired level of skills expected from our learners. Each of the quality definition descriptors occupies one cell in our table and each row represents a particular evaluator criterion. To differentiate the varying quality levels, words from Bloom’s taxonomy or Bigg’s structure of observed learning outcomes are used in our rubrics. These words help to differentiate the varying complex levels of the learning goals. The same weightage of marks can be distributed and totaled to a final score of 25.

At the start of the process, all the members of the judging panel share a common understanding of the assessment rubrics. A ‘calibration exercise’ is carried out and it includes marking a subsample and discussing the agreed marks. In our current assessment grading, feedback is not given. However, to close learning gaps in future, the graded rubrics can be used as a formative class tool to articulate feedback to the respective teams.

Results and Discussion

In this study, we conducted a questionnaire survey comprising of closed and open ended questions on participants’ learning experience, satisfaction and team effectiveness among 25 randomly selected participants.

As shown in Figure 3.0, 80% of participants agreed or strongly agreed that datathon as an assessment tool has helped in their learning experience [Qn.1]. Despite this, 20% of participants preferred not to have datathon as an alternative assessment [Qn.3]. In the open-ended question [Qn.4], students cited their reasons such as the time challenge, difficulties of finding suitable team members and the grading in a datathon. 48% of the participants disagreed the datathon helped them to visualize real world applications, citing reasons that classroom learning is a less stressful mode of learning than a graded datathon where they need to deliver an end-product in such a short time [Qn.5,6]. Finally, a large proportion, 96% of participants agreed they have to collaborate or learn to work in a team for this authentic form of assessment [Qn.7].

![Figure 3.0: Survey Question 1: The datathon assessment helps me in my overall learning experience.](image-url)

Questions 9 to 13 assessed the participants’ opinions on team effectiveness [Qn. 9 - 13] in the
datathon. The team effectiveness is defined as a dependent variable, with suggested independent variables: corporate role, work methods, team achievement, commitment, and membership suitability. Participants ranked the variables based on a 10-point Likert scale ranging from “1” to totally disagree to “10” as totally agree.

Most participants felt team members were committed, cooperative, and they experienced team achievement. This is supported by a mean of 7.37 [±2.056], 7.33 [±1.366] and 7.16 [±1.732] respectively. However, students felt members may not develop systematic and effective work methods to solve problems together and there may not be an appropriate balance in every team in terms of a good “mix” of skills: mean of 6.83 [±1.471] and 6.66 [±2.875].

Questions 14 to 19 assessed the participants’ learning from a learners’ perspective (Qn. 14 - 19) in the datathon. Suggested independent variables influencing learners’ learning perspectives are individual development, creative capacity, learning relevancy, real-life engagement and satisfaction.

From the results, participant rated satisfaction, learning relevancy and real-life engagement highly: mean of 8.23 [±0.923], 7.67 [±0.517] and 7.50 [±1.049]. Individual development was rated higher than creative capacity: mean of 7.00 [±1.090] and 6.50 [±2.258].

Table 4.0: Means, standard deviations of variables on a sample (n = 25)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ranked Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Commitment</td>
<td>7.37</td>
<td>2.056</td>
</tr>
<tr>
<td>Corporative role</td>
<td>7.33</td>
<td>1.366</td>
</tr>
<tr>
<td>Team Achievement</td>
<td>7.16</td>
<td>1.732</td>
</tr>
<tr>
<td>Work Methods</td>
<td>6.83</td>
<td>1.471</td>
</tr>
<tr>
<td>Suitable Membership</td>
<td>6.66</td>
<td>2.875*</td>
</tr>
<tr>
<td>Learning satisfaction</td>
<td>8.23</td>
<td>0.923</td>
</tr>
<tr>
<td>Learning relevancy</td>
<td>7.67</td>
<td>0.517</td>
</tr>
<tr>
<td>Real-life engagement</td>
<td>7.50</td>
<td>1.049</td>
</tr>
<tr>
<td>Individual Development</td>
<td>7.00</td>
<td>1.090</td>
</tr>
<tr>
<td>Creative Capacity</td>
<td>6.50</td>
<td>2.258*</td>
</tr>
</tbody>
</table>

Conclusions
As we move towards a holistic conception of assessment as a total package of both learning and assessment, we decide to adopt data as a measurement of our students’ learning.

It is observed that the nature of the hybrid datathon contributes to the development of student expertise in data-driven activities such as algorithm thinking, data cleaning and dashboard creation on their datasets. It compels participants to create a feasible end product in an authentic environment and experience team commitment, team achievement and teamwork in the process. The entire process is cognitively beneficial because students sharpen their own self-evaluative capacities in the teams. Building models with data analytics and statistical, mathematical and programming skills in a team setting are important areas of data science for the data analysts. Hence, a datathon provides practical experience among our students in key data value chain and analytics skills. There will be exciting new frontiers in data science for analyst who are involved in computing with data and able to cross subject matter disciplines.

A future area of study is the usage of open data and cross collaboration with organizations in educational datathons. Open data are data repositories that are not subjected to restrictions on their distribution and uses Opportunities of institutes collaborating on datasets for the benefits of communities and public good is a possibility with the advent of “analytics 3.0” organizational analytics. Finally, we can look forward to combination of innovation, analytics and open data in the future.

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Abstract

English education at NIT has more potential for investigating an efficient and practical way for young engineers to acquire the language skills. This paper aims to examine the comprehensive teaching methodology which is the science laboratory activities for engineering students of English language learners. To share the evaluation of students and discuss the ways of improvement are also the purposes of this paper. Author conducted three science laboratory activities from November 2017 to June 2018. The levels and courses of the students vary: 1) first-year students of electrical engineering courses, 15-16 years old, 2) first-year students of material science course, 15-17 years old, and 3) fifth-year students of material and mechanical engineering courses, 19-22 years old. Each class had 23-41 students. First, students were divided into six different groups and each group was assigned to conduct an experiment. For example, a group investigated a subject to visualize Gyro Effect using balloons and coins. Students should understand the experiment flow from English instructions. Second, students discussed the background and hypothesis of the experiment among themselves. Then, they conducted the actual experiments using basic materials, scribbling notes on a sheet of paper and taking pictures for reporting. Next, they wrote a lab report in English by analysing what they had observed in the experiment. According to the lab report, students made a speech manuscript and Power Point presentation all in English. Finally, each group made a presentation about their experiments and share results in front of their classmates. More than 65% of students made a positive evaluation while about 30% found it difficult yet better than using textbooks. Even though the activity needs to adjust contents of experiments depending their courses and levels, it was a versatile method for every level and major.

Keywords: English education, English teaching methodology, English language learners, science laboratory, National Institute of Technology

Introduction

The English education at the National Institute of Technology (hereafter called NIT) has more flexibility compared to general high schools in Japan. It is because students of NIT do not need to study for the entrance exam to enter university since its basic curriculum is for five years unlike high schools that has three years. Some students proceed to university to add two more years to acquire a bachelor degree, others start working right after graduation. Either way, they need more practical English skills than just techniques to pass the examination.

Some studies have shown the importance of motivation for English language learners. For instance, Johnson and Johnson (2010) analysed that engineering students tend to study English because of extrinsic motivation such as for their credit or career rather than intrinsic motivation associated with enjoyment to learn new things or fulfilment to speak other languages. Kimura, Nakata, and Okumura (2001) compared engineering students to English major students in Japan and they discovered that students have more pragmatic reasons to study English than English major students. Iwamoto (2018) conducted a survey for engineering majors of Toyo University to examine whether there are differences between their motivation types depending on their English proficiency. She argues that even among engineering students, those who have high proficiency in English enjoy learning English. In other words, motivation is the key to improve their language proficiency. Iwamoto also suggests that it is important to promote extrinsic motivation by using materials to make students understand “how engineers can use English in their professional lives” (Iwamoto, 2018: 11).

There are many teaching methods introduced by scholars who have been investigating how to solve the problems in teaching second language learners. For example, Larsen-Freeman and Anderson (2011) introduced 11 English language teaching approaches namely 1) grammar-translation, 2) the direct method, 3) the audio-lingual methods, 4) the silent way, 5) desuggestopedia, 6) community language learning, 7) total physical response, 8) communicative language teaching, 9) content-based instruction, 10) task-based language teaching, and 11) a politically-oriented participatory approach.
As of now, the NIT, Wakayama college uses high school level English textbooks approved by the Ministry of Education, Culture, Sports, Science and Technology for the first- and second-year students. Professors mostly use these textbooks based on the teaching methods of 1) grammar-translation, 2) the direct method, sometimes 3) the audio-lingual methods. However, professors have freedom to adjust their syllabus and to add extra activities in their classes to help students motivated to use English rather than study English. As the previous work admitted, in order for engineering students to promote motivation, connecting English learning to their professional lives is important.

Therefore, this study investigates the effective way to promote engineering students’ motivation for English learning by using the content-based instruction as well as the task-based language teaching. To increase the intrinsic motivation, English teaching methodology should be related to what engineering students are familiar with and fun of thus the contents are about science experiments and the tasks are to make presentation using a computer and software. This paper analyses the evaluation of students to verify students’ response for this module.

Methods and Pedagogy

I conducted science laboratory activities for three times between November 2017 to June 2018. The level and course of the students varied as Table 1 shows. It was a compulsory course for Class A & B while Class C was a part of elective course.

Table 1. Participants information

<table>
<thead>
<tr>
<th>Class</th>
<th>Year</th>
<th>Age</th>
<th>Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>First-year</td>
<td>15-16 y/o</td>
<td>Electrical engineering</td>
</tr>
<tr>
<td>Class B</td>
<td>First-year</td>
<td>15-17 y/o</td>
<td>Material science</td>
</tr>
<tr>
<td>Class C</td>
<td>Fifth-year</td>
<td>19-22 y/o</td>
<td>Mechanical engineering and Material science</td>
</tr>
<tr>
<td>Class size</td>
<td>40 students</td>
<td>41 students</td>
<td>23 students</td>
</tr>
<tr>
<td>Date of activity</td>
<td>November to December, 2017</td>
<td>November to December, 2017</td>
<td>May to June, 2018</td>
</tr>
</tbody>
</table>

First, students were divided into six different groups with 3 to 7 students depending on the class size. I advised students to move their desks and chairs to start a group work easily. I asked them to decide the roles of each member of the group such as a leader/facilitator, time keeper, reporter, and presenter/s. Each group was assigned to conduct a different experiment and they should first understand the instruction written in English. I assigned six experiments as Table 2 chosen from the experiments introduced in the textbook, whose main authors are professors of NIT, called “Exploring SciTech English” published by Kairyudo.

Table 2. Types of experiments

<table>
<thead>
<tr>
<th>Name of the experiment</th>
<th>Purpose of the experiment</th>
<th>Materials used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyro Effect</td>
<td>To examine Gyro effect and to think about when we can feel it</td>
<td>Balloons and coins</td>
</tr>
<tr>
<td>Magnus Effect</td>
<td>To understand Magnus effect which is useful to break balls</td>
<td>A vinyl tube and some clay to make a ball</td>
</tr>
<tr>
<td>Vibration control</td>
<td>To test the best way for vibration control to know what kind of construction and earthquake suppression</td>
<td>A sheet of paper, a cardboard, glue, paper clips, a pencil, and a cutter knife</td>
</tr>
<tr>
<td>Jet engine</td>
<td>To describe how jet engine works</td>
<td>A long thread, a balloon, a straw, and sticky tape</td>
</tr>
<tr>
<td>Paper plane</td>
<td>To observe how a plane can be in the air for a long time</td>
<td>Some sheets of paper and clips</td>
</tr>
<tr>
<td>Super-cooling</td>
<td>To demonstrate the work of artificial cloud by freezing water with salt</td>
<td>Aluminium foils, a plastic container, ice (100g), a plastic bag, salt (20g), water, and a hammer</td>
</tr>
</tbody>
</table>

Second, I explained about the lab report which students were required to submit. Among three classes, only students in Class C were used to write a lab report already because they were already the fifth-year students thus I needed to explain deeply about what and how to write it for Class A and B. After being explained, students discussed about the background and hypothesis of the experiment in the group and write a first half of the lab report. They also listed up what materials they needed for the experiment.

Then, each group conducted an actual experiment using basic materials that the instructor prepared based on the list made by students. While conducting an experiment, it was suggested to scribble notes on a sheet of paper and take pictures for reporting. All six experiments were done inside a classroom at the same time.

Next, they wrote the second half of their lab report in English by analysing what they had observed in the experiment. According to the lab report, students made a speech manuscript and Power Point presentation all in English. Since the first-year students were not used to make a presentation, the instructor taught them the basic usage of the software in a computer room.
Finally, each group made a presentation to share their experiments and findings in front of classmates in English. It was not only an instructor but also students themselves who evaluated their classmates’ presentations using a judging sheet. The points of evaluation were contents, clearness, attitude including eye contact and gesture, effectiveness of PPT, and teamwork. A group that got the highest score were awarded in class.

Table 3. Schedule of the activity

<table>
<thead>
<tr>
<th>Week</th>
<th>(90mins)</th>
<th>Goal</th>
<th>Class style</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>to understand the flow of the entire activity</td>
<td>Group work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to figure out the instruction of experiment</td>
<td>Lecture &amp; Group work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to discuss the background, hypothesis, and necessary materials of the experiment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>to conduct an experiment per group</td>
<td>Group work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to discuss the results of experiments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 3</td>
<td>to write a lab report in English and to make a manuscript of presentation</td>
<td>Group work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to make presentation about the experiments in English using a software</td>
<td>Presentation preparation</td>
<td></td>
</tr>
<tr>
<td>Week 4</td>
<td>to give a presentation in English</td>
<td>Presentation</td>
<td></td>
</tr>
<tr>
<td>Week 5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Reflection of students

<table>
<thead>
<tr>
<th>Positive comments (%)</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment</td>
<td>14 (35%)</td>
<td>19 (46%)</td>
<td>16 (70%)</td>
</tr>
<tr>
<td>Cooperation</td>
<td>10 (25%)</td>
<td>14 (34%)</td>
<td>3 (13%)</td>
</tr>
<tr>
<td>Fulfilment</td>
<td>5 (16%)</td>
<td>5 (12%)</td>
<td>6 (26%)</td>
</tr>
<tr>
<td>Others</td>
<td>4 (10%)</td>
<td>6 (15%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Negative comments (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficult</td>
<td>14 (35%)</td>
<td>14 (34%)</td>
<td>5 (22%)</td>
</tr>
<tr>
<td>Nervous</td>
<td>1 (3%)</td>
<td>3 (7%)</td>
<td>2 (9%)</td>
</tr>
<tr>
<td>Regretting</td>
<td>1 (3%)</td>
<td>0 (0%)</td>
<td>4 (17%)</td>
</tr>
<tr>
<td>Others</td>
<td>1 (3%)</td>
<td>1 (2%)</td>
<td>1 (4%)</td>
</tr>
</tbody>
</table>

Conclusions

To raise both intrinsic and extrinsic motivation, this natural science oriented English activity makes sense in three ways: 1) most of engineering students like and are used to conducting experiments thus, they do it out of curiosity; 2) it is practical for engineers to write a lab report and make a presentation in English; and 3) reflection from students shows that students feel fulfilment throughout the activity. Even though a lecture needs to adjust contents of experiments depending on their courses and levels, it would be a versatile method for every level and major of NIT.

Acknowledgements

I would like to thank my colleagues, professors and admin staff who always support me at work. Also, a great appreciation goes to my students who participated in my class with enthusiasm.

References


FACTORY CLASSROOM: AN EDUCATIONAL TOOL FOR NURTURING SCIENTIFIC FACT FOR FOOD TECHNOLOGY

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Abstract

This paper presents an onsite learning with training method for undergraduate and graduate students majoring in food engineering and the small and medium entrepreneurs in food industry. A multi-disciplinary laboratory fusing with a multi-function mini-factory, called "Factory Classroom," was established by academic staffs from food, agriculture, industrial and computer departments of faculty of engineering at KMITL. In our factory, prototypes of food machine were designed by ours researchers. Some industrial food machines was supported by the leaders of food machine manufacturing companies in Thailand and Japan. To foster learning, the students are assigned to conduct experiments. They designed their own products produced by machines in the factory. The first objective is that students’ products are served various campus activities. The second objective is to provide a scientific training programs in food product design and technology transfer using the machines for SMEs, called friendly SME services. Ultimately, to nurture professionals, the factory classroom aims to be a role model for serving the food industries and SMEs of Thailand. It is our obligation to design quality products, develop the future food, and implement smart food machines as integration of learning-by-doing and teaching-by-real-world examples. In the first phase of Factory Classroom, the main food processing methods are drying, freezing and thermal processing which aims for developing prototypes nutritious and high value beverage, and ready-to-eat products.

