WE CAN ALWAYS PRODUCE IF WE ONLY CAN SELL…” – NEED OF SALES EDUCATION FOR ENGINEERS

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Abstract

The core of engineering education lies very much on teaching our students knowledge, skills and attitudes related to conceiving, designing, implementing and operating technological solutions. Engineering students are expected to possess good skills in mathematics, physics and other disciplines belonging to the group of scientific knowledge. However engineering is a very versatile profession. There are many different kinds of work profiles where engineers are needed. It could be beneficial for all stakeholders if the scope of engineering could be broadened and the fact accepted that engineers are needed in many different professions.

Creating innovations requested in businesses all over the world calls for an innovative mind-set in our future engineers. Successful innovations need to be commercialized and this requires understanding of business principles. What is needed is proactive understanding about future possibilities and about customer’s reactions to these possibilities. All this belongs to the hearth of a discipline called selling as even the most excellent products are not any more powerful enough to sell themselves without understanding of customer journey.

This paper examines sales in engineering and presents the results of an inquiry about the needs for selling skills among heavy engineering industry. The interviewed companies are situated in south-west Finland and mostly export oriented. At the end of the paper there are some recommendations for engineering educators concerning sales education.

Keywords: Engineering, Sales, Sales engineering, Competences, Multidisciplinary education

Introduction

The sales profession has not traditionally been considered as a career the engineering students are aiming for during their studies. However many graduated engineers have found interesting positions in the field of sales. A commonly known fact is that usually the income level in sales positions is higher than in pure engineering design jobs which are more often considered belonging to the traditional core of engineering.

Selling skills are needed when bringing both new and old products to be reached by the customer. They are desperately needed after launching an innovation coming from research and development and trying to bridge the haunting “death valley” where the innovations sometimes fall.

A big deal of sales in business to business context is done by engineers who work in that profession and many times without hardly any educational background in sales. It is also known that the need for sales engineers is increasing in Europe and this could be the situation all over the world as well. The World economic forum report (2017) researched new and emerging job categories and functions that the respondents expect to become critically important to their industry by the year 2020. In the report two job types stand out due to the frequency and consistency with which they were mentioned across practically all industries and geographies: The first are data analysts and the second are specialized sales representatives. It can be foreseen that practically every industry will need to become skilled in commercializing and explaining their offerings to business or government clients and consumers.

The Academic association for sales engineering (AASE) defines sales engineers as follows: “Sales engineers sell technical products and services to companies. They consult the professional customer and suggest technically and economically feasible solutions with an added value for both the customer and their own company. They combine technical knowledge with commercial skills. They are best trained to understand the requirements of the industry.” (AASE web-site.)

The sales profession as a whole is undergoing big changes due to digitalization and other possibilities offered by the changes in the working environment. In the internet era the salesperson is not any more the only source of information to the customer. Research claims that a big part of typical purchasing decisions have been completed before contacting the selling firm or the salesperson. Adamson, Dixon and Toman (2012) say that nearly 60 percent of a typical purchasing decision has been completed before contacting the selling firm or the salesperson. Hallikainen & Laukkonen (2016) found in their research that 27% of B2B customers had used
digital services by which they mean websites, social media, mobile apps etc. during the customers’ last purchase experience with a company. As many as 18,5 % of the respondents made the purchase decision online and 15 % of these B2B customers also completed the purchase online. The conclusion here is that although the sales profession is undergoing big changes, the demand for salespeople and especially sales engineers is existing and even growing.

**Aim of the paper and methods used**

The aim of this paper is to examine the role of sales in engineering. It first handles the recent literature on the future of business to business sales context putting a special emphasis on complicated and demanding selling situations as it is more likely that sales engineers are to be found there.

The paper also presents the results of interviews conducted among heavy technologies industry companies in South-West Finland. The aim of the interviews was to paint a picture of the present state and art of sales among those companies and use the information for developing material and training needed to improve selling skills of engineers employed in them.

The research was conducted in form of deep interviews where the discussion proceeded according to a list of questions which were freely handled during the conversations. After the interviews all the discussions were transcribed and analyzed. The discussions lasted for 45 min to 1,5 hours and there was space left for the discussion to find a new direction when needed. The people interviewed belonged to the top management of the companies acting in the field of technologies industry in South-West Finland.

**The evolving sales discipline**

Since 1990’s customer value has been something business has been striving to create to their customers. Big companies have understood that rather than selling mere products they must shift their focus on facilitating the emergence of value for their customers. (Eggert & al. 2018.) The function of sales is assisting and helping the customer during the customer’s journey, which is the process of gathering information, making a decision and implementing the solution. During this journey the customer engages with the company in several touchpoints. (Alhonen & all. 2018.)

Alongside with the change in understanding also the definition of sales has been changing. Dixon and Tanner (2013) provide a revised definition for selling and state that it is “the phenomenon of human-driven interaction between and within individuals/organizations in order to bring about economic exchange within a value-creation context.” According to this definition selling is about interaction and about value creation, the task of salespeople is to help the customers to challenge their existing ways of thinking and provide them possibilities to improve their decision-making process.

The change in sales science is likely to continue at an accelerating speed in the coming years. The changes concern not only sales but also purchasing. This is mostly due to the possibilities technology is offering to the profession and the exponentially increasing demands from customers. Even today the buyers have wide access to many important facts related to their buying situation. They can check the offerings of several vendors and inspect other customers’ experiences. In general due to the accessibility and visibility of information their buying power has increased. (Wiersema 2013; Matthews & Schenk, 2018.)

Matthews and Schenk (2018) predict that in the future sales professions will require people who are comfortable working with technology. Analysing data to reach insight about the customers beyond what can be experienced or seen by eyes and ears will become an important skill. They go on by saying that the future of sales will shift from art to science. According to my understanding engineering, due to its applied nature, might be a better word when describing the next phase of sales. This gives space especially for sales engineers.

To whatever direction the development goes and regardless of the share between technical skills and emotional intelligence demanded in the future sales professions, it is likely, that the value of human connection will bring benefit to the interaction when creating and maintaining relationships and networks. (Matthews & Schenk, 2018.) On the other hand when artificial intelligence and other digital solutions will replace human beings in routine like tasks, it becomes more important to concentrate on developing skills that the machines are not (yet) capable of doing. Interaction, teamwork, independent and critical thinking as well as making judgements are such skills.

**On the concept of value**

Research agrees that value should be placed at the core of buyer – producer relationship. The value literature has evolved from a focus on resource exchange and value in exchange to an emphasis on resource integration and value in use.

According to the value in exchange concept the value is embedded in goods and services provided to the customer. Customer value is defined as “the customer’s perceived trade-off between benefits ("what you get") and sacrifices ("what you give") in marketplace relationships” (Eggert & al. 2018; Ulaga and Eggert 2006; Woodruff 1997).

The value in use concept considers the buyer as the ultimate creator of value and argues that value cannot be delivered to the customer but according to Vargo & Lusch (2011) it is “determined by the customer on the basis of value in use”. The role of the producer remains to act as the value facilitator. So value is not seen as something given to the buyer in the exchange process but instead something which is being created together by both parties in the interaction process. (Grönroos & Voima 2013; Vargo & Lusch 2011.) Finding and preparing opportunities for value co-creation together with the customer and acting as a facilitator in them is the salespeople’s’ job. The value perceived by the customer is thus dependent on the supplier’s capabilities but on
also on the customer and on other stakeholders present in the network. (Eggert 2018.)

According to Vargo and Lusch (2011) there is only one market: the actor to actor market where the actors are generically engaged in service-for-service processes. Resource integration and application are the bases for this service provision.

Focusing on customer journey

We are living at the age of the customer. Improving customer experience, e.g. what the customer experiences when being in contact with the company, by understanding their demands towards the seller, lies at the focus of the sales function. (Alhonen & all. 2018.) This means that successful companies are concentrating on understanding the customer journey and how they can produce value at every encounter with the customer. Adding value by deeply understanding customers’ business, the unique situation of the customer and the goals and desires of the customer is the main task of any salesperson. (Matthews & Schenk 2018; Alhonen & all. 2018.)

It has been shown that buyers set high demands towards the possible suppliers especially at the early stages of the decision process. From sellers they expect towards the possible suppliers especially at the early stages of the decision process. From sellers they expect collaboration and to create value. (Dixon and Tanner 2012.) Some of the touchpoints include face-to-face interaction but some occur via internet or other media where the salesperson is accessible and what is available also for the customer.

According to Grönroos and Voima (2013) interactions are “situations in which the interacting parties are involved in each other’s practices.” Interaction can take place physically, virtually or as a mental contact. The interacting parties take actions that influence the other party’s process. During the sales interaction the salesperson creates opportunities to engage with its customers’ experiences and practices. These interactions influence in the outcome and in the experiencing of customer value. As the value-in-use is created through resource interaction, it is actually shifted to a joint sphere, between the salesperson and the customer, where it becomes the responsibility of them both. Value emerges in the use situations and both the seller and the customer share the co-created value (Eggert & al 2018; Grönroos & Ravald 2011.)

In a dialogical sales interaction where the salesperson and the buyer both are active and meet at a coordinated, interactive process the salesperson has a possibility of immediately influencing the buyer’s value creation process. Both salesperson and buyer engage in a joint value creation process where they co-create value. This co-creation of value can take place during interaction only. (Grönroos & Ravald, 2011.)

Engineering companies and evolving sales

This research reveals that sales is emerging among companies within technologies industry in South-West Finland as an issue which should be paid serious attention to. The same fact seems to concern companies all over Finland. Finally we have reached a situation where salespeople and sales work seems to be valued among the companies.