In academic year August 2016- April 2017, Factory Classroom launched more than 20 pilot food products developed by graduate students granted by Thailand Research Fund (TRF). Each product assigned from the entrepreneurs who had their own market. The prototype of drying machine has been designed by graduate students under intensive supervising by staffs from many departments. The work was supported by Thailand Research Fund and National Research Council of Thailand.

Keywords: 21st century learning, teaching entrepreneurship, multiple department collaboration, flipped classroom.

Introduction

Thailand is one of the largest agricultural and food product country. The food industry is a very important contributor to Thailand’s economy and has obtained the country sobriquet as “Kitchen of the World.” Meat and seafood preparations are valued around $6.0 billion (Thailand, 2018). In addition rice, cassava, sugar and canned pineapple from Thailand are the top ten of world export (Thailand, 2016). All food processing industries have been grown rapidly over decades to serve the world market demand. In the year 2016, Thai government had vision THAILAND 4.0 to transform old economy into a value-based economy that is driven by innovation, technology and creativity. Instead of producing simple commodities food products, the high value creation food products must be taken place. In this economic model, the smart farming should be spread over Thailand. Small and medium enterprises in food industries must transform into smart entrepreneurial ones with high creativity and potentials. To produce quality smart manpower for next generation of food industrialization with the 21st century skills and creative research outcomes contributing to value based economy, the engineering education in the Thai universities must be reformed.

From Flipped Classroom to Factory Classroom

Factory Classroom is a research unit of faculty of engineering established for training research students, commercial services with industrial cooperation.

To achieve the aims of THAILAND 4.0 for high-value food products, brands of products should be defined. With this reason, the best material, selecting
from organic or high quality control farm are the priority in consideration. In addition, taste of the best preservation for products are mainly concerned.

To fulfil the mission, three teaching teams from four departments and an industrial board were created. The first teaching team were recruited from department of agricultural engineering responsible to design and implement smart farms, and check quality of materials from the farms.

The second team comprises professors from food and computer engineering departments. This team is the main members of Factory Classroom operating in the laboratory and also in the factory. In this team, the good manufacturing practice (GMP) experts from the food industry are employed to supervise the students and a highly experienced former CEO was invited as an honorary advisor. The last team is a modern marketing one working for feasibility study before launching the products. Job descriptions also include creative packing design and branding of the product.

The three teams are work together with external modern marketers to ensure delivery of real products for the market place. After finishing feasibility study and functional product implementation, the packaging designers from the faculty of architecture are responsible to finalize the prototypes and the products.

**Factory Classroom as a Learning Plant**

The factory classroom plant shown in Fig. 1 is a workplace consisting of a co-working space for teaching, a business office, a food laboratory and a main factory.

In the learning plant, the processing function is to achieve shelf life extension, preserve food quality with optimal temperature and moisture contents and modern design packaging. The Factory Classroom consists of four process units which are collaborated with the food industrial manufacturers and outside funding and granting agencies. For more detail, the four process units are as follows:

1. **Freezing Process**: Freezer is a major food preservation, cooling food maintains temperature below freezing point of water to slow the microbiological activities that cause deterioration in foods. An industrial size freezer was donated by PATKOL shown in Fig. 2, a public company in Thailand that is one of leaders in food processing engineering in Thailand.

2. **Drying Process**: A smart drying machine was designed and built for the process of heat and mass transfer from external heating medium into food. Referred to the machine shown in Fig. 3, smart sensor and intelligence control for programmable condition were designed by Ph.D students under supervising by professors in food and computer departments under the grant supporting from the TRF.

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**Figure 1** In spatial views, Factory Classroom consists of two main spacing utilities: The first floor is a factory and the second floor is a classroom.

**Figure 2** The freezer used to teach and train students for freezing processes.

**Figure 3** A smart medium-temperature machine for fruit drying processes.
3. **Freeze-drying Process**: Freeze drying unit is an effective way for drying by removing water form products after frozen under vacuum. Unlike dehydration by the most drying processes which evaporate water using heat, the process involves freezing the materials or products, lowering pressure by vacuum, then removing the ice by sublimation. This process is suitable for preserving on characteristic of initial form or conditioning materials. The freeze dryer obtained an award form national innovation agency of Thailand and National Research Council award, the machine shown in Fig. 4 was designed and constructed by the ITC company (Thailand). The CEO of the company, the best alumni and a role model for our students in Factory Classroom, devoted this machine.

![Figure 4](image)

**Figure 4** The ITC Kyo-D freeze-drying machine is used by students for learning the process.

4. **Evaporating process**: A multi-propose evaporator is a machine employed to evaporate water from liquid foods to make concentrated liquid products. The machine shown in Fig. 5 was donated under international industrial collaboration between the Faculty of Engineering, KMITL, and Nishida Food Machinery company, Japan.

![Figure 5](image)

**Figure 5** The multi-purpose evaporator is donated by Nishida Food Machinery company, Fukuoka, Japan.

**Students in Factory Classroom**

After the students enroll in a graduate program in food engineering, which includes of course work, seminar and thesis. To fulfil graduate requirement, master degree students must publish at least one paper in a conference proceeding and the doctoral degree ones require publication in international journals. In order to meet program requirement and to satisfy the essential 21st century skills for the professional and career development, the students need to adopt and enhance the following skills:

- Decision making
- Problem solving
- Communicating orally, and
- Creativity.

The project based on real products are assigned for full time students who are employed as food developers in Factory Classroom. The prototype product owners are SMEs supporting financially under grants from the TRF. After finishing feasibility study by the marketing team of Factory Classroom, students have been jointed working closely with SMEs who have own their market positions.

![Figure 6](image)

**Figure 6** Students and SMEs work together to develop commercial products.

To teach decision making skill, each student plays role as a key developer of the product, planning on a laboratory scale to pilot scale experiments as shown in Fig. 7, and the set up are all designed under limitation of time and budget by the student under supervising by the teaching team of Factory Classroom.

![Figure 7](image)

**Figure 7** Students use a UHT machine made in the USA to produce fruit drink products.
The problem solving skill is trained on how to control raw material, looking for process methods using scientific assumptions. Every week, all students must join a seminar with the teaching team and international research students who visit under co-researching programs with the Factory Classroom students. A progress report of each student must be in English to practice both in oral and written communication skills. The presentations are commented and corrected by the teaching teams. Finally, after carrying out the pilot scale, having a product prototype that is a part of the student’s thesis. To enhance creativity, each student works among designers of the marketing team from packaging design to product positng addressed by the product owner as shown in Fig. 8.

![Image of students working in a factory]

Figure 8 Each student has a chance to work with the product designer, the owner, and the marketing team under real situations.

Results

An example of student research output in creating from laboratory scale to prototype a product is the black sesame which is a functional food, premium product thermally optimizing processed by Factory Classroom. The product prototype obtained an award from the Thailand Research Fund, which was a part of the student master thesis.

Another example for the output of the teaching team and student is a project entitled as ‘Penta golden fruits’ products. As the name “penta” implied, five tropical fruits including mango, mangosteen, durian, coconut and pineapple are selected to create high values. To illustrate, mango products are assigned at the first phase of the research, five SMEs with their own ideas for the ready-to-eat products have been selected and invited to work with Factory Classroom. The research procedure starts from a feasibility study, collects mangoes from smart farms with quality assurance, processes in the laboratory, designs packaging, until finish the prototypes of five products. Eventually, topping mango was selected to be one of the best products in the year 2018 and got the SME award from Thailand Research Fund.

Acknowledgements

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Thailand 4.0 policy(2016), Retrieved from: http://thaiembdc.org/thailand-4-0-2/


Abstract

In the last academic year, two gamification packages for the teaching and learning on Mathematics and Programming were developed by the Information Technology Discipline at the Hong Kong Institute of Vocational Education, Vocational Training Council. The packages were designed with a digital game-based or story-based approach to engage the students to learn and enhance the students’ learning experience and effectiveness.

The computer game in each of the developed packages has two modes: the story mode and the challenge mode. In the story mode, the student players will take part in a self-paced adventure for pre-class learning. In the challenge mode, the student players will do self-paced drills for post-class learning.

User feedback collection on the developed packages was carried out through an anonymous survey. The survey result was encouraging. It indicated that the packages were well received by the participants and the majority of them opined that the packages did motivate them to learn and enhance their learning experience.

In this paper, the ideas behind the design of the packages will be shared. The paper will also report the observations and findings from the survey taken by the students who have used the packages.

Keywords: gamification, game-based, story-based, student engagement

Introduction

Gamification is defined as the use of game design elements in non-game contexts (Deterding et al., 2011). It has been recently identified as a promising technique to improve students’ engagement such that a positive effect could be obtained in the learning process (e.g., Ibanez et al., 2014; Connolly et al., 2012).

The Information Technology (IT) Discipline at the Hong Kong Institute of Vocational Education, Vocational Training Council (VTC), has developed two gamification packages for the teaching and learning on Mathematics and Programming to engage the students to learn and to enhance the students’ learning experience and effectiveness.

Background

The first package developed is for teaching/learning Mathematics. All the students studying the Diploma of Foundation Studies (DFS) Programme of all Disciplines at the Hong Kong Institute of Vocational Education, VTC, need to take the module “Foundation Mathematics”. The module requires the understanding of abstract concepts and the mastering of complicated arithmetic and problem-solving skills. Weaker DFS students normally would find difficulties in studying this module. Some educational researchers (e.g., McLaren et al., 2017) commented that the investigation on the ways to inject the learning of traditional subjects, like Mathematics, into computer games had only begun recently. We therefore made this attempt.

The second package developed is for teaching/learning Programming. DFS students of the IT Discipline are required to learn the VB-Programming Language in the Programming module. Computer programs and algorithms are abstract and complex entities. This made the teaching/learning of programming difficult, especially for novice or weak students (e.g., Olsson, Mozelius & Collin, 2015; Guzdial & Soloway, 2002; Lahtinen, Ala-Mutka & Jarvinen, 2005). We therefore made this attempt.
Development Workflow

The following diagram summarizes the development workflow so that feedback from various stakeholders will be incorporated at various stages.

Delivery Pattern

There is a teaching and learning package (TLP) with teaching materials such as lecture notes, tutorials, etc., for each module offered in the VTC. The TLP was developed when the module was introduced and refined gradually by the module teachers. The gamification packages to be developed are designed not to replace but to be integrated into the existing TLPs in a way that the computer game has two modes: story mode for pre-class activities and challenge mode for post-class activities. It is suggested to the module teacher that the gamification package be used along the following line of flow.

(A) Before the Lesson

We have adopted some of the ideas proposed in the “Flipped Classroom” or “Flipped Learning” (e.g., Bergmann & Sams, 2012; Sams & Bergmann, 2013; Tucker, 2012). Students are expected to have some pre-class learning before coming to the class. To encourage the students to do so, we have developed the story mode so that the students when playing the computer game will have at the same time a brief touch on the topic that is going to learn. Learning elements like animations or tutorial clips with examples are included along the game play.

(B) During the Lesson

We suggested the module teacher to begin each class with a small start-up exercise to check how much the students have prepared/learned from the pre-class story-mode game play. The start-up exercise contains only very simple questions. Sample worksheets of this exercise are included in the gamification package. The exercise serves only as a lead-in for the teacher to start the topic. Marks obtained from this exercise will not be counted in the assessment. It only serves as a stimulation to encourage those students who have not done any pre-class preparation to do it next time.

(C) After the Lesson

Students are encouraged to have repeated drills on the topic they have just learned by playing the Challenge-Mode of the computer game. A leaderboard is provided to show all participants’ performance of the game play. This is one of the gamification elements we adopted to provide a platform for students to have positive competition among peers so as to engage them to play more and play better, which actually means practise more and learn better.

Description of the Games

(A) MatheMonster - developed for teaching/learning Mathematics.

The story mode of the game is a 3D adventure game based on a scenario with the Second World War as the background and aliens are involved and have plans to conquer the world. The game player has to collect props to fight against the aliens in his adventurous journey.

Mathematics problems will be encountered at some point of the game.
The challenge mode of the game provides drills on the mathematics topics covered which have to be completed in a certain limit of time.

(B) GhostCoder – developed for teaching/learning VB-Programming.

The story mode of the game is a 2D story-based game in black comedy style. The game player follows the storyline is like reading a story book. Abstract concepts of programming and algorithms are introduced throughout the story.

The challenge mode is a turn-based card game. The player’s hand (i.e., the set of cards that the player holds) will only be effective when relevant programming codes are completed on the card.

Design Strategy

Game-based learning uses an actual game to teach knowledge and skills. A learning game is a self-contained unit with a definitive start, game play and ending. Learners know that they are engaged in a game activity, and at the end there is a “win state”. On the other hand, gamification uses a few game elements. Learners do not play an entire game from start to finish; they participate in activities that include video or mobile game elements such as earning points, overcoming a challenge or receiving badges for accomplishing tasks. (Kapp, 2014).

The design of the two developed packages employed a mixed strategy. The computer game has two modes: story mode and challenge mode. In the story mode, the digital game is of an adventure style which engages the player to continue digging in the adventure, which means at the same time more learning contents could be delivered to the player (learner). In the challenge mode, game elements such as posting a score to the leaderboard, earning points and badges, are incorporated to engage the player to keep on playing, which means keep on drilling.

We think the strategy adopted is appropriate. On one hand, a pre-class preparation in Story-Mode is effective in the learning process, especially for subjects with the content of abstract concepts. On the other hand, a post-class drilling in Challenge-Mode is useful in the learning process, especially for subjects where reinforcement and repeat practising would be helpful.

User Feedback Collection and Analysis

The two packages were tested by a few hundred students in this academic year and user feedback was collected by anonymous surveys which adopted a 5-point response scale from 1 (Strongly Disagree) to 5 (Strongly Agree).

The table below shows the average score of the responses to each question for the two packages.

<table>
<thead>
<tr>
<th>Survey Questions</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 Digital game-based learning software motivates you to learn</td>
<td>3.5 3.6</td>
</tr>
<tr>
<td>Q2 Interactive game elements and visual/audio effects can help you understand abstract concepts</td>
<td>3.5 3.6</td>
</tr>
<tr>
<td>Q3 Story-based learning engages you to learn</td>
<td>3.6 3.5</td>
</tr>
<tr>
<td>Q4 Challenge-mode provides a good way of drilling</td>
<td>3.6 3.6</td>
</tr>
<tr>
<td>Q5 The software provides good means of self-paced learning</td>
<td>3.5 3.5</td>
</tr>
<tr>
<td>Q6 The software enhances your learning experience</td>
<td>3.6 3.7</td>
</tr>
</tbody>
</table>

The average scores obtained by both packages were similar. Users in general agreed that the packages did motivate them to learn and help them understand.
The table below shows a further breakdown that the percentage of responses with 4 or above and with 3 or above were summarized. The results show more than or close to half of the respondents responded agree or strongly agree (4 or above) in most questions. This demonstrates that both packages were quite well received by the respondents. A great majority of the respondents opined that the packages did motivate them to learn and enhance their experience.

(MM – MatheMonster; GC – GhostCoder)

<table>
<thead>
<tr>
<th>Questions</th>
<th>% of responses with 4 or above</th>
<th>% of responses with 3 or above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MM</td>
<td>GC</td>
</tr>
<tr>
<td>Q1</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>Q2</td>
<td>52%</td>
<td>56%</td>
</tr>
<tr>
<td>Q3</td>
<td>57%</td>
<td>51%</td>
</tr>
<tr>
<td>Q4</td>
<td>54%</td>
<td>55%</td>
</tr>
<tr>
<td>Q5</td>
<td>48%</td>
<td>49%</td>
</tr>
<tr>
<td>Q6</td>
<td>54%</td>
<td>58%</td>
</tr>
</tbody>
</table>

In the survey, we asked the respondents how many hours they would play on computer games per day. We adopted a definition that for a person who used to play three or more hours per day for computer games the person would be classified as a frequent computer game player. The distribution of frequent and infrequent game players in the surveys for the two packages can be found in the following charts.

Interestingly, when the responses from frequent and infrequent computer game players are separately counted, some interesting differences could be observed which are summarized in the charts below.

The surveys for both packages have about one third of respondents who are infrequent computer game players.
For the package GC, the responses from frequent and infrequent computer game players are alike. But for the package MM, the responses from frequent and infrequent computer game players look quite different.

The story mode of GC is a 2D story-based game. The game player follows the storyline is like reading a story book. The challenge mode is a turn-based card game. This genre of game and presentation style shows no obvious difference to frequent and infrequent computer game players. The user control interface is also simple and straightforward. While the story mode of MM is a 3D adventure game. Infrequent computer game players need time to get used to this genre of game and presentation style (such as first-person subjective lens view). The user control is also relatively complex. We believe this is one possible reason that accounts for the difference.

Evaluation on Effectiveness

Evaluation on the effectiveness of the package MM was performed by using pre-test and post-test for a few selected classes. The questions in the pre-test and post-test were the same. The full mark of the tests was 10. The distribution of marks in the two tests are summarized in the following tables.

<table>
<thead>
<tr>
<th>Result (Overall Average):</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>2.96</td>
<td>4.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Result (by Category):</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (8-10 marks)</td>
<td>28%</td>
<td>28%</td>
</tr>
<tr>
<td>B (6-7 marks)</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>C (4-5 marks)</td>
<td>4%</td>
<td>12%</td>
</tr>
<tr>
<td>D (0-3 marks)</td>
<td>68%</td>
<td>56%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance (by comparison of marks):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison of Marks</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Post-Test &gt; Pre-Test</td>
</tr>
<tr>
<td>Post-Test = Pre-Test</td>
</tr>
<tr>
<td>Post-Test &lt; Pre-Test</td>
</tr>
</tbody>
</table>

In general, the result shows that the package helped the students to get improvement.

Conclusion and Future Work

The user feedback of the two developed packages is encouraging. The participants opined that teaching and learning using gamification approach and the use of animations or visual/audio means are helpful for them to understand abstract concepts. In the coming academic year, the two packages MM and GC will be fine-tuned with the input from end users to be taken into consideration and formally delivered.

Gamification is best used for subjects that require reinforcement over time (Kapp, 2014). Kapp also suggested to have a structure and a framework to participate in the gamification effort and not simply a “bolt on” of meaningless, superficial game elements. In our future development, the direction of design strategy of adopting a mixed strategy of incorporating gamification elements into the teaching and learning package and at the same time introducing game-based or story-based elements into the content for student engagement is worth keeping on. The framework of using story mode to engage students' pre-class learning and challenge mode to engage the students’ post-class drilling will be continued in the games to be developed.

There will be an extension to GC that the contents in package will be modified for teaching the Java Programming Language for the Programming module offered in the Higher Diploma (HD) programmes. The IT Discipline also has plans to work on building new gamification packages for a Networking module and a Database module for the HD Programmes.

Acknowledgements

The authors would like to thank the support from the Vocation Training Council, and thank Prof. Ronald Chung and Dr. L.L. Ong for suggesting the project. We would like to thank Prof. Jimmy Lee (Chinese University of Hong Kong) and Douglas Morrison (City of Glasgow College) for their invaluable suggestions and support. The authors would also like to thank the teachers and student helpers from the IT Department of IVE (Tuen Mun) who have contributed in the coding and art work of the project. Finally, the authors would like to thank the members of the project team: Dan Kwok, Jeffrey Ho and Sunny Cheng for their effort throughout the entire development period.

References


THE ATTEMPT TO APPLY LITERAL TEXTS AS TEACHING MATERIALS OF ACTIVE LEARNING FOR COMMUNICATION AND CULTURE SUBJECTS: THE CASE OF THE REPRESENTATIONS OF THE REGIONS IN JAPAN

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Abstract

It has been seldom considered that literal texts are a useful medium for engineering students, who have little interest in culture and communication. Although few national colleges of technology (Kosen) in Japan have subjects for literature itself and the literary texts have been used mainly as linguistic materials, the subject has the possibility to give a chance for the students not only to learn regional or global cultures but also to develop their communication skills if we use them from different viewpoints. This presentation will try to show how effective literary texts can be materials for promoting Kosen students’ communication skills in terms of active learning.

Keywords: literary texts, interpretation, cultures, communication skills, active learning

Introduction

It has been seldom considered that literal texts are a useful medium for engineering students, who have little interest in culture and communication. Although few national colleges of technology (Kosen) in Japan have subjects for literature itself and the literary texts have been used mainly as linguistic materials, the subject has the possibility to give a chance for the students not only to learn regional or global cultures but also to develop their communication skills if we use them from different viewpoints. This presentation will try to show how effective literary texts can be materials for promoting Kosen students’ communication skills in terms of active learning.

Background

It is true that some of the students are interested in reading books or novels (as written in their curriculum vitae), not a few are less interested in reading classic texts or authorized texts. It can be said that the time for reading has been decreasing. It might be necessary for us to detect how exactly the situation is since the skill of interpretation is indispensable for engineering students who have to face the unknown texts when they work.

However, it is not easy to build the skill of reading. In not a few classes concerning languages such as Japanese or English, the literary texts, including novels, poems, dramas or essays, are being used as teaching materials. In this case, one of the main targets for using the material is to analyse the structure in various levels; word, idiom, sentence or paragraph. In other words, the material is linguistically treated, and as the text is the final target, it is difficult to go over the text and to, put it more precisely, utilize the material for other purposes. Students can understand how to read, but they can seldom get the idea of ‘why they read’.

For engineering students, the main texts will be machine manuals or operations. They are written with clear aims. Literary texts, by contrast, often having deep and ambiguous meanings, are difficult for students who tend to search for one clear-cut meaning. The dichotomy between the simple reading tendency and the complex texts needs to be more focused since it dramatically illustrates the students’ situation. They have to be accustomed to deep and complex reading, but in order to do that, it is necessary to enable us to make them involved into reading experiences.

To meet this demand, I carried out the ‘reading’ class in a class for tourism in 5th year students at NIT, Hachinohe College (hereafter Hachinohe Kosen). The class is called as ‘Tourism and Culture’, which is opened as one of the selective classes for 5th year students. In the classes.

Since it started in 2013, ‘Tourism and Culture’ has been working on lectures on histories of tourism, tourist sites, tourism resources. In 2018, in addition to the other subjects, travel writing was more focused than previous years. In 2017, the text materials of travel wrings have been included so that students can visualize the image of local communities through reading the descriptions in each text like Unbeaten Tracks in Japan by Isabella Lucy Bird, a famous English female traveller, and “Tsugaru” by Alan Booth. Compared with 2017 version, Bird’s Unbeaten Tracks in Japan was more focused in 2018 version of ‘Tourism and Culture’. By picking up her passage to Aomori, students are expected not only to read and interpret the content but also to make a travel plan.
Task (1) Make a travel plan for Isabella Bird in 1878
Task (2) Make a travel plan for Isabella Bird in 2018

Through these activities, the students are expected to not only come to know about historical situations in the time of the beginning of Meiji period but also to try to think about inbound tourism through the text.

Results and Discussion

By giving a questionnaire, the students’ motivation and their attitudes toward cultural material was examined in addition to their recognition about their own reading skills. The answers were given back from almost all the students.

2018 Tourism and Culture questionnaire

Class: No: Name:

(1) Are you interested in knowing the culture of your area?  
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(2) Are you interested in knowing the culture of other areas? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(3) Are you interested in literature? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(4) Are you interested in history? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(5) Do you know well about your hometown? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(6) Are you interested in enriching your knowledge on the culture of various areas including their history, geography, literature? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(7) Are you interested in enriching your knowledge on the culture of various areas including their history, geography, literature? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(8) How do you often read books? 
1 More than five in a month  2 Four  3 Three  4 Two  5 One (Or none)
(9) What kind of books do you read? 
1 Mystery  2 History  3 Love story  4 Fantasy  5 Biography  6 Travel Writing
(10) How do you often read COMIC books? 
1 More than five in a month  2 Four  3 Three  4 Two  5 One (Or none)
(11) Do you use E-books such as KINDLE? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(12) Do you often read in travel or tourism? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(13) Do you think you often have difficulty in reading texts or books? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(14) As for question 14, what kind of difficulty is that? 
1 Unknown vocabulary 2 Following the plot 3 grasp the relationship of the characters
(15) Do you have confidence in understanding texts or books? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not

Thank you very much for cooperation.

Figure 1. The questionnaire on the students’ attitude toward culture understanding (before TC).

The next data shows the result of the questionnaire.

Figure 2. The questionnaire on the students’ attitude toward culture understanding (abridged; before TC).

The data exhibits how the students think about learning cultures. As for question (9), which focus on the students’ interest in reading, nearly fifty percent answer Strongly Yes / Yes. Concerning (14), which asks their confidence in reading, 40 percent answer Yes while 12 percent answer Not / Strongly Not (There is no answer of Strongly Yes). From these answers, it can be said that the students are not so much disinterested in reading. However, it should be not overlooked that 27 percent answer Not / Strongly Not, which indicates some students have seriously negative attitudes toward reading.

How the students’ attitudes have changed will be shown with reference to the result of the following questionnaire after the class.

2018 Tourism and Culture questionnaire2

Class: No: Name:

(1) Are you interested in knowing the culture of your area after the lecture?  
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(2) Are you interested in knowing the culture of other areas after the lecture? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(3) Are you interested in literature after the lecture? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(4) Are you interested in history after the lecture? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(5) Have you come to be more interested in geography after the lecture? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(6) Do you know well about your hometown after the lecture? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(7) Are you come to be more interested in enriching your knowledge on the culture of various areas including their history, geography, literature after the lecture? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(8) Are you come to be more interested in travel or tourism after the lecture? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(9) Have you enjoyed learning culture through tourism? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(10) Are you interested in reading after this class? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(11) Do you think you often have difficulty in reading texts or books after this class? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not
(12) As for question 14, what kind of difficulty is that after this class? 
1 Unknown vocabulary 2 Following the plot 3 grasp the relationship of the characters
(13) Do you have confidence in understanding texts or books after this class? 
1 Yes, very much  2 Yes  3 Neutral  4 Not  5 Strongly Not

Thank you very much for cooperation.

Figure 3. The questionnaire on the students’ attitude toward culture understanding (after TC).

Conclusions

In this study how texts are useful as a platform for communication and learning culture through the active learning based on Isabella Bird’s travel writing. Although the research is being continued and not finished, this study introduces how the class working on the application of travel writing for planning travel plans can change the students’ attitude toward reading. With the change in their attitude toward reading and texts, it can be estimated that it will have an influence on the students’ mindset for cultural understanding. While this presentation mainly treats how to ‘interpret’ the text, so it will be needed to investigate the relationship between communication skills and cultural understanding through
travel writing from other perspectives such as vocabulary building, geographical mapping, or comparing with other texts or their own experiences. These will be the subjects for following reasearches.

References


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

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

We have held open courses for the junior high school students at NIT, Kurume College during summer vacations since 2010. In these open courses, we gave introductions to “knot theory” and “quadratic curves” with the upper-class students serving as assistants.

We here review “knot theory” and “quadratic curve”. Knot theory is a field of mathematics in which we analyze knots of strings in a topological way. One of the fundamental problems of this theory is to determine whether two knots are equivalent to one another. To put it simply, this theory concerns under which condition a knot is unknotted. In addition, it needs just an elementary computation of matrices to begin to learn this theory. A quadratic curve is in general defined to be zeros of a degree two polynomials in two variables. It is well-known that each quadratic curve is divided into either a hyperbola, a parabola, an ellipse or a circle. In the open courses, we introduce a quadratic curve by showing a section appearing in cutting a cone. Changing the angle of cutting, we can find all of four kinds mentioned above. Then we choose these two themes for the open course since the participants may be familiar with them and need little mathematical background.

A questionnaire sent out after the open courses indicated that the participants gave high evaluations. And it seemed that they liked the assistants because of their kind help. Besides, the upper-class students proceeded to study knot theory. They learned tricolorability, the number of p-colorings and the Goeritz invariant. Through this learning, they came to understand some basic mathematical notions more deeply, such as sets and propositions, congruence and matrices. More surprisingly, they obtained new results independently and gave successful research presentations.

Keywords: Mathematics education, Open courses, Quadratic curve, Knot theory, Active learning

§1. Introduction
Active learning is defined in Collins (2003) as "The process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas. Requiring students to regularly assess their own level of understanding and skill at handling concepts or problems in a particular discipline. The attainment of knowledge by participating or contributing. The process keeps students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving".

The main purpose of this work is to help our students acquire the skills of learning by themselves, unifying knowledge and giving presentation in the class. Moreover, we had the upper-class students help us in low-level active learning: supplementary lessons and open classes so that they can connect this experience to their research and presentation (see Figure 1).

Knot theory is an interesting field in Topology. Beginners can understand it easily since it is not necessary to know its background well and there are various teaching materials of knots in which they can learn visually (e.g., Kawauchi & Yanagimoto, 2012; Miyaji, Sakai & Nakabo, 2013). On the other hand, knot theory is associated with various fields, such as DNA in biology and QFT in physics, which correspond to the relevant feature. Therefore, we think that knot theory is suitable for our students who study in the technological field. In particular, we gave three research themes for three upper-class students respectively: tricolorability, the number of p-colorings (Lickorish, 1997) obtained by considering congruence modulo p and Goeritz invariant which is a non-negative integer sequence obtained by the deformation of the elementary row operation of integral square matrices. They can learn mathematics
deeply because congruence and matrices are the learning contents which they understand in ordinary classes. This paper is composed of ten parts. Section 1 is the introduction, which includes the background of the investigation. In Section 2, we explain the construction of open courses. In Section 3, we review the scenes of open course with some photos. In Section 4, we introduce an open course about quadratic curves. In Section 5, we introduce examples of knots and define knot invariant. In Section 6, 7 and 8, we define some knot invariants: tricolorability, number of p-colorings and Goeritz invariant, and introduce its calculation results which the upper-class students obtained. In Section 9, we describe the result of the questionnaire obtained from the participants. Finally in Section 9, we describe the conclusion of this effort and the future challenges.

§2. The structure of open course

We constructed the open course as follows.

(a) Learning contents
Quadratic curve and knot theory.

(b) Construction
- Participants
Junior high school students (the first to the third grade).

- Leaders
Three teachers and three teaching assistants.

- Time
210 minutes which consists of 60 minutes for quadratic curve and 60 minutes + 90 minutes for preparation and knot theory.

§3. Some scenes of open course

In this section, we review the scenes of the open course with some photos. The teachers write some points to solve the problems on the blackboard or show slides on the screen (see Figure 2). The participants write the points on their answer sheets before solving problems. At the same time, the teaching assistants walk around the participants to answer their questions (see Figure 3). Through these activities, the teaching assistants developed their ability to teach mathematical subjects.

§4. Quadratic curve

A quadratic curve is in general defined to be zeros of a degree two polynomials in two variables. It is well known that each quadratic curve is divided into either a hyperbola, a parabola, an ellipse or a circle. In the open courses, we introduce a quadratic curve by showing a section appearing in cutting a cone.

Changing the angle of cutting, we can find all the four kinds mentioned above (see Figure 5).

§5. Knot and its invariant

First, we define a knot and a knot diagram, and give some examples.
Definition 5.1. A knot is an embedding of a circle in 3-dimensional Euclidean space $\mathbb{R}^3$.

Definition 5.2. Let us consider the projection of a knot onto a plane. A small change in the direction of projection will ensure that it is one-to-one except at the double points, called crossing. The projection which is distinguished between the over-strand and the under-strand at each crossing is called a knot diagram (Figure 6).

Example 5.3. Knot diagrams shown in the Figure 7 are called a trivial knot, a trefoil knot (or $3_1$ knot), a figure eight knot (or $4_1$ knot) and a $6_1$ knot respectively.

Next, we define some deformations of a knot diagram and a knot invariant, or a value which is independent of the deformations.

Definition 5.4. The following deformations $R_1$, $R_2$ and $R_3$ in the knot diagrams are called Reidemeister move.

If two knot diagrams can be moved by repeating Reidemeister moves finite times, they are defined to be the same knots. Moreover, a value which is defined for each knot and is independent of Reidemeister moves is called knot invariant.

We define some knot invariants in Section 3, 4 and 5 to check whether a knot can be unknotted or not, and whether two knots are same or not.

§6. Tricolorability and its calculation results

The definition of tricolorability is given as follows:

Definition 6.1. A knot is tricolorable if each strand of the knot diagram can be colored one of three colors, subject to the following rules:

1. At least two colors must be used in the knot diagram, and
2. At each crossing, the three incident strands are either all the same color or all different colors.

Then it is well known that the following statement holds.

Theorem 6.2. Tricolorability is independent of Reidemeister moves, i.e., it is a knot invariant.

Example 6.3. A trivial knot is not tricolorable because it has a knot diagram which does not satisfy Condition 1 in Definition 6.1.

Remark 6.4. (1) The converse of Theorem 6.2 does not hold because a figure eight knot is not tricolorable.

(2) Considering the contraposition of Example 6.3, we see that a knot is not unknotted if it is tricolorable.