Many of the comments reveal that the top management understands the value of good salespeople: “Salespeople are the most important people in the company”. One of the interviewees, an entrepreneur in heavy fabrication industry continues: “we will not need any engineers if they cannot sell our products”. Or another comment coming from a contract manufacturer: “In a service company we are exactly what we manage to sell and make.” Sales engineers are considered to be the profession “guaranteeing that we will survive” (as a company).

There seems to be a unanimous agreement that sales is not very highly honoured among engineers or the big audience in general. The traditional engineering expertise is what engineers themselves seem to honour. “If you work in sales as an engineer, you maybe don’t dare to reveal that in the family gatherings...”. Sales is considered as a challenging profession especially in the case of exports and when it is necessary to travel and engage with people from different language groups and cultures. Salespeople must constantly step out
of their comfort zone. Travelling and giving the most of yourself are not always easy or comfortable engagements. When working with international sales there are also language requirements, which do make the work more demanding.

Salespeople carry big responsibility: “the whole remaining chain depends on whether you (salesperson) manage to sell or not”. Sales determines whether the production can continue and guarantee full employment to the people in the company. Salespeople are also expected to carry their responsibility and be accessible even during their vacation: “you have to answer the phone and you should never have bad days, at least you are supposed not to show them.” However getting a deal and succeeding in sales is very rewarding: “…to myself succeeding, getting a new customer, new deal is very satisfying.”

Salespeople are also well paid. Sometimes they can be the people with the biggest income in the company: “I have experienced a situation where the country director starts asking about the people who earn more than him in the company. And it turns out that they are the best salespeople….”

When working with technical products it is important that the salespeople have a solid background in knowing about the technology: “It is not about purely selling but there has to be a deep technological understanding at the background also”. And the amount of knowledge needed concerning technology seems to be increasing. A salesperson needs to have basic knowledge about commercial law, business understanding and knowledge about cost effectiveness. A salesperson must have an ability to fix up situations and organize the puzzle as well with the customer as within the company. Deep understanding about the capabilities of the sellers’ company is also essential as the promises made must also be kept and fulfilled.

However, many of the interviewees emphasize the importance of personality and good interpersonal and communication skills. Also adaptability and good command of the situation are mentioned: “salespeople solve the problems together with the customers”, “they have to be able to communicate the added value”. Communicating and facilitating added value to the customer and with the customer, is one of the most important engagements in sales work.

Improving the customer journey

Being customer-centric is emphasized in the answers given by the interviewees. Taking the customer’s perspective and trying to understand customer needs is seen as essential in sales work: “also our designers have to understand how to produce added value to the customers”. This means that it is also seen important that not only the salespeople in the company are sales oriented. The concept of “everybody sells” seem to be the leading principle in the companies which were interviewed. “Everybody sells. Absolutely everybody. Be it the expert, administration, salespeople, or executive director. Absolutely everybody sells.” It is important to handle all touchpoints with the customer well and to their satisfaction. The chief executive officer is often the most important salesperson in the company. “It is the role of the CEO to act in the front building and opening relationships by looking at the world in the surroundings of the company making the path together with the sales force and even going in front of them.” This seems to be characteristic for all the companies interviewed, they are involved in B2B business where the financial value of each deal is big. A specially mentioned common requirement is that all the engineers must have selling skills. “The message is that all engineers need selling skills. Out of our 100 employees, 50 visit the customer surface for a shorter or for a longer period of time.” The requirement seems to be that basic engineering education should include at least some studies in business understanding and sales: “let’s educate our engineers to understand also these commercial and business issues”.

A successful customer journey seems to require characteristics like being punctual and responsive. Sales people need to be self-directed and independent; they must have a strong desire to reach results. “A good salespeople builds a better future for the customer and makes the customer feel that s/he is succeeding.” When meeting the customer sales people also have to be adaptive. “Anticipating the answers when there is no question yet. You will learn that and it will come almost automatically.” Being able to produce added value at every encounter with the customer is important. “Every time you meet the customer you must have added value to bring to the customer.” The question is also about leading the customer to a direction which is beneficial for the customer but at the same time also for the seller.

Trust is an important concept during the customer journey. “If you are dealing with 10 to 20 million business there is no change to win deals if there is no trust.” When there is trust it is easy for the customer to contact the seller during the journey in whatever matter. And this can lead to new possibilities for the seller to recognize customer needs. Open communication is needed when building trust.

Interaction in engineering sales

Interaction is stated to be at the centre of business to business sales work. All the respondents bring it up and there seems to be a general agreement that sales in general and interaction as part of it has evolved to a more demanding direction. A typical engineering company in business to business context in Finland operates also in international markets which increases the requirements concerning the content of interaction. Interaction is needed when digging for new customers but also when working with existing customers and deepening the relationship.

Good interactions skills require that the salesperson is in balance with him/herself. Good interaction skills are needed when exploring the real needs of the customer and when facilitating need recognition together with the customer. Being good with people is part of that, as one of the respondents puts it: “If you are not good with people it is quite difficult to succeed in the field. You do not succeed being cranky.”
The emergence of technology in sales work is understood. However, social media and digitalization seem not to be much used in the sales work in the companies of the interviewees. Especially the older sales people might not be aware of how to apply social media in their work. “Knowing how to use the social media. We are lacking behind.” Also the management sometimes is not eager to update themselves about the latest possibilities offered by technology. Education is needed to fill the existing cap.

Understanding about how sales work is changing due to the possibilities technology offers seems not to be very deep. It is pointed out that work done by people is expensive and that in the future it will to some extent be replaced by technology. How this is affecting sales work, is not very clear in the interviewed companies. “Digitalization has influenced and it will influence our whole existence. Video negotiations, transparency in the whole chain will increase. The final user will see, right from the beginning, how the product is being made.”

Results and Discussion

The role of sales as an important function also in engineering companies seems to be understood. This has not always been the case as earlier it was a widely accepted belief that there is something wrong with a product if strong promotion is needed. No sales function was considered important as “good products will always sell themselves.” Now the understanding seems to be that all employees must adopt a customer-centric approach in their work.

The results show that the role of sales producing value to the customers is well understood among the companies. However, the answers reflect that in many companies the value is still understood as embedded in the product or service. Having this perspective the salesperson is seen as the creator of value whose job is to understand, communicate and deliver value to the customer.

When moving to the “value in use” ideology the companies should rethink the process how value emerges. According to that approach value cannot be delivered to the customer. Salesperson and customer are together in a process where the salesperson is facilitating the value creation process of the customer. Adopting this kind of deeper understanding about the processes of the customer might require some training of the sales force. This would call for resources invested in training but on the other hand, the results could turn out to supersede the money and time invested.

“Everybody sells” seems to be the leading principle in the companies. All the employees must understand the value of the customer and their own role in facilitating the customer journey. Paying attention to this is likely to improve the performance of the companies in relation to customer satisfaction and this way lead to improved financial results as well.

Learning something about selling should form part of every engineer’s education as engineers are the ones who act as salespeople in the domestic as well as in the international market. This is the case specially in the field of technologies industry. In South-West Finland succeeding in this industry is essentially important as the biggest part of exports is gained through the products of this field of industry.

When planning the curricula, the engineering educators should keep in mind that sales job is a possible alternative to the engineering students as well.

Conclusions

The aim of this paper was to examine sales in engineering and present the results of an inquiry about the needs for selling skills among heavy and export-oriented engineering industry in South-West Finland.

The results show that sales is valued and seen important in this industry. Comments like “we can always produce if we only can sell” or “salespeople are the most important people in our company” reflect that the importance of sales is understood as essential for the success of the enterprises. There is a clearly indicated need to include at least some sales-related studies in the curricula of our future engineers. As well, there seems to be space for a special sales engineers’ profession. Sales engineers are specially educated to have both technological knowledge, commercial background needed and selling skills to handle the complex sales situations. In addition to the up-todate knowledge and skills it is important that these engineers have a real sales spirit, a right attitude to succeed in the demanding encounters with customers.

When thinking about the actual selling skills, interaction is seen as forming the core of sales work. Listening to the customer to understand his/her situation and having good knowledge about salesperson’s own company and product form the base for successful saleswork. Acting as a value creator is understood belonging to the core of sales work. Putting emphasis on educating the salespeople to become value facilitators instead of being value creators could help the companies to deepen their relationships with their customers.

New technologies, and especially different digital solutions and social media providing solutions to meet the customer on line during his/her journey before actually getting in physical connection, are not used to their full extent. There seems to be several unused possibilities to help the salespeople in their work. Education should be directed to the companies so that they would start using the possibilities available.

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ENHANCING THE REGIONAL INNOVATION SYSTEM: MULTI-DISCIPLINARY EDUCATION & RESEARCH COLLABORATION NEEDED BY BUSINESSES

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Abstract

The objective of this paper is to show how technological collaboration among industry, academia, and government can be enhanced in order to achieve better actual success in the business world. I suggest a model, based on my research into advanced case examples from a Danish Industrial PhD Program (I-PhD). Even in rural areas, efforts to enhance regional economic development have been made by seeking "Technology development ~ Commercialization, Business establishment, and then Industrialization" through cooperative activities between companies and academia. Currently, these results are not seen in conventional technological collaborations of industry, academia, and government, although the numbers of collaborative research cases and patent applications have increased. In order to overcome this situation, there is a need for a new collaborative approach that can produce better results from the viewpoint of social implementation.

Keywords: Multi-disciplinary education and research design, Industry exposure, Innovation, Technology Collaboration

1. Introduction

As a means of endogenous economic development, regional output from a functioning regional innovation system is desirable and important for growth. A regional innovation system is one where regional industry-academia-government technological collaboration creates a process of "Technology development ~ Commercialization, Business establishment, and then Industrialization," which function autonomously. The good news is that the numbers of collaborative research and patent applications have increased recently from the viewpoint of social implementation (e.g., Kiyoshi 2013a). However, we have not seen results that build toward the autonomous functioning of "Technology development ~ Commercialization, Business establishment, and then Industrialization." To overcome this situation, I believe there is a way to collaborate that can produce better results. The aim of this paper is to show how we can utilize cooperative educational collaboration across industry and academia to promote effective technological results. I believe that it is necessary to support industry-academia-government technological collaboration in the form of a kind of social network of cooperation across industry and academia, namely, "Collaboration, Co-creation → Fostering trust.”