Remark 6.5. We may denote three colors by three integers 1, 2 and 3. If each of $x$, $y$ and $z$ denotes one of the three integers, as in Figure 9, then the condition 2 in Definition 6.1 has an alternative description as $2x \equiv y + z \ (mod \ 3)$ by using congruence modulo 3.

One of the teachers explained the calculation result about three knots given in Figure 7 using a slide and promoted the understanding of tricolorability.

In addition, he suggested that the trefoil knot was unknotted using Remark 6.4 (2) and it was impossible to consider whether a trivial knot and a figure eight knot are the same or not using tricolorability because of Remark 6.4 (1).

§7. Number of $p$-colorings and its calculation results

Using the description in Remark 6.5, a generalization of tricolorability called $p$-colorability is given as follows:
Definition 7.1. A knot is \( p \)-colorable if each arc of the knot diagram can be labeled by one of integers: 1, 2, \( \ldots \), \( p \), subject to the following rules:

1. At least two integers must be used in the knot diagram, and
2. For each triple of integers \( x, y, z \in \{0, 1, \ldots, p-1\} \) at a crossing as in Figure 9, they satisfy the condition: \( 2x \equiv y + z \pmod{p} \). (This condition is called crossing condition at the crossing.)

Next, let us define a number obtained from Definition 5.1.

Definition 7.2. We say that a knot diagram is \( p \)-colored if each arc of the knot diagram is labeled by one of the numbers 1, 2, \( \ldots \), \( p \) in such a way that at each crossing the labels satisfy the condition 2 in Definition 7.1. The number of \( p \)-colored knot diagrams for a knot \( K \) is called the number of \( p \)-colorings of \( K \).

Theorem 7.3. The number of \( p \)-colorings is independent of Reidemeister moves, i.e., it is a knot invariant.

Example 7.4. The number of \( p \)-colorings of a trivial knot is \( p \).

Remark 7.5. (1) The converse of Theorem 7.3 does not hold.
(2) Considering the contrapositive of Example 7.4, we see that a knot is non-trivial if the number of \( p \)-colorings is not \( p \).

Remark 7.6. If the crossing number of a knot diagram is \( n \), then it needs to choose \((x, y, z)\) which satisfies the crossing condition out of \( np^3 \) ways in order to calculate the number of \( p \)-coloring.

Since the figure eight knot has four crossings, it needs to choose \((x, y, z)\) which satisfies the crossing condition out of \( 4 \times 5^3 = 500 \) ways in order to calculate the number of 5-coloring from remark 5.6. Therefore, one of the teachers divided the participants into 5 groups and gave a calculation sheet for each group (see Table 1).

The calculation result about three knots given in Figure 7 is as follows:

<table>
<thead>
<tr>
<th>[Table 2: Number of ( p )-colorings of knots]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knots</strong></td>
</tr>
<tr>
<td>( \text{Trivial knot} )</td>
</tr>
<tr>
<td>( \text{Trefoil knot} )</td>
</tr>
<tr>
<td>( \text{Figure eight knot} )</td>
</tr>
</tbody>
</table>

Moreover he suggested the following results and these three knots as above were different.

- A trefoil knot and a figure eight knot are not unknotted by considering the number of 3-colorings and 5-colorings respectively.
- A trefoil knot and a figure eight knot are not the same by considering the number of 3-colorings.

§8. Goeritz invariant and its calculation result

Let \( D \) be a diagram of a knot \( K \). Then \( D \) divides a plane into finitely many domains \( D_1, D_2, \ldots, D_m \), one of which is unbounded, say \( D_{\text{e}} \). We classify these domains into two classes, black and white in such a way that no domains of the same color have edges in common. For convenience, we assume that \( D_{\text{e}} \) is a black domain. Now we define an index \( \varepsilon = +1 \) or -1 of a crossing point of \( D \) according to Figure 6.

![Figure 11: Index of crossing point](image)

Here, a shaded area indicates a black domain and the orientation of \( K \) is irrelevant. Let \( \{W_1, W_2, \ldots, W_{m+1}\} \) be the set of all white domains. Using these white domains, we define an \((m+1)\times(m+1)\) integer symmetric matrix \( A = (a_{ij}) \), \( 1 \leq i, j \leq m + 1 \) as follows:

**Definition 8.1.**

\[ a_{ij} = \begin{cases} \sum_{j=1, i \neq j}^{m+1} \varepsilon \ & \text{(for } i \neq j) \\ - \sum_{j=1, i \neq j}^{m+1} a_{ij} \ & \text{(for } i = 1, 2, \ldots, m + 1) \end{cases} \]

where the summation \( \sum \varepsilon \) runs over all crossing points of \( D \) that are common to \( W_i \) and \( W_j \). This matrix \( A \) is called Goeritz matrix of a knot \( K \).

Let an irreducible Goeritz matrix \( A \) be a minor matrix of \( A \) that results from \( A \) by removing an arbitrary row and an arbitrary column. Goeritz invariant of a knot is given by deforming the irreducible Goeritz matrix using the following transformations. Let \( M \) and \( N \) be two integral matrices.

**Elementary transformations**

1. Interchange two rows (resp. two columns).
(b) Multiply a row (resp. a column) by \(-1\).
(c) Add a row (resp. column) to another one multiplied by an integer.
(d) If we have \(M = (1) \oplus N\) or \(N = (1) \oplus M\), then change \(M\) (or \(N\)) to \(N\) (or \(M\)).

**Definition 8.2.** Using the above operation, any integral matrix, especially, the irreducible Goeritz matrix \(A_1\) can be deformed into a unique diagonal integral matrix: 
\((k_1) \oplus (k_2) \oplus \cdots \oplus (k_d)\) which satisfies the following condition (i) and (ii). Then the non-negative integral sequence \((k_1, k_2, \cdots, k_d)\) is called Goeritz invariant of a knot \(K\).

(i): If \(d = 1\), then \(k_1 \geq 0\).
(ii): If \(d \geq 2\), then \(k_i \geq 0, k_i \neq 1\) \((1 \leq i \leq d)\) and 
\[k_{i+1} = mk_i\] \((1 \leq i \leq d-1; m: \text{integer})\)

**Example 8.3.** Since a trivial knot is described as in Figure 7, we have its two Goeritz matrices \((1)\) and \((\begin{array}{cc} 1 & -1 \\ -1 & 1 \end{array})\). Therefore, the Goeritz invariant of a trivial knot is \((1)\).

![Figure 11: Trivial knot](image)

**Theorem 8.4.** The Goeritz invariant is a knot invariant.

**Remark 8.5.** (1) It is well known that the converse of Theorem 8.4 does not hold.
(2) Considering the contraposition of the conclusion in Example 8.3, we see that a knot is non-trivial if the Goeritz invariant is not \((1)\).

One of the teachers suggested that these three knots as above were different considering Goeritz invariant.

<table>
<thead>
<tr>
<th>Knots</th>
<th>Goeritz matrices</th>
<th>Goeritz invariant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trivial knot</td>
<td>((\begin{array}{cc} 1 &amp; -1 \ -1 &amp; 1 \end{array})) ((1))</td>
<td></td>
</tr>
<tr>
<td>Trefoil knot</td>
<td>((\begin{array}{cc} -3 &amp; 3 \ 3 &amp; -3 \end{array})) ((\begin{array}{cc} 1 &amp; -1 \ -1 &amp; 1 \end{array})) ((3))</td>
<td></td>
</tr>
<tr>
<td>Figure eight knot</td>
<td>((\begin{array}{ccc} 2 &amp; -1 &amp; -1 \ -1 &amp; 2 &amp; -1 \ -1 &amp; -1 &amp; 2 \end{array})) ((\begin{array}{ccc} 1 &amp; 1 &amp; 1 \ -1 &amp; 1 &amp; 2 \ 1 &amp; -1 &amp; -2 \end{array})) ((5))</td>
<td></td>
</tr>
</tbody>
</table>

**§9. Results of the questionnaire**

We have carried out the questionnaire for the participants about the above themes since 2013 (except 2015). The items of questions and their results are the following:

Question 1. Did you understand this course?
Question 2. How was the level of this course?
Question 3. Was this course useful for you?
Question 4. Were you satisfied with this course?

**§10. Conclusion of this effort and a future subject**

We had the following comments about our teaching materials from the upper-class students.
- It was interesting that whether a knot can be unknotted or not using congruence.
- I was able to understand that various mathematical methods decided whether a knot can be unknotted or not without deforming knots by hand.
- I want to study knot theory and calculate various knots and links in the future.

Knot theory is one of the fields of current mathematics. Using teaching materials concerning knot theory, the authors tried to have students pay attention
to relevance of the theory and be motivated to learn (Kawashima, Sakai & Tanaka, 2014). The trial of this time is aimed that students notice knot theory is closely related with various contents of mathematics and understand them deeply, paying attention to cautions and relevance.

The questionnaire showed good results. As is in the comment, we think that themes which are relevant to their field such as DNA in biology were well received. Though the original guidance plan was to help students calculate knot invariants of a trefoil knot and a figure eight knot using the number of $p$-colorings and Goeritz invariant respectively, the upper-class students have studied knot theory enthusiastically, and at last they have succeeded in calculating more complicated knot; 61 knot. They presented these results at a symposium held in 2015. Their presentations were brief and to the point. In addition, they all got an extremely high score on the national mathematics test, the unified National Institute of Technology examinations for the third-year students. This means that they had a good grounding in mathematics through this trial including the supplementary lessons and an open class. From the above, this trial can be regarded as a positive one.

Now we introduce the following teaching material so that we can help students’ research and presentation in the future.

"L-S category" (Cornea, Lupton, Oprea & Tanre, 2003; Miyaji & Sakai, 2013) in homotopy theory. It is an invariant for various figures and can be understood relatively easily since we can learn it visually as knot theory, and need to have little preliminary knowledge on it. Then this theme would be interesting for students. For example, the L-S category of a torus and a Klein bottle are both two. There is a fibrewise version of the L-S category and it is known to have a possibly different value from the ordinary L-S category. As a simple example, a torus has the value two as its ordinary L-S category, but one as its fibrewise version (Cornea, Lupton, Oprea & Tanre, 2003). Using the property of the fibrewise $\Lambda_\infty$-structure, one of the authors gives that the fibrewise L-S category of the Klein bottle has the value two (Sakai, 2010). In addition, it is known that the fibrewise L-S category is related to "topological complexity", a field of research involved in the motion planning of robot arms (Iwase & Sakai, 2010).

Acknowledgements

The authors would like to express their gratitude to the upper-class students in NIT, Kurume College for their great contributions.

References


A STUDENT-CENTRED APPROACH TO TEACHING CLASSICAL MECHANICS

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Abstract

Declining enrollment in technology and engineering courses is global issue as fewer students seem to be interested in learning about technology and engineering even though there is strong demand for graduates with these specialized skills. It has also been observed among Ngee Ann Polytechnic's engineering students that even though they are enrolled in the programme, many are not very keen to learn about engineering subjects. Many of the students are also unmotivated to learn, and engineering educators are finding it increasingly difficult to equip students with the necessary skills and aptitude that will be required of them in the industry. Engineering educators have to try and find suitable ways to engage students with the engineering content and to spark their interest to learn. One of the teaching and learning strategies adopted by engineering educators in the tertiary institutions is to move towards student-centered learning with game-based learning as one of the approach to enhance students' motivation and improve their learning achievement. The pedagogical intervention of game-based and cooperative learning gets the students to be curious, interested in the module content, and enhances the students' motivation.

This paper presents a study which analyses the effectiveness of infusing game-based learning and cooperative learning with an experimental group consisting of 32 students from the Mechanical Engineering course at Ngee Ann Polytechnic. The study collected evidences of students' attitudes towards the implemented pedagogical intervention.

Keywords: Engineering education, student-centred approach, cooperative learning, game-based learning.

Introduction

Since 2003, there has been a decline in interest in science and engineering amongst the young people around the world including the United States, Britain, Australia and Singapore. The decline in student enrollment in the technology and engineering courses has led to numerous challenges in engineering education in a number of countries. It has been reported by Orsak (2003) that between 1982 and 2000, 25% of its undergraduates in United States of America chose fields rather than engineering as a major. Similar trends are also observed in Malaysia and Australia. It has also been reported that more students had given up the option of reading STEM (Science, Technology, Engineering and Mathematics) subjects in the secondary and tertiary institutions (Arfudi, 2016; Panizzon et. al, 2014).

Despite the declining student enrollment in the technology and engineering courses in major universities around the world, occupations (e.g, Computer and Mathematical Scientists, Life Scientists and Engineers) related to science and engineering are still in high demand in line with globalization and economic competitiveness (Benson & Kirn, 2013).

Engineering as an industry has lost its “attractiveness” as the preferred choice for students as they have opted for studies in business and banking and finance courses. Despite various outreach initiatives over the years, companies have found it increasingly hard-pressed when looking for talents in the engineering field. Besides the poor salary prospects, most people think of an engineering job as boring and a job which involves getting one’s hands dirty. For three consecutive years since 2012, it was reported that engineering jobs in Singapore had the most vacancies (Seow, 2015).

The lack of interest in Engineering courses among students have also been reflected in Ngee Ann Polytechnic (NP) as students enrolled in the Mechanical Engineering course are less keen to learn due to the lack of interest in the engineering. The onus is then, on educators to innovative and find different teaching and learning models to spark the interest in learning science and engineering.

Game-based and cooperative learning are teaching and learning strategies that have been used by engineering educators in the recent years. Both strategies have been known to be useful classroom interventions to enhance learning and motivation amongst the students. The use of games provides a context where game-play and content could increase skills acquisition and knowledge. Cooperative learning has also been applied to the educational context since the 1970s. It encourages a setting where students learn
from one another via discussions or debates, leading to new perspectives and innovative solutions. (Lauzon, 1992).

This paper will analyse and study the effectiveness of game-based learning and cooperative learning in a Mechanical Engineering courses. Classroom activities for 32 students were re-designed to implement game-based learning and encourage cooperative learning. The study aims to collect evidences of students’ attitudes towards the implemented pedagogical intervention in the experimental class and 2 other classes (control group that adopts didactic lecture-based classes) of similar size.

Literature Review

Game-based Learning

Game based learning is an approach which builds upon the theory of constructivist learning (Li & Tsai, 2013). The constructivist philosophy is based on the assumption that ‘knowledge is constructed by learners as they attempt to make sense of their experiences. Learning can only be effective when it is active, social and well-positioned. Infusing play into the learning activity can also be conducive to learning (Vygotsky, 1978). The sociocultural theory of learning and flow theory lends itself well for a successful, effective game design and learning objectives (Csikszentmihalyi, 1990; Vygotsky, 1978). The ‘play’ environment allows students to formulate and test hypotheses, explore their social roles, and most importantly, establish and learn the skills in the process of playing (Gee, 2005; Squire, 2005).

Game-based learning has been known to be a useful classroom intervention to improve content and skills acquisition as well as increase learning and motivation amongst the students. The learning environment created within a game setting creates opportunities for students to develop their higher-order thinking skills through resolving problems in the game-play, in a non-judgmental, enjoyable setting (Pivec et al., 2003). Another benefit of game-based learning is the “repetition” which students go through as part of the game process. This “repetition” in game design can increase the opportunity for practice and to “remember” process, which is an important skill especially for technical subjects such as mathematics and sciences where it is important for students to remember certain key concepts. Also, game-based learning can motivate students through their successes in the game-play when they are able to solve problems as part of the game activities which provide students with a sense of achievement after solving the problem. Applying educational games in the classroom needs careful consideration, thorough research and focus on its contemporary learning theories (Young et al., 2012). For game-based learning to take place effectively, it is not just a straightforward move by employing a game and expect students to have increased knowledge acquisition and motivation. For the outcome of the intervention to be positive, learning theories would have to be fused into the design (Wu et al., 2012).

Cooperative Learning

Students form groups and learn together in Cooperative learning (Gillies, 2016; Hennessey & Dionigi, 2013). In their individual groups, students interact, discuss and exchange knowledge and students act as information providers to each other. Each member of the group contribute viewpoints and knowledge to the groups and work together to complete a task, project or an assignment (Johnson and Johnson, 1991). Cooperative learning has been reported as a pedagogy that develops critical thinking and higher order thinking. It has also been suggested that cooperative learning provides students with the opportunity to fuse together experience and knowledge from different disciplines which is an essential skill for the workplace (Johnson and Johnson, 1991).

The enthusiasm in cooperative learning first began in early 1980s where a study was done by education researchers on the effects of competitive, cooperative and individualistic goal structure on students’ productivity and achievements. Johnson et al. (1981) conducted a study on a sample of schools in the United States and found that cooperation was more effective than having interpersonal competitions. In addition, they also noted that striving through individual efforts and cooperation together with inter-group competitions were also more effective than interpersonal competitions and individual efforts.

Research Design

Figure 1. Schematic diagram depicting the various tasks at the planning and experimental stages

There are two stages are involved in this study. These include planning and the experimental stages as illustrated by the Figure 1.

Table 1. Summary of a typical tutorial lesson between the control group and the experimental group
<table>
<thead>
<tr>
<th>Lesson Objectives</th>
<th>Controlled Group</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate the fundamental understanding of stresses. - <em>Compute the stresses on a body.</em></td>
<td>Direct Instruction where lecturers would go through the steps to calculate the stresses and solve the static equilibrium problems in front of the class.</td>
<td><strong>Game-based learning</strong> is infused into the tutorial lessons where students were formed into groups (roughly 2-3 per group). The game is played by posing to students questions which test key concepts of the topic. (Hooke’s Law, calculation of stresses).</td>
</tr>
<tr>
<td>Description of Hooke’s Law and states the conditions for which it can be applied. - <em>Derivation of expression relating stress to strain. Application of Hooke’s Law to solve static equilibrium force problems.</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A quasi-experiment was conducted on two groups (i.e. the control - and the experimental groups) of students during the experimental stage. The students from both control and experimental groups are 2nd year Mechanical Engineering students undertaking the Strength of Materials Module. The mode of teaching to the control group was largely via traditional direct instruction, while the alternative pedagogical intervention of game-based learning and cooperative learning was employed at the tutorial sessions of the experimental group. Table 1 shows a summary of the difference in the mode of instruction between the control group and experimental group in a typical tutorial lesson. The objective of the pedagogical intervention into the curriculum is to enable students to learn and better understand the topics taught in the Strength of Materials module.

A total of 145 Mechanical Engineering students were enrolled in Strength of Materials module in April 2016. Two classes of 35 students which formed the control group were randomly chosen from the population via simple random sampling. The experimental group had 32 students of similar population from the two classes. At the end of the semester, the experimental completed an online google survey to solicit their attitudes towards the implemented new pedagogy, i.e. game-based and cooperative learning methods.

### Instrument Development

An online google survey is used to measure students’ attitudes towards the new teaching pedagogies. This questionnaire contains six statements. Students indicated their responses on a 6-point Likert Scale. In addition, an open ended question seeking feedback from students on how, the new teaching pedagogies can be improved. The survey was revised from a pilot study of the previous cohort. To ensure the validity of the questionnaire, a small group of 15 students from the previous cohort were tasked to go through the survey and a focus group discussion was set up to gather feedback. Bearing in mind that the questionnaire would have to be understood by the students and comprehensive enough to collect relevant information, needed to address the goals and purpose of this study, the questionnaire was revised for this study.

### Results and Discussion

The results consolidated of the survey were positive with the majority of the students agreeing that the pedagogical intervention has aided in understanding the module.

![Figure 2](image.png)

**Figure 2.** Percentage of students who felt that they have learnt the module with the introduction of the pedagogical intervention.

From Figure 2, it can be seen that the majority of the students felt that the game-based learning and cooperative learning instructions have its learning value, with 24% of the students strongly agreeing to the statement and slightly more than half of the sample (52%) agreeing that they had learnt topics in the module through the conduct of these sessions.
Figure 3. Percentage of students who felt that the pedagogical intervention was helpful in the understanding of the module.

In Item 2 (Figure 3) of the questionnaire, students were asked if the game-based learning and cooperative learning sessions had benefited them in their lectures and tutorials. The percentage of students which agree that these sessions had helped them understand the module better was 96% (namely 17% strongly agree, 45% agree and 34% somewhat agree).

All in all, 97% of the students felt that the game-based and cooperative learning sessions had offered them a positive and good learning experience (namely, 17% strongly agree, 48% agree and 31% somewhat agree). Only 3% (1 student) somewhat disagrees with this statement.

As said, games engage people. This, with elements of cooperative learning, aid to make a significant positive impact in students learning. The survey results in this study have shown that students felt that they have learnt and better understood the topics in the module with the introduction of game-based and cooperative learning. These educational games contributed as a motivating element and made learning enjoyable for students. The students have also showed more enthusiasm in learning as compared to the traditional direct instruction approach.

Conclusion

The results generated from this study suggests that students had felt that the new pedagogical intervention of game-based and cooperative learning was useful and that it has enabled them to deepen their knowledge in the module. The students have also indicated that they have enjoyed the learning experience with this new pedagogical intervention. Game-based learning, with cooperative learning has provided the students a learning structure which engaged them in a non-judgmental, competitive yet fun manner. These findings are consistent with the studies of Henry (1997) and Sward et al. (2008) where students found motivation and enthusiasm to what they learn via game-based learning.

With the findings of the study, future work would entail the investigation of the impact of game-based learning and cooperative learning along with the students’ learning achievement such as problem-solving, conceptual knowledge and critical-thinking skills. These results would aid in the design of active learning approaches to enhance students’ learning in various modules.

Acknowledgements

The author would like to thank Dr Lye Che Yee, University of Adelaide (Australia), for her patience, invaluable suggestions and guidance in this project.

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DEVELOPMENT OF STEM WORKSHOP – DNA EXTRACTION FROM HUMAN CHEEK CELLS USING DESIGN THINKING APPROACH

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Abstract

Education Bureau of HKSAR has introduced interdisciplinary learning concept called STEM education (Science, Technology, Engineering and Mathematics) in 2015 in response to global trend of education reform and competence requirement of rapid changing society in term of economic, science, innovation and technology. There are not many STEM educational activities available for children and youngsters in Hong Kong in the context of biotechnology. The reason may because the aforementioned activities involve the use of many sophisticated apparatuses and equipment, which cannot easily be transported and used in the environment of primary or secondary schools. Therefore, a STEM workshop of DNA extraction from human cheek cells, which is feasible and applicable to be launched in secondary school, was developed and tested with an adoption of design thinking approach in the project-based learning (PBL) curriculum of a tertiary education institute (HKIVE). The comments and expectations from the users and stakeholders were collected, analyzed and prioritized. Based on the defined needs and expectations on workshop (i.e. attractiveness, simplicity, total time, cost and safety), seven models of DNA extraction protocol were then devised. Their performance was evaluated in terms of DNA purity, concentration, integrity, size of pellet and successful rate in Polymerase Chain Reaction. The uniqueness, cost and time of the workshop were also considered. With embedding the learning content into the finalized prototype, a pilot run of the STEM workshop was conducted with 22 secondary school students and teachers. The feedbacks from the participants showed that they were highly satisfied with the content and learning outcomes of the workshop. In a score range of 1 (most unsatisfied) to 5 (most satisfied), >75% of participants scored 4 or 5 (average score at 4.61 ± S.D. 0.56) in terms of the knowledge learnt, workshop attractiveness and the final take-away product of the workshop. The workshop had also aroused their interest in the field. Continuous improvements of the workshop are underway to enrich the learning needs of students.

Introduction

In response to the rapid change of global environment in term of economy, science, innovation and technology, HKSAR government introduced STEM (Science, Technology, Engineering and Mathematics) education in her policy address in 2015 and 2016.1-2 It is believed that STEM education can help students to cultivate their interests towards STEM subjects with strong knowledge and skill background, to train them with innovative, collaborative, problem solving skills, the entrepreneurship and the lifelong, self-directed learning, which are essential in 21st century world.3 The Education Bureau (EDB) released consultation paper and report on “Promotion of STEM Education - Unleashing Potential in Innovation”, which introduced the collected views from different stakeholders and the strategies of EDB in the promotion of the STEM education.3 The strategies include the renewal of curriculum, providing resources, enriching activities, enhancing professional development, strengthening partnerships with key stakeholders, etc. Within all these strategies, STEM workshop is one of the major activities that can help promotion of STEM education. These workshops can be offered by NGOs, private companies or tertiary institutes. Currently, STEM workshops in Hong Kong only involve science such as biology, engineering and technology such as programming, robotics, 3D-printing and virtual-reality.4 However, there are not many bio-technology workshops for youngsters due to equipment limitation, this may inhibit the nurturing of the interests of students towards biotechnology, which is an important area of innovation for future development of Hong Kong.5-9 Therefore, a STEM workshop with bio-technology based theme is sought to launch. It is reported in this paper for the design, implementation and evaluation of a biotechnology based STEM workshop of DNA extraction from human cheek cells, with the adoption of design thinking (DT) approach10-12 in the project-based learning (PBL) curriculum13-15 in the Institute of Vocational Education (HKIVE). The designed workshop would be launched in form of pilot test in a secondary school for evaluation purpose.

STEM education is an integrated curriculum that involves hybridizing of different key learning areas (KLA) in primary and secondary schools -Science, Mathematics, and Technology, there are mainly two approaches suggested by EDB for organizing the STEM
learning activities. The learning activities is either based on topics in a KLA for students to integrate with relevant elements from other KLA or a project that integrate relevant elements from different KLAs. The element of engineering design is incorporated into the learning activities to facilitate integration and application of knowledge into practice with competent skills such as creativity, innovative and analytical skills. In order to facilitate STEM education within and outside school, project-based learning (PBL) is a good mediator for IVE students to design, implement and evaluate a STEM workshop to secondary school. PBL is an important part of curriculum in IVE programme, which brings students in groups with practical experiences outside lecture. It is the learning process for students to work together, to analyze in different angles and to apply the prior knowledge, skills and tools obtained into practical for solving problems in social reality. PBL is a student-centered pedagogy that facilitate interdisciplinary understanding such as STEM education, which is encouraged by EDB to facilitate students’ integration, innovativeness and problem-solving skills. Within the PBL, students adopt the design thinking (DT) approach for the design, implementation and evaluation of STEM workshop. DT is a tool of human-need-oriented approach to solve problems through seeking innovative solutions in possibilities of technology and requirements of success in business. Students can learn actively by transforming the knowledge and information of “human-needs” obtained into continuous improving product design through reasoning, problem-solving, creativity, innovating and collaborating skills, which are essential competent requirements for graduates in 21st century. DT involves five stages including “Empathize”, “Define”, “Ideate”, “Prototype” and “Test”, these steps are in cycles that continuous deconstruction and rebuilding of ideas and products is taken place, which transform the students from a fixed mindset to a growing mindset for continuous improvement and advancement. Therefore, DT can be incorporated as a tool of cultivating skills in student-centered STEM education.5

Materials and Methods or pedagogy

Purpose and significance of study: The purpose of the project is to plan, design, implement and evaluate a STEM workshop with the content of DNA extraction of human cheek cell, which can be launched in secondary school, by using design thinking tools in project-based learning of IVE. The STEM workshop output involves the consideration of needs from teachers as user and students as stakeholder, which can help optimizing and smoothing the STEM workshop for launching. Therefore, it can be used to promote STEM education in Hong Kong for arousing students interests in STEM-related subjects and hence, for the future development of innovative expertise, particularly in the growing field of biotechnology.

STEM education6 and PBL: The STEM workshop is designed and implemented by HKIVE students through project-based learning curriculum. The STEM workshop involves biochemical Science and Technology as main theme involving the extraction of DNA, it also involves mathematics such as calculation of the concentration of DNA to optimize the experimental condition. Finally, it involves engineering design which utilize science and mathematics to solve the problems and optimize the DNA extraction workshop. Throughout the planning, designing, implementing and evaluating the project-based learning for STEM workshop output, it fulfills the students’ curiosity, interests, needs and actualize the sense of self-determination as well as acquiring skills and knowledge in biotechnology through DNA extraction, Polymerase Chain Reaction (PCR), and gel electrophoresis, etc.

Design Thinking: DNA extraction is a process to obtain and purify the DNA using physical and chemical methods. The general procedure for DNA extraction of animal cells, such as human cheek cell, is well documented, however, it is obvious that some criteria has to be considered in order to modify the experiment and bring it into the STEM workshop for launching in secondary school. The design thinking approach is introduced in order to optimize the product output of the STEM workshop. The steps of DT are empathy, define, ideate, prototype and test, the details of application of each step are reported below:

1. Empathy
It was to understand the users and stakeholders’ needs for the characteristics of the product output of STEM workshop with content of DNA extraction. The information was obtained by interview.

2. Define
It was to analyze the information obtained in the first step by prioritizing the needs. Strategies were formulated using prioritized needs by the discussion among student team members.

3. Ideate
It was to generate various idea from strategy to fulfil the needs of users and stakeholders. Idea are generated through the discussion among student team members.

4. Prototype
It is to produce quick models for the possible solutions utilizing the idea generated. It involves the production of the prototype using various experiments methods and equipment according to the idea generated. In this context, the procedure of original DNA extraction experiment was modified and incorporated in the STEM workshop. The extracted DNA product was put in a specially designed souvenir.

5. Test
After the prototype was established, the pilot test of the STEM work is launched in a secondary school for 22 students and teachers on 21 March 2018. The comments of users and stakeholders are collected by questionnaire (n= 21) and analyzed. The questionnaire adopts the 5 equivalent points Likert score and the results are reported as mean ± SD.

Original DNA extraction protocol: Design thinking is employed to modify the existing documented DNA extraction protocol. The original protocol is described as below for reference:
Preparation of digestion buffer: The digestion buffer (100 mM NaCl, 10mM Tris-HCl (pH 8), 25 mM EDTA (pH 8), 1% (w/v) SDS, 0.1 mg/ml proteinase K (add fresh) was prepared at room temperature and the proteinase K was stored in -20°C.

DNA extraction method16-21 and measurement: Swab was used to rub the cheek cell from mucus membrane for about twenty times of each side. After that, the cells were dispersed into the 2 ml microcentrifuge tube containing 200 μl of digestion buffer. The cell will be lysed by incubator at 56°C for 45 minutes. Two hundred microliter of phenol-chloroform was added to purify the DNA from cell. The microcentrifuge tube was mixed gently by inversion for five minutes, then it was centrifuged at 3000 rpm for five minutes at room temperature. The upper layer was transferred to a new 1.5 ml microcentrifuge tube. Fifteen microliter of 3 M sodium acetate and 300 μl of ice-cold absolute ethanol were added into the 1.5 ml microcentrifuge tube. The solution was mixed by pulse-vortexing for fifteen seconds. The microcentrifuge tubes were placed at -80°C for fifteen minutes. The DNA precipitate was collected by centrifugation at 14000 rpm for ten minutes at 4°C. The supernatant was then discarded leaving the DNA pellet. 400 μl of 70% ethanol was then added to the centrifuge tube for redispersion. The tube was then centrifuged at 8000 rpm for 1 minute. The supernatant was discarded as much as possible and the DNA pellet was dried in a Speedvac evaporator. The size of the DNA pellet can be measured. Fifty microliter of sterile water was added to the DNA pellet for resuspension and was incubated at 55°C for 5 minutes. The A260/A280 ratio and direct concentration were measured by using Nanovue spectrophotometer for the determination of purity and concentration of DNA extracted. The DNA integrity and target sequence quality were measured by agarose gel electrophoresis and PCR respectively.

NanoVue Plus spectrophotometer: Two microliter samples were pipetted directly onto the sample plate for measurement of A260/A280 ratio and direct DNA concentration, and they can be then simply recovered using a pipette.

PCR protocol: Polymerase Chain Reaction (PCR) is a technique to amplify single copy or few copies of specific segments of DNA into several order magnitudes copies.22-24 The primers used for the amplification of target GAPDH gene with 205 base pairs25-27 The sequences of forward and reverse primers are GAPDH-F: 5'-AGG GCT GCT TTT AAC TCT GGT-3' and GAPDH-R: 5'-CCC CAC TTG ATT TTG GAG GGA-3' respectively. The protocol of PCR was described as follow: Initial denaturation was performed at 95°C for 30s, then 40 Cycles of three steps were performed. The first step was denaturation at 95°C for 5s, followed by annealing at 60°C for 30s and extension at 72°C for 3 min. After that, 1% gel electrophoresis of PCR product was performed.

Agarose gel electrophoresis: 1% agarose gel electrophoresis was used to determine the band pattern and molecular weight band distribution of extracted genomic DNA and PCR product, which indicated the integrity and quality of the extracted DNA.28-30 Six microliter DNA samples with loading buffer and 4 μL 100-bp molecular markers were loaded into separate wells. Power supply at 100 V was connected to the anode and cathode of the gel apparatus to perform gel electrophoresis. When the dye front had migrated three-fourths of the gel, the gel was disassembled from the gel tank and was visualized under UV screening system.