My research identifies a mechanism related to the mobilization of industry, academia, and government technological collaboration, specifically for small and medium size firms in rural areas. The research, as a practice case study, also aims to identify how we can revitalize regional industries through the “creation of a mechanism that drives innovation” within a regional system so that "high value-added co-creation” can be achieved. Today, various local communities are impacted by the effects of globalization. Thus, creating a globally competitive regional innovation system is an urgent task for local areas. This task is seen as extremely significant. To achieve such a competitive advantage in the region: new technologies need to be developed; various industry-academia-government collaborations need to occur; local public policies need to be established; and firm business and social performance need to be managed; among other efforts. To this end, institutional and human capital have to be accumulated that can utilize regional resources through organic development. Therefore, the field of economic sociology, I believe this research has academic significance for system research in regional economic sociology.

2. Background: Regional activities and research

In Japan, by issuing various policies, the revitalization of technological collaboration of industry-academia-government has been promoted mainly by the Ministry of Education, Culture, Science and Technology through its Policy Industry Collaboration and Regional Support Division and its University Technology Transfer Promotion Office.

I believe that the aim of these policies has been the creation of a unique regional innovation system through the creation of intellectual clusters. However, except in some excellent individual cases, the formal structure of these clusters has been emphasized ahead of
collaboration as the aim. In many cases, there is not substantial cooperation leading to "Technology development ~ Commercialization, Business establishment, and then Industrialization," which should be the aim.

The theoretical background underlying such policy development is derived from the regional competitive advantage in Porter's (1990) strategic theory and his widely known "Diamond model." Subsequently, in the regional system referenced by Saxenian (1994), the existence of a social network where competition and cooperation coexist was highlighted. In social exchanges in a community, informal information, mutual learning, and transfer of tacit knowledge are naturally shared, building the transition to a knowledge-based society.

Cook et al.'s study (1997) is a well-known reference to a regional innovation system. This regional innovation system refers to technology transfer and commercialization from universities. The cooperative interaction of credit and trust is a social process and creates feedback for the innovation process as knowledge development. In addition, there is Etsukowitz's Triple Helix (2008), which models industry-academia technological collaboration. On the other hand, Florida developed the regional theory where innovation is an area of learning caused by knowledge creation.

3. Methodology

Here, I refer to human capital and assume that the key to regional economic growth is strong contribution from highly educated and highly productive human resources. The relatively new concept of "creative capital" is comprised of scientists, and artists, among others, who "create some meaningful new form." The existence and attraction of these creators are important for regional economic growth (Florida, 2005). This research focuses on the realm of "cooperative realization" among small and medium sized firms and academia. To achieve the aim of my research, I investigated overseas cases that had achieved distinctive innovations. In truth, this task itself is not completely novel, as there are cases that have been conducted on the strategic utilization of coordinator talent and the university research administrator (URA). However, it seems there is a need for an approach from a completely different viewpoint that considers the current situation, namely, there is an inherent problem such as the existence of no real cooperation, as mentioned above.

In other words, I hypothesize that we need to "foster social capital for better collaboration" in our knowledge-based society rather than pursue the traditional idea of seeking an ideal match among the related parties. Thus, I believe the Danish Industrial PhD Program can provide support for this hypothesis. I-PhD is a doctorate degree acquisition program produced by an industry-academia-government project-based collaboration in Denmark. It is a practical doctoral degree in line with the industry perspective and actual corporate projects and includes a mechanism of industry-academia-government collaboration involving the creation of actual innovation.

4. Current Technological Collaboration Process

1: Even though it is collaborative research, industry-academia-government technological collaborative activities are mainstreamed in the transfer of science and technology, going from development at the university and moving to the private sector (of course, there are cases where research starts with technology brought in from the company side); however, it is commonly one-way traffic. 2: The promotion of technology collaboration is a partnership with companies, aiming at "Technology development ~ Commercialization, Business establishment, and then Industrialization." The basis of the partnership is the logic of the market economy with each partner in a different position. 3: In the case of the technology itself, it is difficult to adapt qualitative and qualitative data into a linear, rational promotion method based on evidence of the causation by induction.

Here, I look to improve on the cooperative process. However, this is difficult to achieve in technological collaboration between industry and academia.

5. Use Case

5.1 The Industrial PhD Program

The I-PhD is a doctorate program where the degree is attained through industry-academia-government collaboration. Over three years, in a project environment, the participating human resources (students) are developed as they conduct fundamental and applied research from viewpoints based on industrial needs under the public assistance from the government. As a result, the accumulation of human capital is achieved together with contributions to the community through the business of the companies involved; this then becomes profitable activity. In fact, the outcome is a regional embedded innovation system that creates economic value for local communities.

In Denmark, under the Ministry of Science, Innovation and Higher Education, which is the jurisdiction agency concerned, the program is implemented through Innovation Fund Denmark (InnovationsFonden), which invests in new knowledge and technology creating growth and employment in Denmark and through a direct organization, the Danish Agency for Science, Technology and Innovation (DASTI). Although it is a program that provides doctoral education, from the perspective of the organizations concerned, it has an extremely strong orientation towards industrial development.

The program system was first introduced in 1971 at the Technical University of Denmark and at the Academy of Technical Science as a "two-year program" for the education of an "industrial researcher." The doctoral degree was added in 1988 and, in 2002, under the jurisdiction of the Ministry of Higher Education, the field of academic education expanded dramatically. The I-PhD program is regulated by Danish educational laws and other regulations and must be in compliance with
ordinary PhD degree rules. Therefore, when a degree is awarded, it is an ordinary doctoral degree, but at the same time, Innovation Fonden issues a certificate for the I-PhD. The I-PhD proceeds in the form established by DASTI, which applies for the enterprise projects. At the time of the application, candidates are selected as employees to continue in the future; three people, including the doctoral candidates and professors, work together, and the project schema is planned.

Once a project is accepted, the doctoral students become full-time employees of the companies, while at the same time, they remain as doctoral students of the universities where they collaborate. Their jobs at the companies are as registered doctoral students at the university where, for three years, they conduct research that focuses on the industrial side.

5.2 Utility of a Multi-Disciplinary Education

The utility of the I-PhD program is as shown in Chart 1. The number of patents applied for and the amount of each firm’s profit rose under I-PhD program participation.

6. Results and Discussion

6.1 Collaborative Governance in Theory and Practice

From these survey, it became clear that I-PhD is a strong cooperative model, especially for small and medium sized firms that can take advantage of the characteristics of the program. For comparison, I followed a previous academic theory developed by Ansell and Gash (2008), which I used as a theoretical framework to verify that the actual human interaction in the I-PhD program was effective [Chart 2]. The theory shows the utility of educational collaboration.

Looking at the five dimensions in Chart 2, "① Starting Condition," "② Institutional Design," "③ Collaborative Process," "④ Facilitative Leadership," and "⑤ Outcomes," it can be said that the collaborative activities act to foster mutual, positive relationships. In promoting the project, they establish a "commitment to the collaborative process" by confirming mutual dependence and motivation for pursuit of mutual benefit. Moreover, during the collaboration, they clarify the mission and tasks to create a "common understanding," which is important to accomplish. The collaboration generates "intermediate results" by accumulating small accomplishments throughout the process such as finding new facts and formulating future plans. By faithfully negotiating "face to face dialog," they establish "trust building," which leads to positive "⑤ Outcomes." Even in the cooperative process of this case, by formalizing the process of human resource development through dialog, it can be said that small results are visualized and trust developed.

From collaboration with industry in this case, there is a new discovery, which is "④ Facilitative Leadership" that is outside the "③ Collaborative Process." As a matter of fact, it is important to ask the industry members to actively commit to the project.

6.2 Academic Theory of Dialog in Collaboration

If we consider the autonomous functioning of the actual work flow through collaboration, we can express it as "Sharing→ Co-creation → Fostering trust." Thus, it can be said as well that this is a line of effort for the realization of the positive relationship between industry and academia, building a nondeterministic theoretical structure as collaboration secures freedom and is independent of causality. This can be explained by the logic of the “SECI” model (Nonaka, Takeuchi (1995)). The model shows "Socialization," "Externalization," "Combination," and "Internalization" creating new knowledge.

When building mutual relationships, first, "Socialization" is formed through empathy where future experiences are shared. This is the creation of further tacit knowledge through the sharing of tacit knowledge. It can be said that this is the process of sharing through the empathy of knowledge. This is the awareness and understanding of mutual human resource development (education).

In the actual collaboration of industry and academia, the following occurs: 1) Select and confirm collaborating consultants and establish regular meetings; 2) Confirm the significance of human resource development for industry and academia; 3) Confirm the collaborative problems and clarify the path to the solutions, which represents collaboration with sharing and empathy, as described above.

The next step is to "Externalize" the tacit knowledge that is shared through the construction of a program design to make tacit knowledge explicit knowledge. After externalization, the parties deepen their mutual understanding and clarify the concepts through dialog. Furthermore, it becomes necessary to
formalize the knowledge so it becomes more substantial. This act is deemed as the "Combination," which is the collaborative work that identifies the details of the human resource development program. Here, the question is: What should the curriculum be that embodies the training goal? Moreover, what talent should an appropriate supervising teacher have and who is responsible for this? Further, how are industry members involved? The answers will lead to the creative realization of human resource development. In addition, these processes are driven by dialog. Through such processes, it can be said that the relationship between industry and academia is realized through collaboration ("Collaboration, Co-creation → Fostering trust"). Taking time into consideration, this relationship is fostered through the interactions of dialog and practice, which is repeated through past, present, and future collaboration.

The collaboration of industry and academia needs to be supported in the form of a kind of social network that occurs, where "Sharing, Co-creation → Fostering trust" is likely to take place; a lack of these characteristics makes the realization of the collaborative process difficult in industry-academia collaboration. A flow line returning between the science community (academic research/universities, etc.) and real society (industrial society/enterprises, etc.) is necessary to achieve a regional innovation system of industry-academia-government collaboration where the framework of "Technology development ~ Product development, Business establishment and then Industrialization" functions autonomously. This flow aims at knowledge creation through collaborative activities starting with the recognition of problems in industrial society at the early stage of industry-academia-government collaboration moving to the creation of concrete results in the final stage (social implementation, etc.).

Therefore, in summary, industry-academia-government technological collaboration needs to be supported in the form of a kind of social network in order to realize substantial collaboration for "Technology development ~ Commercialization, Business establishment and then Industrialization," which should be aimed at "Collaboration, Co-creation → Fostering trust" [Chart 3].

7. Conclusion

In conclusion, the I-PhD program can be regarded as a so-called trans-disciplinary educational activity and also "Super-interdisciplinary," which means creating new results from different viewpoints and ideas through collaboration with multiple academic fields (beyond one single specific field) [Chart 4].

In industry-academia technological collaboration, the research is often framed against the backdrop of specific academic fields. However, "Super-interdisciplinary education" as a prerequisite for collaborative research, as well as "Super-interdisciplinary" in its original meaning, as described, can demonstrate the collaborative activities that mediate education to build mutual relationships.

Such industry-academia educational collaboration can lead to the creation of a social network by utilizing and promoting existing alliances such as "university consortiums in the region" already established in many areas in Japan. I believe this type of effort can lead to the realization of a regional innovation system, a system of industry, academia, and technological collaboration, which utilizes "Sharing, Co-creation → Fostering trust" as the basis of a successful regional system.

Acknowledgments

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DESIGN OF A MULTI-DISCIPLINARY FRAMEWORK FOR IMPROVING GENERIC SKILLS AND PRACTICAL EDUCATION IN A DEPOPULATED MOUNTAINOUS AREA

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Abstract

Not only domain-specific knowledge but also versatile abilities are required for leading engineers of recent technologies. Especially, it is pointed out that community education with industry-academia collaboration is of benefit to developing talents who contribute to region and industry. At the same time, since many industrial developments have been achieved in relatively limited regions, the decline of rural areas is problematic in many countries. National Institute of Technology Toyota College (NITTC) has launched the “Dormitory + town = Dormitown” project to improve students’ generic skills and to contribute to a revitalization of a local community. The project features a multi-disciplinary collaboration of NITTC faculty members in different research area: Economic geography, urban planning, concrete engineering, condensed-matter physics, English education, and material science. All activities in the project are carried out in a depopulated area in Toyota city where some regional innovation has been highly desired, for which the faculty members take advantage of their expertise, and the students are encouraged to plan and carry out volunteer activities. In this paper, we study how the project is effective to develop the students’ skills. As a concrete example, we introduce one of the project events in this year, “Workshop of making miniature concrete ship” for younger children, and examine how students who organized the event acquired practical and generic skills through this project.

Keywords: Multi-disciplinary collaboration, generic skills, practical education, community education, regional revitalization

Introduction

In modern society where science and technology have been highly developed and segmentalized, possibilities of innovations are often found on boundaries between different fields. Therefore, it is desirable for young students to learn and experience various things which stimulate broad interests in a wide range of fields beyond their own major subjects. One may consider that such knowledge or experiences are readily available in the modern internet society. However, it is the case only when we already know what we want to know; the information technology is not very useful when we do not even know a “search word”. Furthermore, real communications and collaborations with other people are indispensable to develop a multi-disciplinary perspective. Thus, it is desirable for colleges to perform cross-cutting educational programs.

However, in practice, it is difficult to assemble such a multi-disciplinary education program as a part of regular classes, mainly because of time limitation: In recent years, every research field is highly advanced and segmented, and thereby curriculums in all department are fully occupied (Sato, 2018). In fact, in National Institute of Technology Toyota College (NITTC), most of the faculty members are too busy with their regular duties to have cross-disciplinary collaboration and/or cooperation, which would be otherwise expected especially in the colleges of technology. The lack of cross-disciplinary activities also affects education; students tend to have rather narrow perspectives limited to their own major subjects (Muroga, 2017). To resolve such an issue, a new framework for multi-disciplinary education is highly desired.

To establish the multi-disciplinary new framework, we adopted the two educational strategies. The first one is the project-based learning (PBL) which has many advantages in the practical education. Especially, we focus on the fact that understanding progresses in stages as in the order of “learning”, “using”, and “teaching”. 
The practical education is also effective for developing generic skills, such as problem-solving skills and communication skills, required for leading engineers. In addition to the practical skills, PBL is expected to increase student's spontaneity.

The second factor is the community education. Most industries are concentrated in city areas, and the rural areas such as inter-mountainous area have been depopulated and declining. In accordance with globalization and depopulation of the society, various problems in the mountainous areas such as the decline in agriculture and forestry industry are extremely crucial. As a means of solving these problems, it is helpful to locate schools and social educational facilities as the core of the local community, which contributes to the promotion of the region and to reinforce the autonomous community. Through the activities serving to the revitalization of the local community, the students can spontaneously acquire the generic skills. Indeed, it has been pointed out that community education with an industry-academia partnership has a considerable potential to develop promising human resources.

Based on the above points, we launched the “Dormitown” project. It started from the town development plan “NITTC Dormitown” that students and one of the authors proposed in a contest in 2014. In this contest, we made a proposal to make use of human educations at “Dormitory” in student autonomy, which is one of the characteristics of NITTC, leading to the development of a “Town” in the inter-mountainous area. The project name “Dormitown” was named by students as a slogan connecting these above two elements (Tanaka, 2017). When we planned to implement this project in 2015 under the aid from the administration, we have included the third element of “Multi-disciplinary education” from the above idea. The Dormitown project is a framework of educational activities with multiple objects, where we support PBL activities in the inter-mountainous area conducted by students in the cooperation of teachers of different branches. In this paper, we describe the assembly and actual activities of this project and discuss its educational effect.

Materials and Methods

In the following, we summarize our purpose and implemental method of the Dormitown project.

1. **PBL education under multidisciplinary collaboration.** The project provides a framework for the implementation of workshops and summer schools for elementary school students organized by the students in different majors as multidisciplinary collaborative education. This is carried out as student-centered free activity outside lectures, curriculums, and club activities. This workshop aims at promoting understanding by teaching specialized contents to participating children and students in different majors and nurturing communication skills and leadership through the management of the event. Furthermore, students can touch various expert knowledge by participating in the operation of the workshops planned by students from different departments.

<table>
<thead>
<tr>
<th>Faculty (core)</th>
<th>Faculty (support)</th>
<th>Students (core)</th>
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</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>2015</td>
<td>2018</td>
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<td>2</td>
<td>4</td>
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</table>

Faculty members from different departments organize this framework. They provide their own expert knowledge to the students and educate students in other departments for workshops as necessary. The specialized areas of the current leading faculty members are as follows: economic geography, urban planning, concrete engineering, physics, English education, and superconducting engineering (see also Table 1). Depending on the content of the workshop, other faculties also participate and teach the students. The details of specific implementation are described in the following section.

2. **PBL in Community education.** All workshops of this project are held in the mountainous area. Continuous participation of students in the depopulated areas for the workshops stimulates the community and, in turn, naturally brings students’ attention to the local problems. This enables us to help students to notice regional problems such as depopulation and difficulties in agriculture in such area and to try to find solutions for them. In this way, we also aim for students to acquire the ability to utilize their knowledge and techniques practically.

Toyota city is a suitable location for such community education, because prosperous industrial areas represented by celebrated Toyota Motor Corporation and depopulated inter-mountainous area coexist. In the Dormitown project, we chose Sasado town in Toyota city as the main activity place. This town is one of the mountain villages located about one hour from the center of Toyota city. In the past, a tourism industry of hot spring was flourishing there. However, due to the shrinking public works and the diversification of travel, the number of hotels in Sasado city has decreased from 8 in the 1990s to 3. This is accompanied by population decline and aging population, which makes it difficult to maintain the agriculture. It is necessary for educational research institutes to work together on such issues in their own regions.
Table 1 shows the organizations of the faculty members and students of the Dormitown project by department. The number of support faculty is counted only for faculties who have actively participated in the Dormitown events and does not include faculties whom the students asked for professional advice to carry out the workshops. The numbers of students are also counted only for the core staff. Although participation in the project is not mandatory, at least for the students, personnel composition can cover most departments.

We pick up several examples from the workshops and collaborative research that the Dormitown project has done so far, and summarize them in Table 2. Except for the collaborative research with a laboratory like “Guardian of the Field“ in Table 2, all workshops are driven by the faculty and students of a specific department. However, management of the workshops and explanation of the procedure of the work for children are also handled by students from all other departments. On that account, before the workshop, participating students take a lecture on the subject matter of the workshop from members of the leading department. Therefore, students in the leading department can deepen their expertise practically by organizing their workshop and teaching on children and students of other departments. On the other hand, students in other departments can learn new knowledge outside their major by taking a lecture from the project members and giving it to children.