Results and Discussion

Design thinking (DT) is used for the design, implementation and evaluation of the STEM workshop with the content of DNA extraction. Starting from empathy, the information concerning the needs of users and stakeholders were collected through interview. The second process is “Define”, the needs of users are collected, and the results of the interview were collected. Attractiveness, simplicity, time, cost and safety are the needs of the user concerned. For attractiveness, the DNA product should have a good-looking and can be taken home after the workshop. For simplicity, the procedure in the workshop should be easy to follow, the steps required to produce the product should be simple. For time, the STEM workshop with objectives accomplished should be finished within limited time (2 hours) due to the availability of school and students. For safety, the chemicals used in the STEM workshop should be safe and easy to handle. These needs are prioritized according to the interview conducted with the users. The third process of DT is “Ideate” to fulfill users’ needs. For addressing the need of attractiveness of product, the DNA product should be with observable size of pellet and is stored using the well design and attractive bottle for increasing the attractiveness of the workshop.

In order to address the concern of the simplicity and running time limit of the workshop, the procedure including the chemicals and instruments used is modified to have a simple flow and to shorten the running time. Moreover, the cost and safety of the workshop is optimized by using cheaper but safer chemicals.
<table>
<thead>
<tr>
<th>Step</th>
<th>Model</th>
<th>Testing material</th>
<th>Material to be replaced in original method</th>
<th>Addressed concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell lysis</td>
<td>A</td>
<td>Household detergent</td>
<td>Sodium dodecyl sulfate(S.D.S.)</td>
<td>Simplicity, Safety</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>Meat tenderizer</td>
<td>Proteinase K</td>
<td>Cost</td>
</tr>
<tr>
<td>Concentration</td>
<td>C</td>
<td>Sodium Chloride (salt)</td>
<td>Sodium acetate</td>
<td>Simplicity, Safety</td>
</tr>
<tr>
<td>Cell lysis and Concentration</td>
<td>D</td>
<td>Detergent + Sodium Chloride</td>
<td>S.D.S and Sodium acetate</td>
<td>Simplicity, Safety</td>
</tr>
<tr>
<td>Cell lysis</td>
<td>F</td>
<td>No Proteinase K</td>
<td>Proteinase K</td>
<td>Cost</td>
</tr>
</tbody>
</table>

Table 1. The modification of procedure from original DNA extraction protocol and its addressed concern.

Then, the “prototype” is constructed using different modification of procedure and chemicals. The related concern is addressed by formation of different model (A-F) through replacing chemicals used in the original DNA extraction protocol as shown in Table 1.

The attractiveness of DNA product is addressed by monitoring the DNA pellets size in the above model during testing and modified the procedure if necessary. Also, a well design and attractive container is designed to store the DNA product. The time of procedure is shortened from 3 hours to 2 hours by reducing time in cell lysis and tightly following the procedure step by step without break between steps.

The effect of DNA product produced by different models A-F was compared with the original protocol. The pellet size, concentration, purity, integrity and quality of DNA was tested in response to the impact of modified procedure according to the concerned needs in balancing of scientific grounds in STEM. A good modification of procedure should give a little negative, the same or even better impact on the DNA product. Therefore, the DNA extracted using different modified model is still valid for the future use of bio-authentication. The DNA pellet size produced by different models are rated from 0 to 5 points by observation. It was found that different models can produce similar (A-D and F; 1.5–2) or even better (E; 3.5) pellet size compared with original protocol. The concentration of DNA was measured directly by the Nanovue spectrophotometer, it was found that different models can produce little negative (E; 4.65 ng/µL, F; 4.75 ng/µL), similar (A-C; 10.25–15 ng/µL) or even better (D; 30 ng/µL) concentration of DNA compared with original protocol. The purity of DNA was measured by the A260/280 ratio through Nanovue spectrophotometer, it was found that different models can produce little negative (B; 1.076), similar (A and F; 1.374–1.376) or even better (C-D and E; 1.545–1.813) concentration of DNA compared with original protocol. As the typical A260/280 ratio is around 1.8, the model E (1.813) gave an even better result compared with original protocol, indicating the highest purity of DNA among all models.

The integrity of DNA was measured by the band pattern and size determination in 1% agarose gel electrophoresis. It was found that some models (A, C, D and E) can form single band with similar band size compared with original protocol. Extracted genomic DNA of satisfactory intactness should show a smear with a single band appeared above the resolution capability of the gel. It indicated that replacement of chemicals from original protocol for these models will not lead to failure in extraction of genomic DNA. The quality of DNA was determined by the PCR result of GAPDH gene found in extracted DNA in human cheek cell. The band size of the target DNA segment is 205 base pair which was analyzed by 1% agarose gel electrophoresis. It was found that model A to E can give successful PCR result as the target band size was obtained, it showed that the extraction of DNA was successful in model A to E such that the extracted DNA can be used in bio-authentication. Model E was chosen as the prototype as the performance is the best in term of attractive pellet size, in balance of the DNA properties (concentration, purity, integrity and quality) for potential future use of bio-authentication.

The final DT process is “Test”, the pilot test of STEM workshop is launched in a secondary school on 21 March 2018. The comments from users and stakeholders were collected after the workshop. The questions in the questionnaire adopted the 5 equivalent points Likert score with 1 (most unsatisfied) to 5 (most satisfied) scores for each question (n = 21). The questions consist of comments concerning knowledge learnt, change in attitude, usefulness, attractiveness of the STEM workshop, etc. The feedbacks are listed in Table 2 and it showed that the participants were highly satisfied (average score more than 4 in each item) with the learning content and outcome of the STEM workshop in term of view on workshop (e.g. knowledge obtained, interest aroused, useful information for further study obtained, satisfactory production process, spatial and learning experience), and were likely to join similar
type of workshop again with satisfaction. The users and stakeholders also gave suggestions to the workshop in open-end question. Some of them gave suggestion to has a greater time allocation for souvenir making, or even to increase the time duration and space for the workshop. These suggestions can be taken into consideration in the next cycle of design thinking.

The design thinking cycle was completed through the STEM workshop design, implementation and evaluation. The user-centered design thinking process produce a STEM workshop that enable students to learn STEM knowledge and concepts through addressing the users’ needs. It also aroused the interests of participating students to learn science and technology. The workshop is practicable since it produces attractive product with simple procedure, short running time, reasonable cost and safe. It also has sustainability for the consideration of teacher’s and student’s feedback during the design thinking process and the workshop contains entertainment element and has a simple and repeatable procedure.

Limitation and suggestions: There are some limitations in this project, the workshop is still a pilot test that require further investigation on the efficiency and effect on users and stakeholders on STEM education. The number of schools participating in the workshop should increase to give a more concrete conclusion on the results. More space, time duration and appropriate time allocation of workshop are sought to be provided in next cycles of workshop. However, since the design thinking tool is highly users-orientated, each group of users may have different needs due to the school and users background. Therefore, it is expected that design thinking may be implemented for each workshop conducted to check whether the needs from each group of users vary. The project is a quasi-experiment with single group post-test of questionnaire, therefore, it has several limitations such as selection effect. However, the effect of history and maturation are not important as the treatment of workshop is one-shot of 2 hours. The post-test of questionnaire may not sufficient to test whether the users and stakeholders learned in STEM workshop effectively. In order to give a stronger conclusion on the result of STEM workshop, it is suggested that pre-test and post-test of written format of STEM (including biotechnology) knowledge should be given, also, control group should be added to the experiment with randomization assignment of experimental and control group members to elimination selection effect.

Conclusions

A STEM workshop with content of DNA extraction has been launched in pilot test effectively, and it utilized the design thinking approach in IVE student project, the users’ and stakeholders’ needs were taken into consideration throughout the design of the workshop. The attractiveness of product, simplicity of procedure, time duration, cost and safety of workshop are the needs of users that have been catered by the modification from the original DNA extraction procedure with the addition of attractive container design, bigger DNA pellet size and in balancing of the validity of DNA (concentration, purity, integrity and quality) for future use in the aspects of scientific grounds in STEM, therefore, one of the seven proposed model of prototypes was selected for the STEM workshop procedure.

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References

Abstract

This action research explores the use of exit ticket for diagnostic teaching and reflection on learning computer programming in an innovative and plausible approach. Students in School of Engineering often consider their first attempt in a software programming subject disconnected and uninteresting as they find the language very different from that used for interpersonal communication. They find it hard to remember the syntax of programming language and tend to forget the rules and special names or keywords used for specific purpose. Two different cohorts of students participated in this action research. I attempted diagnostic teaching (DT) in my first iteration with the main objective of understanding the knowledge gap of my students and to determine the next step of instructions or reinforcement necessary for that particular lesson. Based on students’ answers to the questions I posed, I noticed a possible common misconception amongst students in the class. Students feedback that the follow-up diagnostic teaching clarified their misconceptions and reinforced their understanding. Though DT could be adopted in some cases to help students understand their learning gaps, it is usually adopted by teachers for the same purpose and to inform them of their teaching instructions and strategies.

In my second iteration of action research, I adopted exit ticket which comprises a set of reflective questions that help students reflect on their learning. I leveraged on their reflection to inform and support the reinforcement strategies and instructions I constructed for the subsequent practical lessons. This action research reviews how exit ticket for reflection on learning can benefit both students and tutor to achieve the goals of enhanced learning and facilitation respectively for the subject, Computer Programming for Problem Solving (CPPS).

Students’ feedback revealed that exit ticket for reflection on learning is beneficial if well-implemented. I observed that regular use of such exit ticket, in a programming subject, at the end of a lab session for reflection on learning helps students make connections to their prior knowledge, be more mindful of common errors, remember solution for specific errors, and most importantly, envisage their learning gaps and needs.

Keywords: exit ticket, diagnostic assessment, diagnostic teaching, reflection on learning, computer programming, action research

Introduction

This action research was conducted in the premise of Temasek Polytechnic, for year 1 students taking a software programming subject called Computer Programming for Problem Solving (CPPS). As a practitioner and educator, I found that regular ‘self-reflective inquiry’ (Carr and Kemmis, 1986, p162 cited in Cohen et al., 2005, p227) and keeping abreast of current education innovation guide my belief system which form my knowledge base and influence my practice.

In this action research, I attempted diagnostic assessment in the first iteration with 22, year-1 semester-2, students taking the subject CPPS, with the objectives of understanding the knowledge gap of my students and to determine the next step of instructions or reinforcement necessary for that particular lesson. Besides informing my instructions to help close students’ knowledge gap, I wanted the assessment to help students reflect on their learning needs. Students feedback that the discussion cum explanation given after the diagnostic assessment helped them understand the taught concept better. This assessment took up much of the class time. I felt that helping students improve their skills in reflection on learning would help them understand their learning needs, link and apply their prior knowledge to the current lab exercise, and note the mistakes they encounter in each lab practice.

In the second iteration, I used exit tickets to help students reflect on their learning at the end of lab lessons 3, 5, 6 and 8 in term 1. The purpose of using the exit tickets was to provide opportunities for students to reflect on their learning, to link the concept taught in the previous lessons with the current lab exercise and also to enhance their ability to understand their learning needs. I used the exit tickets as a diagnostic assessment tool to inform me of their learning needs. With that, I constructed instructions and reinforcement strategies in the next lesson to close the learning gaps and address common
misconceptions. Students were motivated to jot down their thoughts in the exit tickets, when they realised that I actually used what they wrote to address common misconceptions.

Focus of research

In this action research, I am collaborating with my students, using their reflections on learning in the form of exit ticket at the end of selected practical lessons. As a tutor, I hope to collect information of their learning needs which I could use to strategise my teaching approaches, in the form of diagnostic teaching in the subsequent lessons.

I observed that student who lacks the skills of reflecting on learning – unable to make sensible meaning of the situation without reflective inquiry and thinking (Dimova & Kamarshka, 2015), has poor ability to connect learning points, unable to quickly leverage on his/her prior knowledge, and hence, lack confidence in the project code implementation.

In my attempt to help students improve their ability to reflect on learning and using their reflections to diagnose their learning needs, I envisioned that these research questions would be beneficial in informing me of the effectiveness of the strategies I employed. These strategies would enhance my students’ ability to reflect on their learning, to link the concepts taught in the previous lessons with the current lab exercises, and to enhance their ability to unravel their learning needs.

Research questions

1. How can exit tickets help students engage in reflective learning?
2. How can exit tickets help tutors in diagnostic teaching?

These research questions were formed after my observations and reflections on students’ feedback on the first iteration of action pertaining to the use of diagnostic teaching, and discussion with my colleagues from Learning Academy of Temasek Polytechnic. Having carried out one round of diagnostic teaching and data collection in one lesson, it was revealed that there was a lack of class time in completing the intended lab practical exercises. This led to a change in the cause of actions for the second iteration, which will be described in detail in the methodology section.

In this paper, reflection on learning is construed as a thought process or cognitive activity that takes place, after an experience, event, lesson, and group or individual active participation for making connections to past experiences and generation of new knowledge (Hickson, 2011; Quinton & Smallbone 2010; Chirema, 2007). The literature review, in the next section, provides more insights of diagnostic teaching, exit ticket and students’ motivation to learn.

Literature Review

Exit ticket for diagnostic teaching

The use of exit tickets for garnering inputs from students about their understanding, and to achieve the desired learning outcomes can be effective if it’s well-planned and well-administered.

The prevalent use of exit tickets in different educational levels can be adopted for diagnosing students’ current learning gaps. These information help teachers plan and facilitate their lessons (Danley, McCoy & Weed, 2016; Doug, n.d.b). Well-thought reflective questions in exit tickets help students to reflect on their learning (Learning Sciences International, 2012). Dimova & Kamarshka (2015, p. 37) mentioned the use of “reflective cards” for focused reflection on action to occur quickly. The idea of reflective cards for guided and fast reflection is similar to the use of exit tickets for reflection on learning. This practice promotes self-reflection on learning (Doug, n.d.a).

The process of diagnostic teaching comprises finding out individual students’ learning needs with respect to the desired learning outcomes and designing teaching approaches to create learning opportunities to fulfill individual learning needs (Palmer et al., 2014; Eisele, 1967). Providing guidance and monitoring students’ learning progress should be perennial throughout the diagnostic process (Bell, 1993; Bell, n.d.; Eisele, 1967). Diagnostic teaching contributes to forward learning and promotes transfer of current knowledge to applications in different context when cognitive conflict is encountered within a learning activity (Scalfie, 2011; Bell, 1993). Figure 1 shows the iterative diagnostic teaching approach adopted in this study. The prior assessment of individual’s current knowledge level is imperative for informed application of relevant and effective teaching activities and strategies (Palmer et al., 2014; Ontario, 2013).

Figure 1. Diagnostic Teaching

The use of exit tickets in the lens of reflective journal writing aids in deconstruction of thoughts and assumptions (Hickson, 2011). There are many ways of
reflecting on learning; through journal writing, talking or discussing with teachers or peers, and self-deconstruction of thoughts and assumptions (Hickson, 2011).

Importance of reflection in tertiary & higher education

Quinton & Smallbone (2010) noted that students’ engagement in reflection is salient in tertiary education, and that, it should be explicitly included in the curriculum design. Our exposures to past situations may encumber our ability to make sense of the present circumstances, and hence, to carry out a sensible act (Miettinen, 2000). Quinton & Smallbone (2010) stated that reflection in the form of writing is more powerful than that through discussion, and it allows students to view their reflections at a later stage in their learning. Though research on the effectiveness, outcome and processes of reflection is lacking (Hickson, 2011), writing of journal to encourage reflection and learning in the milieu of education is prevalent (Hickson, 2011; Chirema, 2007).

As my students are young adult learners in the first year of polytechnic education, the learning experiences, positive or negative, they garner now, engender self-directedness in learning.

Students’ motivation to learn

Topala (2014) argued that students’ motivation to learn can be increased when their learning needs are well-managed and fulfilled. Diagnostic teaching based on students’ reflection helps to address learning needs and close the learning gaps. This in turn may enhance students’ perceived self-efficacy in the subject, which is one of the factors that increases their motivation to expend effort in mastering the subject (Tan, 2014; Zimmerman, 2000). The reflection process improves their ability to perform self-assessment (Quinton & Smallbone, 2010) and self-regulation (Zimmerman, 2000). Critical reflection, being the ability to reflect on experiences, performances, and asking relevant questions to verify one’s belief system is a core skill in self-directed learning (Hickson, 2011). Self-directed learning is an important skill to be acquired by our students.

Methodology and Participants

First Iteration

In the first iteration of the action research, I conducted diagnostic assessment to understand students’ learning gaps in the topic, Functions. The diagnostic teaching tool consists of two technical questions about functions based on a given set of C language codes. I noted that more time is needed for such activities for a bigger class size. The activity took about 30mins; comprising time allocated for students to attempt two questions, explanation of misconception, discussion of students’ answers, and doing a short survey. The survey consists of three five-point Likert rating questions and two open-ended questions to garner their perspectives pertaining to the usefulness of the activity and my explanation. All indicated that their level of understanding increased after the activity.