In this paper, we describe this educational process in detail of the most recent workshop “Making a Miniature Concrete Ship“ as an example. This workshop was organized by one of the students in the department of Civil Engineering, and he proposed to create a concrete ship under the guidance of a faculty specializing in concrete engineering in his department. They conducted experiments several times to determine the formulation

<table>
<thead>
<tr>
<th>Workshop/Research</th>
<th>Year</th>
<th>Leading department</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Guardian of the Field”</td>
<td>2016</td>
<td>I</td>
<td>Development of notification device for vermin control (collaboration with Hirano Laboratory in NITTC)</td>
</tr>
<tr>
<td>“Creating an Air Plane”</td>
<td>2016</td>
<td>M</td>
<td>Making a small air plane of wood and paper and study of the mechanism of lift and flight direction</td>
</tr>
<tr>
<td>“Programming with the Microcomputer IchigoJam”</td>
<td>2016</td>
<td>I</td>
<td>Workshop on computer programming with microcomputer</td>
</tr>
<tr>
<td>“Building an Electromagnetic Train”</td>
<td>2017</td>
<td>E</td>
<td>Making a small electromagnetic train with coil and dry cell</td>
</tr>
<tr>
<td>“Making a Corrugated Chair”</td>
<td>2017</td>
<td>A</td>
<td>Strength design of structures by the making a corrugated chair (one of events in summer school)</td>
</tr>
<tr>
<td>“Get Creature in the Water!”</td>
<td>2017</td>
<td>C and E</td>
<td>Observation of aquatic organisms in rivers of Sasado Town</td>
</tr>
<tr>
<td>“Making a Miniature Concrete Ship”</td>
<td>2018</td>
<td>C</td>
<td>Making miniature concrete ship and buoyancy experiment</td>
</tr>
</tbody>
</table>

Results and Discussion

Table 1 shows the organizations of the faculty members and students of the Dormitown project by department. The number of support faculty is counted only for faculties who have actively participated in the Dormitown events and does not include faculties whom the students asked for professional advice to carry out the workshops. The numbers of students are also counted only for the core staff. Although participation in the project is not mandatory, at least for the students, personnel composition can cover most departments.

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Figure 1: (a) Preparatory experiment by the faculty and students of the department of Civil Engineering. (b) Lecture on concrete working to students of other departments by the student of the leading department. After this lecture, experiment for the concrete ship was carried out in the laboratory. (c) Student doing instruction for children at the workshop.
of concrete and the shape of the ship (Fig.1(a)). At the same time, they made easy explanatory materials so that children could understand the principle of the concrete ship, with advice from the faculty of physics regarding buoyancy. After these preparations, they gave a lecture to other students going to participate in the workshop (Fig.1(b)). The students consist of one from the Mechanical Engineering, five from Electrical and Electronic Engineering, three of Information and Computer Engineering, nine of Civil Engineering, and one from Architecture. Based on the knowledge they learned there, they instructed the children to manufacture concrete and create a ship from it at the workshop.

In this way, students in multiple departments collaborate to plan and manage workshops for children, so that they can acquire 1) sharing of expert knowledge, 2) leadership, and 3) presentation and communication skills. At the same time, in this Dormitown project, the effect of regional revitalization by continuing the activity in Sasado town is also recognized, as reported by Sato (2017).

Conclusions

In this paper, we introduced the Dormitown project in NITTC, which has launched to improve student’s multidisciplinary knowledge and generic skills, and also to contribute to the revitalization of a local community. The project is organized by faculty members from different research areas. All activities in the project are carried out in Sasado Town, which is one of depopulated areas in Toyota city, to contribute to revitalization of the local community. In this project, student plan and manage workshops for children in collaboration with other departments, and share their specific knowledge. In this way, it is indicated that they acquire not only the new knowledge of other major but also leadership and communication skills. We expect that this framework of the project can be widely effective for nurturing talents who contribute to region and industry.

Acknowledgements

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References


SIMILARITIES AND DIFFERENCES BETWEEN THE HIROSHIMA AND THE GUANAJUATO TUTORSHIP SYSTEMS

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Abstract

It’s hard to find a co-presented paper between two professors of different nationalities at ISATE. Therefore, we consider that this text can be very enriching for anyone who read it. The purpose of this writing is to compare the Hiroshima and the Guanajuato tutorship systems in a broad spectrum, including the role of a tutor, the topics touched during a tutorship session, the students’ channeling toward other departments, the number of students assigned to each tutor, the amount of time devoted to each group, the digital platform used to register the tutorship sessions and the impact that our role as a tutor has had on our students’ human and academic performance. The focus of our research was qualitative, the research type was case study, the sample selection was theoretical, the data gathering was simple observation and the data processing and analysis was comparative. We are pleased to share the results that our contrast could reach at the end of our research. In the results section we show each one of the aspects that were analysed, discussed and compared. Every feature of the tutorship that we mentioned before was reviewed and the whole tutorship process in both contexts could be understood. The conclusions section was significant for our study since at the beginning we had assumed that the outcomes would show that our tutorship systems were very different to each other, but at the end we were shocked to find out how similar they can be, both, broadly in the entire tutorship process and particularly in the impact of our work as tutors on the students’ development. Also, we could learn from what the other professor was doing to improve the tutorship system in our own University. We are very proud to recommend not only to get the chance to know tutorship systems in foreign countries, but also to co-create a presentation with someone from a totally different background, which will give you a fresh perspective on any issue. Discussion of similarities and differences will give you some unique educational insights from different cultural perspectives.

Keywords: Tutorship, Japan, Mexico, Hiroshima, Guanajuato, cultural differences

1. What are the Purposes of this Paper?

This paper is focusing on the comparison of the tutorship systems between Hiroshima and Guanajuato in a broad spectrum. The role of a tutor itself, for example, varies according to the educational stages. This paper especially focuses on cases in a high school and a college. During a tutorship session, the students’ channeling toward other departments, the number of students assigned to each tutor, the amount of time devoted to each group, the digital platform used to register the tutorship sessions and the impact that our role as a tutor has had on our students’ human and academic performance. Comparing the two different cross-cultural cases, the similarities and differences are to be clarified, which will suggest some unique educational insights from different cultural perspectives.

2. Real Case in Hiroshima, Japan

In Hiroshima, the tutors, class teachers, home room teachers, are responsible for home rooms and in charge of many different tasks for the general daily curriculum of education, while they teach their own specialized subjects.

In Japanese schools, there are so-called a home room which forms a greater part of students’ lives, with home room teachers acting as a substitute parent in many ways. Students usually have the same home room teacher and fellow students during their entire life at a given school. Students are expected to take on tasks for their home room, including cleaning, day duty (note-taking and classroom organization), and the organization of competitive events between home room classes. Students also often eat lunch in their home room. Since teachers must usually travel to the students’ home room, rather than students going to a classroom dedicated to a particular subject, the depth of lessons often suffers. Teachers must carry all materials needed for multiple classes, therefore the lessons usually end up taking on a lecture style with students simply taking notes in preparation for testing.
In high schools in Japan, they have a short homeroom time for 10 min every morning and after school every day. The morning homeroom means checking a daily schedule and students’ health, while the after school homeroom means giving information for the next day and cleaning. Two students are usually allocated on weekly duty: cleaning the blackboard after every class, writing daily journals to hand in to their homeroom teacher, checking homeroom cleaning, and getting information for their class if any.

They have two parent-meetings and individual talks a year. The PTA, Parent-Teacher Association, is organized and the PTA meetings are held several times a year. The parents who are appointed to the board have another executive meetings and even drinking party with the principal and the teachers in the evening. They tend to have a very intimate relationship and commit the school organization.

When a problem or trouble among students comes up such as bullying, the homeroom teacher immediately investigates the case and reports the case to the related parents and the teachers in higher ranks or responsibilities.

In college, the tutors’ role is not as strong as the ones in high school comparatively. They have a parent-meeting and individual talk once a year. They don’t have any morning or after school homeroom. Once a week they have a period of LHR, Long Home Room, where the homeroom teacher or the student affairs department in college can make some events for the class.

They have some points in common between high schools and colleges. In an emergency, the homeroom teacher has responsibility to take care of the students and report it afterward. They have to encourage the students to get a better grade in order not to drop out and give them advice. They guide the students in the choice of a career or further education in universities. They write recommendation forms if necessary. They have the closest roles to the students to consult with.

3. Real Case in Guanajuato, Mexico

In Guanajuato, an adviser is not the same as a tutor. Both of them are professors that also play the role of an adviser or of a tutor. An adviser provides students extra help to understand topics of the subject taught by that same professor, that couldn’t be completely understood by the student or students. A tutor talks to students individually of in group about their academic performance to make sure those students who haven’t been able to approve all of their subjects have a plan to become regular students. This text is devoted to describing the role of the professor as a tutor.

The University of Guanajuato has training at different levels, from high school, up to postdoctoral degree. Particularly in high school, there are no special spaces to provide students with a tutorship session. It takes place at a regular classroom, which has been previously reserved by the tutor.

During a group session, the students’ on-line file is consulted and students are asked for their plan to pass the subjects that they have failed. If needed, students are sent to receive help from people different than the tutor. If students have doubts on specific topics, they are sent to get advice on those topics from the professor that teaches them a particular subject or with any other professor that teaches that subject. During a group session students help each other too, by telling each other which professor to choose and his/her schedule. The Salamanca school, for example, has an academic advice program that collects all the information about advisers, the subject they teach, their agenda and where to find them. Besides the advice given by professors, some students are advisers too. Adviser-students are brilliant at certain topics and have a natural gift to teach. During a tutorship group session, students frequently tell each other about other students who are outstanding at certain subjects. At the Salamanca high school, some of the adviser-students do their social service by teaching their partners the subject they’re good at. This activity is called PANDEMIA (Students panel with the mission of advising).