The 22 year-1 semester 2 participants were students from Diploma in Infocomm & Network Engineering taking Computer Programming for Problem Solving (CPPS). These participants generally found diagnostic teaching, done promptly after their attempt to answer the questions pertinent to the code, helped them better understand the concept that was taught in the previous lesson.

Second Iteration

Based on my observations and students’ feedback from the first iteration, I decided to use exit tickets to help students reflect on their learning in this iteration. On one hand, students can learn to ask reflective questions for reflection on learning, and on the other hand, their responses were used for informing my teaching pedagogy. In the subsequent semester, 53 year-1 semester-1 students in two of my classes participated in the research. Before the start of the activity, I explained to the participants the reasons for writing their reflection on the exit tickets, and emphasised that their responses informed me of the areas that require my attention. I advised them to take a picture of the exit tickets with their hand phone before submitting them to me. This endows them the opportunity to revisit past reflections while learning the subject, and for future related developments (Quinton & Smallbone, 2010).

I gave out the exit tickets at the end of lab lessons 3, 5, 6 and 8 in term 1 (each semester has two terms). These lessons were chosen because they are the second or third lesson of a new topic. There is more about exit tickets in the next section. For diagnostic teaching, I went through each of the exit tickets and noted down the key common responses. During the next lesson, I employed targeted exercises with explanation to clarify misconceptions that was revealed through students’ reflections.

Exit tickets, the intervention tool

The exit tickets comprise seven open-ended questions. Each question aims to promote thinking of the learning experience related to the key concepts, and making connections to the prior knowledge in drawing of flow charts, and coding to solve one or more authentic problems. The exit tickets help students recognise and remember the errors they make and what are done to correct those errors which served as self-learning moment.

One of the questions allows students to describe the concepts they do not understand. This question serves as a good feedback to inform teaching approaches for the next lesson (Exit Tickets, n.d.). The last question asks about other observations and comments they have of their learning. The nature of such question empowers students to reflect on their emotions (Learning Sciences International, 2012; Quinton & Smallbone, 2010), strength, weakness and areas in which they are open to make their voices heard.

The exit tickets were given to each student during the last 30mins of the 2-hour lesson. They were then instructed to spend no more than 15mins to reflect on the
questions on the exit tickets. I had explicitly informed the students that I will use their exit tickets for planning my teaching strategy insofar to close their learning gaps. I observed that using exit tickets for diagnostic teaching and engaging students in reflection helps information retention, and realisation of one’s weakness and strength in this subject. These approaches motivated them to participate in reflective journal writing (Hickson, 2011; Chireman, 2007). The questions in the exit tickets are shown in Table 1.

1. What did I learn today?
2. What errors/problems did I make in my flowchart today?
3. What errors/problems did I make in my coding today?
4. What did I/ tutor do to solve the errors / problems indicated in question 3?
5. What knowledge did I apply from my previous lesson/s?
6. What concept I am still not clear about?
7. Other observations and comments about my learning.

Table 1. Exit Ticket

**Questionnaire**

The questionnaire in the second iteration consists of 10 five-point Likert rating multiple choice questions, 2 true-and-false and 3 open-ended questions. The five-point Likert rating questions provide the quantitative inputs while the open-ended questions garner rich qualitative data for better understanding of students’ perspectives (Tan, 2014; Cohen et al., 2005). To avoid misinterpreting students’ feedback in the questionnaire, participants’ identity was authenticated, but was kept confidential throughout the research. My classroom observation together with the data collected provide more accurate interpretation of students’ perspectives.

**Data Collection**

Multiple data collection processes may be essential in mixed method action research based on initial analysis and planning, with respect to the evolution of the research iterations (Tan, 2014; Merriam, 2009). Triangulation of data through collecting data from different sources, employing various methods, and engaging different evaluators to validate the data increase its validity and reliability (Tan, 2014; Cohen et al., 2005).

My perspectives and observations were constantly reflected upon throughout the various phases of the research. This way of triangulation of data reveals the possible mismatch of mine against the participants’ views (Tan, 2014; Cohen et al., 2005). To avoid being bias in analysing the data, I reminded myself that any discrepancies in my observations, and perspectives against the data, could be illuminating insights for further improvement in current and future research studies (Tan, 2014; Cohen et al., 2005). In the second iteration, an online questionnaire was published to the 53 CPPS students. The next section highlighted the results of the online questionnaire.

**Data Analysis**

33 out of 53 students participated in the online questionnaire. 18.2% of the 33 participants indicated that they have learned C programming before joining the course. This gave them an edge over other learners. I observed that these students could grasp the concept quicker than the majority. They generally gave little or no details in the exit tickets – this could be due to the fact that they hardly encountered difficulty in class.

81.9% found reflection helpful in summarising key learning points while 93.9% of the participants strongly agree or agree that reflecting on how they overcome the mistakes they made during lessons helped to reduce the occurrence of similar mistakes again.

84.8% of the participants felt that reflective journal writing helped them understand their own learning needs, and 94% noticed that it enhanced their ability to code in C language. 78.8% noted that their ability to code in C language for solving simple problem was in the range of 5 – 10; where 10 means good and 0 means poor. In my view, this confidence level is satisfactory for first time programmer. 93.9% of the participants found diagnostic teaching using information garnered from their reflections useful in clarifying misconceptions, and reinforcing their understanding.

From the qualitative feedback, the majority of the participants felt that 5 to 10 minutes were sufficient for them to reflect and complete similar reflective journal writing. All, except one participant, felt that the class time given for reflection was enough. Four participants revealed in the open-ended question that they disagreed that reflective journal writing was helpful. One student indicated that he had already learned and remembered his mistakes while attempting the lab exercises - I observed that this efficacious student was motivated to learn the subject right from the start. Another student indicated that she found it hard to reflect on her mistakes and problems. A student commented that doing reflection at the end of the lesson was a bad idea as he tended to rush through, so as to leave for home. The fourth student commented that the questions in the exit tickets were not specific enough to help her think of what she had learned.

The majority of the participants acknowledged that reflection on learning has enhanced their learning of this subject. The survey results revealed that most students felt positive about using exit tickets for reflective journal writing and diagnostic teaching. They observed an increase in confidence in programming, as compared to the beginning of the semester.

Careful analysis of their written reflections could unravel the level of engagement, positive or negative, in
writing reflection journal. However, not all students gave useful details to the various questions they were asked to reflect on. I believe these students need more practices and more time to reflect on their learning.

Results and Discussion

A well-planned and well-administered process of facilitating the use of exit tickets in promoting reflection on learning and diagnostic teaching is salient. Many students wrote on the exit tickets one to three of the most memorable mistakes they had made. Some included detailed explanation of the errors they made. I observed that having found relevance and knowing the advantages of writing reflective journal motivated these students in writing more details while reflecting on their learning.

When I reflected on my approaches to diagnostic teaching, I realised that students acknowledged the consolidated reflection outcome, with respect to their learning needs. They also appreciated the use of their reflections to inform my teaching approaches. The qualitative feedback students gave for my teaching evaluation showed that many found the strategy of diagnostic teaching, and my approaches to teaching effective. Table 2 shows some of the comments extracted directly from my staff teaching survey given by this group of students:

Table 2. Online Feedback on Staff Teaching

This was their first experience in using exit tickets for reflection on learning. Nevertheless, this experience has a positive impact on them in engaging in reflective practice in future learning. In class, I was confronted with fewer questions pertinent to troubleshooting syntax related errors, as compared with the past semesters. This unveiled a positive outcome of using exit tickets for reflection on learning. In this study, results and observations revealed that the use of exit tickets in reflective learning and diagnostic teaching is feasible and less time pressing if well-planned and well-administered.

Limitation

This action research and many others on using exit tickets or other approaches to foster reflection skills have not adequately assessed the effectiveness, outcome and processes of reflection. Future research can consider assessing the effectiveness, outcome and processes of reflection using a systematic model or developing criteria for assessing the quality and outcome of reflection. Though this study in the context of a programming subject cannot be generalised to other learning milieu, it provides practitioners and educators insights into how exit tickets and diagnostic teaching can be adopted in a programming subject. I envision that this research serves as a support for myself and practitioners who attempt to inculcate and develop reflection on learning, to promote deep learning and self-directed learning. As Prouty & Prillaman (1970) has succinctly put, diagnostic teaching can also be adopted to help younger students with learning difficulties and behavioural problems to cope with their learning. This research should be read by teachers and practitioners from different education milieu and levels as it gives them ideas on how they can improvise and strategise their teaching approaches to engage students in reflective learning.

Conclusion

The research questions pertaining to the use of exit tickets for engaging students in reflective learning and for teacher to apply diagnostic teaching had evolved from the initial idea of purely diagnostic teaching to strengthening students’ reflective learning ability. The overall engagement level of participation in reflection on learning, though short, was a positive and relevant experience to many of the student research participants. With the benefits and positive impacts that this paper has illustrated in the literature review and data analysis sections, I envisage that inculcating students’ ability in reflective learning and critical reflection (Mezirow, 1990), give rise to more deep than surface approaches to learning. In order for students to reap the benefits of reflection on learning, which is a cognitive skill for deep learning (Mezirow, 1990), self-assessment and self-directed learning, reflective writing in the form of exit tickets should be considered for implementation in tertiary education curriculum (Quinton & Smallbone, 2010).

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References


AN APPLICATION OF THE PROCESS OF MATHEMATICAL MODELING TO THE MODEL CORE CURRICULUM

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Abstract

The model core curriculum fully carries out in National Institute of Technology (KOSEN) from fiscal 2018. The required abilities for engineers are clarified, and reforms of curriculums and lessons are required that can acquire such skills. In particular, we aim at the application level, not the comprehension level, with regard to the fundamental abilities that we need to acquire in common fields. In other words, it is necessary to aim to be able to utilize knowledge in real situations. However, almost of former mathematical education in KOSEN was aimed at acquiring knowledge and confirming it. The part of application of mathematics in engineering is entrusted to specialized fields of KOSEN. Obviously, there exists the gap between previous mathematical education and the future mathematical education in KOSEN. Moreover, there also exists the gap among instructors. Hence, we want to investigate the construction of lessons of mathematics for the application level. To do this, we focus on the following aspects: (1) Consider the question to change from the problem of the comprehension level to the problem of application level; (2) Consider a method that many instructors can easily do, not a method that only a specific instructor can do; We have developed the experiment with respect to the above aspects in the class of the mathematics for first year students in National Institute of Technology, Asahikawa College. We consider the development of lessons based on the process of mathematical modeling and share the lesson plan. Here, the process of mathematical modeling means a series of the processes for solving problems in the real world by using mathematical methods. Then, in particular, we focus on the ease of sharing. To do this, we also construct a lesson plan. As a result of our approach, we find a certain approach to change from the comprehension level to the application level. Moreover, we can make lessons easier to construct and share.

Keywords: Model core curriculum, Mathematical education application level, mathematical modeling, real-world problems

Introduction

Currently, National Institute of Technology (KOSEN) carries out the model core curriculum. The model core aims to develop skills that engineers should have. In particular, we aim at the application level, not the comprehension level, with regard to the fundamental abilities that we need to acquire in common fields. The subjects of mathematics in KOSEN also aim at the application level. For example, we have the following problems: In the education provide at KOSEN, mathematics subjects are basic to the education of engineering. So, all KOSEN students spend a lot of time on mathematics. However, many subjects of mathematics in KOSEN keep learning mathematical processing. Namely, most of the students do not grasp the contribution of mathematics to engineering. Roughly speaking, most of them can not apply mathematics to engineering.

On the other hand, many subjects of specialized fields are intended only for higher year students. Hence students do not fully grasp the contribution of mathematics to engineering until the later years of their education. In addition, most of them have not used mathematics for solving real-world problems. We also wondered whether students suddenly could use mathematics for studying subjects of specialized fields at KOSEN. It is necessary for them to construct how to connect mathematics and specialized fields. To do this, we want to construct a way to deal with applications of mathematics in the class of the mathematics for lower year students. We also want to share that way with other instructors.

In the mathematical education, the notion of “the process of mathematical modeling” is well known (Miwa, 1983). This notion is a series of processes for solving problems in the real world using mathematical
methods. We consider that these processes provide a smooth connection between the mathematics and its applications. Namely, these processes are useful to make it an application level. In addition, if students learn these processes earlier in their education, teachers can train them for solving problems.

In this paper, we report our approach for first year students in Asahikawa KOSEN.

The Process of Mathematical Modeling

In this section, we recall the process of mathematical modeling. Miwa (1983) defined this notion. After that the process of mathematical modeling has been extended and modified by many mathematical educators. This research uses Nishimura’s process of mathematical modeling. These processes are the following (Nishimura, 2012):

1. Social problems (Problems in the real world)
   - Interpreting the problem
   - Formulating
2. Mathematical problems
   - Making mathematical model
   - Mathematical processes
3. Mathematical results
   - Interpreting the solution
   - Evaluation

By repeating these processes, students obtain a more rigorous solution for social problems (spiral development). These processes do not necessarily proceed as shown in the figure. There are things that go back and jump forward.

![Figure 1: The process of mathematical modeling.](image1)

Our Approach in Asahikawa KOSEN

Most first-year students have not had the experience of formulating social problems (see the result of Q1 in Figure 4). Hence this process is difficult for them. However, this process is inevitable for solving problems in the real world. The authors have tried to seek to help students formulate of social problems (see Okumura and Takamura (2017)). However, we could see that students felt difficulty to interpret the social problems. In general, it is also difficult to find how formulated a given problem can be formulated. Even under such circumstances, we need to aim at application level in KOSEN.

We considered the following two methods as a method of making it to the application level:

1. The instructor gives real-world problems;
2. The students create real-world problems.

The method (1) seems to be standard method. However, it is difficult for instructors to prepare real-world problems for all mathematical matters. Furthermore, the problems given by the instructor tend to depend on the characteristics of the instructor. Hence the method (1) may be difficult to share with other instructors.

In this research, we focus on the method (2). So, we have developed the lesson with respect to a quadratic function in the class of the mathematics for first year students in National Institute of Technology, Asahikawa College. In particular, the students have investigated the application problem of the maximum or minimum value of the quadratic function. To do this, we adopted the following teaching tools:

1. Create real-world problems that can be solved by finding the maximum or minimum of the quadratic function (see Figure 2);
2. Check each other for problems students created.

By this approach, the students themselves investigate how the problem of finding the maximum and minimum values of quadratic functions can be utilized. Moreover, the process of solving the problem was organized using the figure of the mathematical modeling process.

![Figure 2: Creating real-world problems.](image2)

This method is simple and easier to share than the way instructors give problems. Indeed, we shared the above teaching tools with other instructors. To do this, we prepared the lesson plan (Table 1).

Students’ Reactions

The students created real-world problems as homework. They created the following problems:

- The problems with respect to the constant acceleration motion;
• The problems with respect to the parabolic motion;
• The problems with respect to finding the area of the rectangle from the given circumference length;
• Problems that maximize the sales of certain products.

They solved each other’s problems and evaluated the problems. The viewpoint of evaluation was set as follows:
1. Is it realistic?
2. Is it clear what you want?
3. Is the problem established?
4. Is there enough information to solve the problem?
5. Can it be solved without using the maximum of minimum values of the quadratic function? (Are there other solutions?)

Based on evaluations and comments, they revise the problems they created.

Figure 3: The students solved each other’s problems and evaluated problems.

Analysis of Questionnaires

We conducted a follow-up questionnaire with the following items:
Q1 Have you ever experienced solving problems in the real world using mathematics?
Q2 Have you ever experienced creating mathematical problems?
Q3 Did you understand the problem of finding the maximum or minimum value of the quadratic function even more by creating a problem?
Q4 Did you solve the problems that other students created?
Q5 Do you want to apply the mathematics for future learning activities?
Q6 Do you want to learn the process of the solving problems for future learning activities?

They evaluated the above items on a 5-point scale, where 5 = strongly agree, 3 = neither agree nor disagree, and 1 = strongly disagree.

Figure 4 contains the results of the questionnaire.

Results and Discussion

Figure 4 indicates that many students understood the problem of the maximum or minimum values of the quadratic function even more. Hence it means that they can understand the notions of mathematics even more by creating real-world problems and evaluating each other.

In particular, result of Q5 and Q6 indicates that they recognized the necessity of learning applications. In addition, they also felt that they wanted to use the mathematics to solve future problems in learning activities. For that reason, they felt that they also wanted to learn how to solve problems.