During an individual session the tutor talks informally to students or to the students’ parents. If the tutor finds out that students have a problem, not concerning a topic understanding, he/she sends them to the psycho-pedagogic department, where students get
specialized advice to fix any personal or familiar issue that isn’t allowing them to have a regular academic performance. Other services provided by this department is delivering information on learning and studying techniques, as well as applying tests to help students choose their career. If the tutor realizes through the talk that students aren’t eating enough, or notices that they have won or lost some weight, they are sent to the nutritionist, so they can get advice on a healthy diet, exercise, or even get psychological help too. Students have sports facilities and sport clubs at every school and campus. These services are free for the students. Also, students who can’t afford enough food to eat can ask for a scholarship at the beginning of each semester.

The number of students assigned to each tutor at the high school level in Guanajuato is around 90, three groups of 30 students. Some schools of Guanajuato assign the same tutor for the whole 3-year high school program and some other assign a different tutor every year. The amount of time devoted to each group must be at least of an hour per week, this means it is common for a tutor to spend 3 hours per week talking to their students about their grades; their family and friends; and their feeding and exercise habits.

Also, there is a meeting with the students’ parents per semester, in which the grades of every student are shown to his/her parents. Some other information is provided too, such as the calendar of regular exams and extraordinary exams (at Guanajuato university students have two extra opportunities to approve the subjects that they have failed), so they can make sure their sons and daughters are getting academic advice if it’s needed. Specifically, at Salamanca high school, during the parents’ meeting, the tutor delivers the schedule of academic advice program. It is important to mention that in Mexico, people who turn 18 years old are considered adults, so it isn’t mandatory for students over that age to take their parent to the school meetings. Also, the grades of students over 18 can’t be shown to their parents, unless students give their permission to do so. Independently of the students’ age, parents can approach the tutor anytime to discuss about social or family issues that can be affecting the students’ development, so the tutor can channel them, if they agree, to the psycho-pedagogic department or to the nutritionist.

At Guanajuato university, the presence of the tutor in college is not as strong as in high school, but it remains an important figure, specially to help students find strategies to approve the subjects that they have failed, such as looking for academic advice and being aware of the exams schedule. In both, college and high school, every session with a tutor is registered on a digital platform, which is called SIIA (Administrative Information Integral System). This platform was the first of its kind in Mexico and in the last years, universities from other states have launched their own tutorship platforms. All the information of every student (photography, name, address, telephone number, e-mail and academic record) is loaded there and is only available for the student and his/her tutor.

4. Comparison between two Cases
Hiroshima and Guanajuato universities have a very outstanding common trait, their interest in making sure students are having a proper academic and personal performance. Tutors from both institutions do big efforts to achieve this. This is something positive we have in common.

An important opportunity area that we share is that the tutor must meet students in different spaces, which makes it hard for him/her to carry what he/she needs to accomplish a successful meeting with students. This is something negative we have in common.

A significant difference between both universities is that in Guanajuato high schools each group stays for the whole academic day in one classroom, while in college students move from one classroom to another depending on their schedule. In Mexico we are not familiar with the idea of a homeroom and it is usually forbidden to eat inside of the classrooms. Also, even if high school students spend a long time in one classroom, they are not made responsible for cleaning it. It would be a good idea to implement that. This is something Guanajuato can learn from Hiroshima.

5. Future Prospects and Conclusions
Tutorship programs around the world are very different and similar at the same time, but also perfectible. Comparing both programs allowed us to realize that, within a tutorship setting, there are certain activities that don’t even exist elsewhere, like the tutorship digital platform used in Guanajuato or the home rooms in Hiroshima, and some others that are almost the same, such as the parents meetings.

We would very much recommend professors from different countries to present works in association about other educational features since it can be a very enriching experience for everyone. This could be the beginning of new international collaboration activities. For instance, it would be very interesting to coordinate an international agreement that could allow tutors from two or more universities to do short stays, in which they could observe the other country’s tutorship program. This experience could have as its main advantage that professors could learn from what the other country is doing and propose it to be applied in his/her school or faculty.

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PROFESSIONAL LEARNING FOR INTERNET OF THINGS (IOT) : A MULTI-DISCIPLINARY AND INDUSTRY PRACTICE PARTNERSHIP

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Abstract
A Global Smart City Performance Index that ranks the top 20 global smart cities in terms of their integration of Internet of Things (IoT) technologies and connected services across four key areas namely mobility, healthcare, public safety and productivity has Singapore emerging at the top of the ranking for 2017, as reported by Navin (2018). This paper posits that this is achieved in part with the educational and training programmes that are in place in the Republic to train such professionals. This paper describes the implementation, experiences and lessons learned of one such programme called the Specialist Diploma in Internet of Things (SDIoT) at a polytechnic in Singapore, which adopts Professional Learning (PL) practices such as industry case studies, industry projects, industry study tours as well as industry practitioner delivery in its programme. The role of industry is a key feature that will be elaborated. This paper also describes the adoption of multi-disciplinary collaborations in its curriculum as well as technology-assisted learning in the form of a mobile learning platform to complement the programme.

Keywords: Professional Learning, Industry Engagement, Internet of Things, Smart Cities

Introduction
Singapore has a Smart Nation programme that represents her journey of economic, business and public sector transformation where technologies such as the Internet of Things (IoT), data analytics, artificial intelligence (AI) are leveraged upon to transform herself into a smart city. A Smart Nation and Digital Government Group, GovTech was reported by Teo (2017), to have been formed to drive several of these national strategic initiatives. One such initiative is the Smart Nation Sensor Platform which is an island-wide network of IoT-connected sensors that facilitate data collection and sharing (across various government agencies) for which insights gathered from the data can contribute to innovative solutions that help improve the lives of its citizens.

As Singapore embarked on its Smart Nation initiatives, it was challenged with the ability to meet the demands of suitably trained ICT professionals as reported by Weizhen (2016). Since then, we have implemented a programme that is targeted at working professionals or adult learners in support of this demand. The design of the programme, specifically in the way it engages its students, considers the characteristics of adult as learners such as adult learners having experiences that are rich and which should be seen as an important learning resource, adult’s orientations to learning being more problem centred than subject-centred and adults being more capable of self-direction as reported by Knowles (1990) and James (2013). These characteristics, in combination with the need to equip with skills that are industry relevant sees the application of an approach in the programme termed as Professional Learning (PL).

Professional Learning is defined as the development of professional capabilities through teaching and learning experiences and activities that integrate academic, discipline-specific and industry-referenced knowledge, skills and attitudes as reported in Lawson (2011) and Billett (2011). Specifically, professional learning, encompasses the skills, qualities and attributes required by industry, with students participating in industry-oriented processes by engaging in real industry issues which encourages deep learning and where industry partners can be engaged in the development and delivery (including evaluation) of the curriculum.

The literature on PL describes a number of main approaches, noting that the practice of these approaches are not mutually exclusive. These approaches include industry case studies, industry projects, industry study tours / seminars, industry practitioner delivery, industry simulation, industry mentoring, industry placement and industry competition. In our programme, the first 4 approaches listed have been adopted and their application are explained in this paper. Beyond the above, the adoption of technology assisted learning and other
initiatives to support a professional learning programme is discussed, including the issues faced.

Curriculum Design

The professional learning programme that we have designed is named the Specialist Diploma in the Internet of Things (SDIoT). To fulfil the manpower needs in a field where technology is fast evolving and the use cases of IoT as applied in the context of smart cities is expanding rapidly, the training programme for working professional’s needs to be as industry relevant as possible. Besides skills training to fulfill job roles in IoT or to increase the job prospects of relevant as possible. Moreover, the programme is offered to include the following:

1) The requirement of a multi-disciplinary approach, as well as the qualification obtained is recognized Industry-relevant skills is a critical and key approach, and the engagement model include the role of the subject matter coverage, the teaching more advanced learning.

The key considerations in shaping the SDIoT in terms of the subject matter coverage, the teaching approach, and the engagement model include the following:

The key considerations in shaping the SDIoT include:

1) The requirement of a multi-disciplinary approach, as demanded of any professional who is to work effectively in IoT. IoT project teams will be composed of different professionals who have to work collaboratively in teams and each need to have knowledge beyond their own areas of expertise to be effective, as described in Shenna (2015). Multi-disciplinary in our case refers primarily to computer science and engineering subject matter and specifically to foundational modules. Hence the inclusion of modules such as Basic”, “Systems and Programming Basics” and “Introductory Statistics and Analytics” in the SDIoT programme.

2) Industry-relevant skills is a critical and key feature intended of the programme. As such, industry case studies, industry projects are some of the professional learning approaches adopted. Adult learners tend to be more inductive than deductive reasoners i.e. learn better from cases or examples and their response to cases or problems have to be driven from the practices and processes as applied in industry. This is reported in Duncan (2018).

3) A hands-on or very practical engagement to the modules is essential. Clear efforts are also made to ensure that the hardware used are industry-edge devices such as waspmote or Bosch XDK 110 as compared to just the use of Raspberry Pi or Arduino per se. The same applies to the use of software such as the ThingWorx IoT platform for developing industrial IoT applications. Besides, after a long day at work for these working professionals, lecture-based learning per se, where a classroom tends to be more passive, hardly aligns with efforts to engage and motivate student learner’s especially adult learners.

4) Industry practitioner delivery, whether in the modules or in the form of industry study tours or industry seminars is also a key part of the intended programme. However, this is not possible for all engagements in the programme. Yet every effort is made for faculty staff to be trained by industry practitioners and gather relevant industry-level experiences beforehand. The programme that support the latter is named the Industry Attachment Scheme (IAS) and is described briefly later.

5) Technology enhanced learning was another feature that was introduced to deepen the students engagement with learning beside formal face-to-face sessions. In addition, such platforms afford for peer learning. In the SDIoT’s case, a mobile platform called ULeap affords students the opportunity to engage with a wider community of learners outside of their peers. U-Leap is described later in this paper as well.

The structure of SDIoT therefore consist of two Post-Diploma Certificates (PDC’s), with each to be completed within a six month semester, offered after office hours. The first PDC consist of 5 modules and the second PDC consist of 2 modules. See Tables 1 and 2. For some of these modules, students may be granted exemption on the basis of Recognition of Prior Learning (RPL) given the profile of adult participants that apply into this programme.

Table 1. PDC in Fundamentals of IoT

<table>
<thead>
<tr>
<th>Post-Diploma Certificate (PDC) in Fundamentals of Internet of Things (IoT)</th>
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<tbody>
<tr>
<td>1) 3D Printing Fundamentals</td>
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<tr>
<td>2) Engineering Basics</td>
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<tr>
<td>3) System and Programming Basics</td>
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<tr>
<td>4) Introductory Statistics and Analytics</td>
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<tr>
<td>5) Internet of Things (IoT) in Consumer Electronics, Health, Homes – A Case Study Approach</td>
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Table 2. PDC in Advanced Applications in IoT

<table>
<thead>
<tr>
<th>Post-Diploma Certificate (PDC) in Advanced Applications in Internet of Things (IoT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Internet of Things (IoT) in Cities, Industry, Business – A Case Study Approach</td>
</tr>
<tr>
<td>2) Design Thinking Capstone Project</td>
</tr>
</tbody>
</table>

Upon successful completion of the SDIoT, the students will be well equipped to design, build and test complete IoT solutions that comprise sensors, wireless network connections, data analytics and display/actuators and write the necessary control software. Driving these outcomes are the design of assessment components, modes and weights that are industry or practice driven, in keeping with the professional learning approach adopted.
The Practice of Professional Learning

1. Industry Case Studies

The use of case studies are not new and their application in education is widespread especially in the fields of management, public policy, social sciences, medicine, law and engineering, as described by Bowe (2011), Yadav (2010) and Sarah (2011). Within the context of a professional learning programme, we have incorporated industry case studies as they afford an engagement that is more experiential, where students learn by doing. They are encouraged to ask questions and make informed decisions. They will need to participate and collaborate as they would as professionals at work where they need to understand the facts of a case and the variables to be debated, grasp what is going right and what is going wrong, what are the goals and objectives of the case and develop an action plan based on industry practices and standards, optimizing where necessary, in deriving a solution. The nature of such forms of engagement in learning enhance the employability or career of the students.

In our Specialist Diploma, two of the modules namely “IoT in Consumer Electronics, Health, Homes” and “IoT in Cities, Industry, Business” are taught using the industry case study approach where carefully selected case scenarios that are drawn from the projects of industry partners are used. These modules build on the foundation of the 4 introductory modules, though lesson matter content will still be taught within the two modules. But in this case, the lessons will be driven by the intended outcomes of the case scenario.

For a recent cohort undertaking the module, “IoT in Consumer Electronics, Health, Homes”, students were engaged in discussion and in designing and solutioning activities for a case study related to the pest situation in Singapore. The module culminated in the development of various prototype(s) that demonstrate the different approaches students took to addressing the pest situation.

Case Study: Connected Mouse Trap

Background: Huiwen (2016)
Industry: Pest Control
Issue (In Brief):
- A company had wanted to improve their product offering and competitive advantage. They wanted to create an intelligent mousetrap that lets users know when the trap has caught a mouse, thus preventing the user from having to check the trap every day.
- In order to make this happen, the company needed a way to send signals from battery-powered traps to an email or mobile phone. Because the traps run on batteries, the company would need something low-powered but could still send a strong enough signal inside a building.

In the module, the students went through a few stages, starting with identifying/clarifying on the problem/opportunity. In this case:
- Each team was tasked to list down the possible business/operational challenges and address the “why” questions. For example, why is this company deciding to embark on a journey for a connected mousetrap? etc.
- Each team is also required to also think and estimate how much this particular problem would cost. They need to develop a Return of Investment (ROI) metrics and identify users, buyers and financiers.

Following from the above, the teams moved towards technical solutioning where they adopt industry informed processes or workflows for building IoT systems, such as that described in Fuller (2016). In this case, a 4 stage architecture is adopted in which the technical elements to be considered at each stage start with sensors and actuators to the internet gateway, then the edge IT processing systems and finally the data centre and the cloud. As expected, teams have competing views and proposed different solutions to the ‘problem’. Figures 1 and 2 demonstrate the solutions from two teams.

Figure 1. Student Prototype Mouse Trap

Figure 2. Student Prototype Mouse Sensor

For the same cohort undertaking the module, “IoT in Cities, Industry, Business”, students were engaged in the case study below:

Case Study: Overall Equipment Effectiveness (OEE) of Collaborative Robots
Background: Woo (2017)
Industry: Manufacturing
Issue (In Brief):
- As more companies move towards the adoption of automation and robotics into their operations, IoT technologies are incorporated to track daily operational metrics. One such key metric is the OEE where uptime will directly impact the profitability of the company.
- In this case, the company concerned had purchased two sets of collaborative robots to help with their production assembly. To realize rapid deployment, they wanted to utilize the industry-ready IoT sensor – Bosch XDK110 and the Thingworx Application Platform to capture data that allows for an assessment of OEE.

A widely used industry-based 5-step problem-solving technique based on DMAIC (Define, Measure, Analyse, Improve and Control), as described in Ng (2014), was applied in this case. Solutions utilizing IoT were developed as students moved along the DMAIC methodology as they analysed the different data presented by the sensors in deciding which sensors data are effective in keeping track of the OEE.

A student survey to gather feedback on these modules that used an industry case study approach was conducted. The questions are shown in Table 3 and the outcome of the survey are shown in Figures 3 and 4. On the whole, the survey rated an average of at least 4 for all questions.

Table 3. Module Survey Questions

| Q1 | The objectives of this module are clearly stated.                        |
| Q2 | The module has achieved its learning objectives.                       |
| Q3 | The coverage of the module is adequate.                                |
| Q4 | The depth of the module is appropriate.                                |
| Q5 | The lesson materials (lecture notes/hand-outs, worksheet questions, laboratory and practical worksheets) are well designed and organised. |
| Q6 | The lesson materials (lecture notes/hand-outs, worksheet questions, laboratory and practical worksheets) have aided my understanding of the topics covered. |
| Q7 | The contents (such as concepts and skills) presented in this module are useful and relevant to my work. |
| Q8 | The amount of work required in this module is reasonable.              |
| Q9 | The assessment method(s) for this module is appropriate and fair.     |
| Q10| The recommended list of readings and resources are useful in increasing my understanding of the contents covered. |
| Q11| My overall rating of module delivery is...                             |

Figure 3. Survey Result for Q1 – Q6

Figure 4. Survey Result for Q7 – Q11

Qualitatively, the overall student feedback was encouraging and on the whole, positive as well. Students claim greater confidence, skills and professional awareness after these modules as they experience the benefit of applying theory and knowledge to practical problems. Even though the problems may be more challenging, they found them energizing.

2. Industry Capstone Projects

In this module, students will demonstrate their competencies in designing, architecting and building a larger scale prototype IoT solution in response to a problem scenario that is provided by an industry partner. In some cases, a problem scenario from the student’s workplace can be accepted. It was a clear decision in the design that we wanted students to work on actual industry projects. And student will also work in teams as they would do in the real-world, as much as they will be required to synthesize and apply the IoT knowledge and skills acquired to real-world issues and opportunities. Students will also use this module to further deepen their skills in specific domains of their interest.

A unique feature in this module is the incorporation of Design Thinking as described in Dam (2018). Design Thinking is described as a methodology that is used to solve complex problems and find desirable solutions for clients. The mind-set is solution-focused and action is oriented towards creating a preferred future. Design thinking will draw upon the imagination, intuition, logic and systemic reasoning of the individual and/or team which we wanted to develop in the students as they explore...
possibilities of what could be and to create desired outcomes that benefit the end user or client. Especially pertinent in the area of smart cities.

To facilitate such an engagement, students will attend a series of design thinking workshops in the module and come up with a proposal for their project based on the industry scenarios. Once the project proposals are submitted, students will be matched with their respective project supervisors and/or industry sponsors for further consultation.

3. **Industry Study Tours**
   The purpose of study tours is to allow students to see theory in practice and enquire of the professionals on site their specific issues/challenges on the ground which can enrich and complement, as well as connect their classroom learning to industry practice. On this, study tours are arranged for internal and external sites. One such study tour was a visit to the Centre of Innovation for Supply Chain Management (COI-SCM) which was jointly set up between RP, SPRING Singapore and the Economic Development Board. This centre specializes in innovation, process re-engineering, and the adoption of technology, including IoT to help companies improve on their supply chain capabilities. In this visit, practitioners shared how IoT solutions used in their supply chain eco system allowed them to gain insights that were previously not possible.

4. **Industry Practitioner Delivery**
   The SDIoT programme actively engages industry practitioners, from the teaching of modules to delivering specialized lectures or seminars including assessment of student projects where possible. These engagements afford students direct exposure to the varied experiences of industry practitioners and often, on topics outside or more advanced than those of the declared learning outcomes. At the point of writing this paper, at least 2 industry seminars had been conducted by industry leaders on such topics. One is briefly described below:

   **Seminar Title:** *Cyberattacks on IoT Systems.*
   This seminar addressed the state of security in the IoT space, the pros and cons of current security technologies and standards in IoT, the challenges of Public Key Infrastructure (PKI) in IoT and future security challenges envisaged in IoT.

**Industry Associate Scheme**
   To support professional learning, there are a number of enablers that are key.
   - Institutional support in encouraging professional learning is important e.g. putting in place policies and procedures that are “friendly” when engaging external industry partners. Part of this include staff training and development on industry practices to ensure their relevance and currency to the programme.
   - Staff being encouraged and trained to develop their teaching practices for professional learning. Staff within the institution need to also work with industry partners to ensure academic rigour.