Moreover, by sharing the lesson plan with other instructors, many students are able to aim the application level. As a result, it makes the model core curriculum easy to operate.

However, several problems remain. Specifically:
1. We need to consider objective evaluation by the instructor.
2. We need to develop the smooth connection between mathematics and its applications for middle-year students.
3. Teaching materials must be developed to help students learn application of mathematics.

Conclusions

We think that in order to apply mathematics to real world problems, it is useful to create real-world problems to some mathematical problems. The students can understand the notion of mathematics even more by creating real-world problems and evaluating each other. Moreover, they feel that they want to utilize mathematics for future learning activities by our approach.

References
### Table 1: The lesson plan (in Japanese).

<table>
<thead>
<tr>
<th>段階</th>
<th>学習活動</th>
<th>予想される学生の反応</th>
<th>◇教師の指導・援助</th>
<th>評価</th>
<th>時間</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>学習問題を確認する。</td>
<td>◇学習活動の内容を確認する。</td>
<td>ワークシート①</td>
<td>スライド</td>
<td>5分</td>
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<td></td>
<td>2次関数の最大値、最小値を求めるで、解決できる実際の問題を作ろう。</td>
<td>◇作成してきた学習活動を、ワークシート①に記入させ、他の学生に紹介できるように準備させる（問題をやっていない学生がいればこの段階で協力しておく。その学生は、解く様に例示させる）。</td>
<td>ワークシート①</td>
<td>7分</td>
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<td></td>
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<td>◇作成してきた学習活動を、ワークシート①を活用して、ペアで出題し合、解かせる。</td>
<td>ワークシート②</td>
<td>4分</td>
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<td>2</td>
<td>問題の解が実際の問題が明らかに解けやすいか確認する。</td>
<td>◇作成してきた学習活動を何らかの観点で、見たら良いかな学生からの意見をもらう。</td>
<td>ワークシート③</td>
<td>9分</td>
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<td>3</td>
<td>作成した問 題を出題する。 (a) 例えば、面積に関係する実際の問題は、2次関数の最大値、最小値を求めることで解決できることが分かった。 (b) 問題の解が実際の問題が明らかに解けやすいか確認する。 (c) 情報が不十分していると、2次関数でないことも考えられるので、不足している場合は2次関数になる変数を付与する必要がある。</td>
<td>◇最終2人の学生に、出し合い、解いてもらい、全体で確認した観点に則って、コメントし合う。一つ内面を自由に動いて相手を見つけて良いと指示する。</td>
<td>スライド</td>
<td>16分</td>
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<tr>
<td>4</td>
<td>感想、アンケートを行う。</td>
<td>◇感想、アンケートを書きせる。</td>
<td>アンケート</td>
<td>9分</td>
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<td>5</td>
<td>主に数学の内容を適用する方法を考察する。</td>
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FROM BUSINESS ACADEMY TO BUSINESS AND ENGINEERING ACADEMY

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Abstract

Future professionals in all fields need entrepreneurial mindset and innovation competences. Entrepreneurship goes hand-in-hand with innovation – the ability to produce new ideas and to provide better solutions. A fruitful environment for innovation consists of individuals with different backgrounds working together on the same real life problems. Business Academy and the future Engineering Academy consist of students representing business, chemical engineering as well as industrial engineering and management.

Business Academy is a multidisciplinary learning environment where active learning standards in the form of real working life assignments, innovation pedagogy approach of Turku University of Applied Sciences and student centered learning environment meet.

The Business Academy program gives a great opportunity for the students to work together in order to learn about modern team entrepreneurship but at the same time to focus on their own field of specialization.

Business Academy is a learning environment, where students can reach entrepreneurial and teamwork capabilities by actually doing business in a co-operative. Research and development activities are done with visionary local companies.

Learning program creates Synergy between Practice and Theory

Academic studies in the Business Academy model are based on active learning process as individual and as part of a team. The elements of the learning process are intertwined, i.e. both theory and tools are learned by activating methods in training sessions and reading circles. The theories are put in immediate action in each co-operative’s business. The reflections of business, continuous feedback and development enhance deeper learning and bring up new needs for further theoretical learning. Positive cycle and the flow-feeling of doing business yield more knowledge, skills and competences. In Business Academy model learning is both theoretical and practical. This model is going to be applied to the engineering education in order to provide an alternative to the traditional engineering syllabus.

Keywords: Business Academy, engineers, chemical engineering, students, companies, multi-disciplinary, collaborations, entrepreneurial

Introduction

The importance of entrepreneurship in society is growing constantly. As many as 80% of new jobs are created in the small and medium enterprises, SME-sector, so it can be stated that the burden and responsibility of Finnish employment now lies with the SME-sector. This trend will continue and grow stronger in the coming years. Entrepreneurship is needed to secure economic growth and to keep the welfare economy alive. The number of companies in Finland in 2013 was 266 909. The so called micro-companies (employing less than 10 people) are dominant and represent over 93% of all companies. SMEs employing less than 250 people are in total 99%. The turnover of all Finnish companies in 2012 was about 389 billion euro. The percentage of this in micro-companies was 17% and in the total SME-sector 53%. (Elinkeinopoliittinen mittaristo 2016)

Most recent employment statistics from Finnish companies (revenue producing companies) are from the year 2014. The total number of full-time employed was 1 408 353 persons. Micro-companies formed 25% of this and the whole SME-sector 63%. (Elinkeinopoliittinen mittaristo 2016)

From the perspective of the European Union there are several documents that highlight the importance of entrepreneurship for the area. For example, the Entrepreneurship Action Plan (European Commission Entrepreneurship 2020 Action Plan - Reigniting the entrepreneurial spirit in Europe, 2013) is a blueprint “for decisive action to unleash Europe's entrepreneurial potential, to remove existing obstacles and to revolutionize the culture of entrepreneurship in Europe”. Investments in changing the public perception of entrepreneurs, in entrepreneurship education and to support groups that are underrepresented among entrepreneurs are indispensable if a lasting change is to be created. Only if a large number of the Europeans
recognize an entrepreneurial career as a rewarding and attractive option, can entrepreneurial activity in Europe thrive in the long term.

The Entrepreneurship 2020 Action Plan, referred earlier, is built on three main pillars:

1. Entrepreneurial education and training
2. Creation of an environment where entrepreneurs can flourish and grow
3. Developing role models and reaching out to specific groups whose entrepreneurial potential is not being tapped to its fullest extent or who are not reached by traditional outreach for business support.

The European Commission will through the competitiveness and industrial policy follow up the Action Plan and its crucial pillars. A document called Small Business Act. The European Commission analyses the current situation of entrepreneurs in the EU and spots the obstacles and attitudes as well as the policy of each EU country, which may hinder the entrepreneurial activities not only in businesses but for example in education. Small and medium sized companies depend on entrepreneurs - the individuals who have the ideas and are willing to take the risks necessary to get a firm off the ground. Europe needs more entrepreneurs and the Commission is looking for ways in which potential entrepreneurs may be encouraged to establish firms. Other forms of enterprise, such as co-operatives, can play a crucial role in economic growth and they are often underestimated or thought to be “not so real companies”. However, these types of company forms can encourage people in all kinds of professions to test their business ideas. (European Commission 2009a)

Beliefs hampering the entrepreneurship and tools to disperse the apprehensions

First, there are cultural factors discouraging too many people from starting a business. In the Higher Education Institutions (HEI) it is a necessity to develop a more entrepreneurial culture, starting with young people and students on each level in an educational system. Institutions of higher education should foster students creativity and teach them the ability to think “out of the box”, innovation, self-efficacy, self-confidence, problem solving and, in general, how to manage complexity and unpredictability. Interestingly, when it comes to substance knowledge, it is often stated that “basic business and financial skills” must be covered. However, the importance of a learning environment in which learning takes place is considered very important, too. (See for example European Commission 2009b; Richardson and Hynes 2008; 2014)

Being an entrepreneur involves always an economical risk. There is too often a stigma attached to this risk and a possible failure. The attitude towards becoming and being an entrepreneur must be fostered and changed. Moreover, the total image of the entrepreneurship must be renewed: “You are either born an entrepreneur or you will never become one” – types of myths and beliefs are dangerous. Thus, facta based information is needed. (European Commission-Enterprise and Industry 2013)

Second, the administrative requirements are often the major reason hindering entrepreneurial activities. And third, entrepreneurs need to find it easier to attract investors. (European Commission 2014)

Furthermore, considering the entrepreneurial culture and entrepreneurial development from both individual and collective perspectives visions must be developed, as Koiranen and Ruohotie (2001), Kyrö and Ripatti (2006) and Henry (2013) suggest. They state that learning entrepreneurship takes place in four paths.

The paths are:

a) About entrepreneurship, which highlights rational thinking and theory,
b) For entrepreneurship, which presses the will and skill to start one’s own business,
c) Through entrepreneurship, which supports developing of gathering and using information and moreover creating actions for starting a business and finally,
d) Acting in a real company-like environment, in which one enjoys the freedom and uncertainty and the possibilities they give and, at the same time, develops the skills of sensing possibilities and creating those possibilities and opportunities oneself.

e) The last but not the least, is the fear, which comes up from time to time when entrepreneurial activities are added into the curriculum and the hard scientific substance seems to disappear. However, these topics should be seen as complementary to each other.

Pedagogical concept of Business Academy

The cooperative or limited company form of studying is nowadays an essential part of HEIs. In Turku University of Applied Sciences at the faculty of Engineering and Business, all the business, media and some ICT students have the possibility to join or establish a company during their studies. These students own and conduct companies in which real-life assignments are implemented with local SMEs, bigger companies and other organizations in growing numbers. Especially local SMES’s are favoured partners for student-owned companies for multiple reasons. For example, their needs are typically smaller and easily manageable.

Students invest 30-50 euros in the companies; they run their firm and at the same time study towards their degree. Students study in their co-operative teams of 15 to 20 persons, doing real life projects. On the other hand, they are also obliged to run their business and take care of the paper work of the company such as establishing papers, tax notes, salary issues etc. The payments of the projects go directly to students, not to the university.

Today, we combine business and Media production students in the Business Academy concept. In the future chemical engineering as well as industrial engineering and management are joining the BA concept.

The study plan consists reading materials, group discussion, and real-life projects targeted at the curriculum competencies of a certain level as well as
personal objectives of the student. Classical lecturing can be taken as a part of the study plan but is not, however, the most important sector. Identifying and recognizing the learning in various situations, also outside the university, is a key part of studying in the company. Reflections and evaluations are made by the coach, but also by the students themselves, by clients in projects as well as by fellow students.

The Business Academy Model is presented in Figure 1.

**Figure 1. Business Academy Model**

The Business Academy Model or concept typically consists of the following nine elements:

1. **Training Sessions**
   Each team has training sessions twice a week. The contents and topics of the sessions come from the team’s own business and learning goals. Training sessions are students’ active learning by innovative methods. The planning, preparing and implementation of the sessions are the students’ responsibility. The coach supports and enhances the learning in the training sessions, in which knowledge is shared, built and deepened. The requirement level in training sessions grows as the learning progresses.

2. **Reading Circles**
   Every student prepares for the Reading Circle by choosing the topic area as well as a book that boosts both the business and the learning. The book should be red and the relevant tasks should be made before the Reading Circle meets. In the Reading Circle are the lessons learnt deeper discussed and shared. Also the personal reflections are elaborated further and a common product that summarizes and supports the learning is produced.

3. **Learning Agreement**
   The Learning Agreement crystalizes student’s prior experience, current state, goals and ways to measure the progress. The students strive to actively reach the set goals and develop themselves towards the chosen career.

4. **Project Work/Running Business**
   The student team sets up a co-operative company and develop the business according to their own plan. Knowledge and skills are put to direct and immediate action. Continuous feedback from the stakeholders help the students to learn and develop further.

5. **Markets/Customers**
   Student-teams operate in open business markets. Genuine customer contacts and co-operations with companies make it possible to apply the theories in action.

6. **Networking**
   Students have excellent opportunities to build relationships and networks with business decision-makers, stakeholders and partners during their Business Academy studies.

7. **Coach**
   The students are by their team coach supported in finding their best way to learn. The basic role of the team coach is to support the team and its individual members to learn and develop themselves, so that everyone can find their own way of learning. Hence the concept: guided self-organized learning. The team coach has the most important role in the educational program.

8. **Team**
   The team is the most important learning unit. Team-learning provides possibilities to become a versatile business expert. The team starts a company, creates its own business and is responsible for the theoretical
learning process. The coach supports and challenges the team which co-works with other teams.

9. Feedback, Evaluation and Continuous Development. Continuous feedback is a part of the Business Academy best practices. Each project and learning situation is analysed by using a four-square model. Based on the feedback and assessment the learning is summarized and adjustment of actions points and/or development ideas are agreed.

The Entrepreneurial Engineer

During the past decades engineering education has been widely criticized as the focus in the various degree programs has mostly been on theoretical studies instead of practical work. The traditional engineering curriculum is no longer sufficient to address the contemporary industry concerns for improved graduate competency. The curriculums have been fragmented and concentrated on specific subjects rather than larger entities developing holistic views, mind-set and skills enabling the students to create and realize new value for people and organizations needed in the companies. The need for improved professional skills such as critical thinking, problem solving and interpersonal skills have widely been addressed.

Business creation and business development competences are keys to the global business arena of the future. Furthermore, such competences are generally a requisite for a range of knowledge-based organisations, from large to small and medium-sized private companies, start-up companies, as well as public services. Through a combined study programme both Business Academy students and Engineering students have the opportunity to acquire tools, methods, knowledge of processes, as well as an organisational and managerial understanding of innovation and entrepreneurship that will allow the youngsters to make a difference.

The teaching in the programme is research based. This means that the lecturers are doing research within the same academic field as they are teaching. This gives the students as well as the collaborating companies the access to the latest knowledge and dedicated personnel who are passionate about their subject. The teaching material not only includes books but may also consist of, for example, current academic articles from journals.

Engineering is combined with practical hands-on activities. A large part of the company assignments for the engineers take place in various laboratories where i.e. customer product development assignments are performed. The laboratories are of the highest standard, and they play an important role in teaching. Students in the programme will work under the best laboratory conditions with access to the latest technology, which is vital for benefiting from the teaching in their future companies.

Results and Discussion

The philosophy, how future business people and engineers as well as entrepreneurs should be educated, has changed during the last decade. In addition, the idea of what kind of mind-set and skills education providers should produce and promote among young people has moved from closed classroom based learning environments to open and company like concepts.

The word development also stands for important milestones such as building new curriculums together with local companies, real company work while studying, cross- and multidisciplinary student and staff teams working together etc.

In addition, the fear that when so-called generic, soft or human skills are added to the learning curricula, the scientific hard substance of the subjects will become less important has diminished. The attitude of both staff and students in HEIs must change towards more modern, educational environment, open up the faculty and welcome a dialog with the outside world. Naturally, this will demand a clear concept, in which roles, responsibilities and goals of the stakeholders (students, academia staff and industry) are well defined. The demand for a strict model is constant but also flexibility and openness for possible new elements must be kept in mind.

Preliminary practical results among business students based on the 12 years’ experience are as follows:

- Graduation time for Business Academy students became shorter than for average business students (3.4 years compared to 4.2 years)
- Satisfaction of the student is higher than an average student (4.6 compared to 3.8, the scale 1 the lowest and 5 the highest)
- 16 certified coaches
- 32 teams graduated → 500 business professionals
- 89 % after graduation are in business life and/or acting as entrepreneurs
- 92 % of the alumni would recommend the Business Academy

These numbers have been collected from the university student databases VIRTA and the questionnaire for graduating students AVOP. Also an alumni survey was conducted.

Conclusions

Business Academy model contributes to existing academic knowledge of learning by suggesting broader connections to local companies, not only in the field of research but in implementation and prosecution of the projects. The learning concept postulated in this paper provides an additional step for development of learning environments in different fields, to enhance both substance and other skillset such as entrepreneurship.
From the more practical point of view, the case Business Academy has value for practitioners operating within education industry. The experience suggest that in the early phase of studies, here in the 2nd year, students must be put in contact with the industry. Moreover, the forming theory and practical project work can be together, not only in causal order (first the theory and then the implementation) compared to classical learning approach. Different parties can do the assessment along the learning process, also the student him/herself. There are basically two options to change learning approaches in academia and industry 1) promote the learning pedagogy as itself as a solutions or 2) change the learning environment structure combining various learning elements and put people to operate there. The second option is usually the more difficult and expensive one since academia typically resist attempts to change their opinion and behaviour in learning: the environment must be very different, not only simulating real world but to be the real world – act as an entrepreneur.

References