   In RP, one such policy or scheme is called the Industry Associate Scheme (IAS) in which academic staff are encouraged to be associated with the industry in a systematic, coordinated and sustainable way so that the experience that they gather through their association with industry would augment their pedagogic training. Staff are kept abreast with industry trends and are exposed to cutting-edge technologies which increases their ability to create relevant educational problems centred on the institution’s unique Problem-based Learning (PBL) pedagogy. In the case of the SDIoT, our practice of Professional Learning.

**Mobile Learning and Extended Community Engagement**
   In keeping with current trends on learning, we have also complemented the programme with the inclusion of a mobile learning platform for professionals called ULeap. ULeap is an initiative of The National Trades Union Congress’ (NTUC) e2i (Employment and Employability Institute) in Singapore, in partnership with RP, amongst other institutes of higher learning.

   The students, as working professionals, can tap on this convenient learning application to get quick, up-to-date, bite-size information on issues (see Figure 5) and exchange know-how with other experts in the field, including trending discussions, as part of a wider learning community (see Figure 6). This platform and its learning community offers “timely” and a real-world perspective that sets it apart from other learning portals and courses.

**Industry Support – Lessons / Insights**
   Engaging industry is not always easy for reasons of time and effort, for which the benefits to the organization if any, are not immediately or necessarily measurable. We have experienced instances where the benefits of such an engagement from “industry” lay...
solely on a said individual or two and may be guised as a Corporate Social Responsibility (CSR) initiative. The latter suggest that the position is precarious. For our program, we have expanded and spread our industry engagements across a diverse group of industry partners whose motivations are similarly varied.

Conclusion
The practice of professional learning in SDIoT has seen a number of benefits for both the institution and students. The use of industry case studies and projects, with industry practitioner engagement in the curriculum, brings authenticity and relevance to the curriculum where the students ability to apply the multi-disciplinary knowledge and skills gained to tasks has seen students being more engaged and enthused with their learning. The application of industry practices in addition exposes students to actual workings within industry and they are better equipped to fulfil job functions or seek (new) employment or opportunities. Industry practitioner engagements in the form of study tours and seminars further expose students to the varied experiences of industry practitioners, especially on issues, problems on the ground through ‘corridor conversation’ that stretch beyond a formal curriculum.

Developing industry engagements is key in a professional learning programme. Initially, it will be time consuming and arduous but as relationships become more established and win-win in structure and nature, the efforts will moderate. On the long term, a virtuous cycle that benefits the institution, its students and industry is on offer.

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FREE VIBRATION OF CRACKED FUNCTIONALLY GRADED BEAM WITH AN EDGE CRACK UNDER TEMPERATURE EFFECTS

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Abstract
Functionally graded structures have been attracting great attention due to their unique attributes and benefits. It is well accepted that cracks occasionally exist in engineering structures, which introduce a local flexibility and significantly influence the dynamic performance of the structures when subjected to vibration. For this functionally graded beam, the beam is 100% aluminum with Young’s modulus being \(70\) GPa and mass density being \(2780\) kg/m\(^3\). The material properties of the beam in the thickness direction are expressed as following exponential equations:

\[ E(z) = E_o e^{\beta z}, \rho(z) = \rho_0 e^{\beta z}, \alpha(z) = \alpha_o e^{\beta z} \]  (1)

where \(E_o, \rho_0\) and \(\alpha_o\) are the Young’s modulus, mass density and thermal expansion coefficient of the materials at \(z = 0\), and \(\beta\) is an index determined by the material properties of the top surface of the beam. The Young’s modulus of the bottom surface of the beam is denoted as \(E_2\). By setting the value of \(E_2/E_1\), the parameter \(\beta\) and the Young’s modulus \(E_0\) will be obtained. Particularly, when \(E_2/E_1 = 0\) the functionally graded beam reduced to an isotropic homogeneous beam.

To simplify the modelling, plane 182 element is used for build the beam. Here it should be noted that for finite element modelling it is possible to obtain the continuous varying material properties in thickness direction as described in equation (1). From our previous modelling, it is found using 30 layers will be accurate enough to get functionally graded beam. For each individual layer, the material properties will be calculated by equation (1) by substituting \(z\) with corresponding values. For modal analysis of the beam in ANSYS, Block Lanczos method is adopted by extracting the first 5 mode shapes. The reference temperature of the structure is set as 300 K. In order to take the thermal effect into account, the beam is analyzed when temperature increase is applied. Then the modal analysis is done by considering pre-stress effects.

Keywords
Functional graded materials, free vibration, beam, composite structure, thermal environment

Introduction
Investigation of the effects of the cracks on the vibration characteristics of the structures is essential for their engineering applications. In addition to cracks, when structures are exposed to temperature, thermal expansion of the functionally graded materials also plays important role in altering the vibration of the structures. Extensive studies [1, 2] have been found on the free vibration of functionally graded beam with the consideration of crack. However, the majority of previous works are focused on analysis without considering temperature effects. This paper will investigate the free vibration of a functionally graded beam with considering both cracks and temperature effects by finite element simulation.

Finite element analysis
A functionally graded beam as shown in Fig. 1 will be modeled by finite element package ANSYS. The lengths, width, thickness of the beam are \(L\), \(b\) and \(h\), respectively. As can be seen, there is a crack on the top edge of the beam. The location of the crack is denoted by length \(L_1\) while the depth of the crack is represented by \(a\).

Fig. 1 Configuration of FGM beam with edge crack

For this functionally graded beam, the top surface of the beam is 100% aluminum with Young’s modulus being \(E_1 = 70\) GPa and mass density being \(\rho_1 = 2780\) kg/m\(^3\). The material properties of the beam in the thickness direction are expressed as following exponential equations.
Without considering any each of them might induce inaccuracy and error in predicting the performance of the beams.

(a) 300 K

(b) 400 K

(c) 500 K

Fig. 2 Variation of frequency ratio with crack location for C-C FGM beams (a) 300K; b) 400 K; c) 500 K.

Conclusion

Free vibration characteristics of a functionally graded C-C composite beam is studied by finite element analysis with consideration of crack and temperature effects. It is found that the natural frequency of the beam is highly dependent on the location of the crack and the material distribution in the thickness direction of the beam. The increase of the temperature can significantly decrease the natural frequency of the beam. The natural frequency of the beam is more sensitive to the material gradient when the temperature is high. It is also noticed that without considering temperature, beams with the ratio $E_2/E_1 = 0.2$ has the lowest natural frequency when $L_1/L = 0.5$. However, beams with the ratio $E_2/E_1 = 5$ have the lowest values when considering temperature effects.

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IMPLEMENTATION AND THE CONSIDERATION OF THE GLOBAL ENGINEERING EDUCATION

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Abstract

In the field of engineering education, Toyohashi University of Technology (TUT), Nagaoka University of Technology (NUT), and National Institute of Technology (NIT) have conducted the construction of the global educational environment (Tri-Institutional Collaborative/Cooperative Educational Reform Project), since 2014. As one of the global activities, TUT has provided Global Faculty Development (GFD) project since 2013 including the preparation. In GFD project, teachers from TUT, NUT, and NIT joined to develop and brush up the teaching skill to conduct lectures and practical workshops, for the global engineering education. The project has been carried out in three places: TUT Head Quarter, City University of New York Queens College (CUNY QC), and TUT Penang Campus in Malaysia. The acquisition of teaching and learning skill in the area of multi-cultural and multi-ethnic society was very effective and meaningful to step up the international skill of teaching. After the training in New York, actual lectures have been carried out in polytechnics and a university in Malaysia, to complete the outcome of the project. The technical subjects based on engineering field such as mechanical, electrical, chemical, architecture, civil engineering have been lectured in Politeknik Tuanku Sultanah Bahiyah (PTSB), Politeknik Seberang Perai (PSP), and Universiti Sains Malaysia (USM). The author made lectures of image processing technology for production engineering. In order to lead the students for the introductory learning of the industry field, basic and fundamental topics were lectured and explained. To encourage the comprehension of the learning contents, simple but useful concepts of image processing theory and practical examples were provided. In this paper, the detail of the trial of the technical subject lecturing, the evaluation, and considerations are described.

Keywords: image processing, quality control, production engineering, industry 4.0, engineering education, faculty development of teaching, international activities

1. Introduction

As the growth of global economy and industry, ethnic diversity has been spread and developed in many regions of the world. It has also given rise to the needs of globalization of education, especially in the fields of science, technology and engineering (e.g., Banks, J.A. (2007) and Downey, G.L. (2010)). In a part of conventional and traditional style of higher education, teaching and instruction had been done to the native students as the majority, and to the foreign students as the minority in the native language. However, as the worldwide movement of ethnic diversity spreads, the new trials of education have been needed to respond to the globalization of education (e.g., Ness and et al. (2017) and Moore C.B. and et al. (1997)). In order to fulfill the needs, teachers and instructors have to have the teaching skill in common language such as English even in Japan, and the sense of mutual understanding in international circumstances (e.g. Hoff, E. (2009)).

As described in the abstract, the author joined the GFD project in 2017. It was one-year project, and the trainees including the author have developed and reinforced the teaching skill under the international educational environment. In order to complete the project, and as the final stage of training of the project, the trainees had an opportunity to make lectures in three educational institutes in Malaysia. They were conducted mainly in mechanical, electric, electronic, and computer science classes. The contents which the author lectured are oriented to learn the fundamental and basics of image processing for industries, so that the students can easily start the study, and be interested to learn the technology.

This paper describes the details of conducting the lecture. It consists of main three parts, the preparation, the implementation, and the feedback & assessment. In the section 2, the concept and the topics of the lecture are described as the preparation. In the section 3, the implementation of the lecture is described. In the section, the contents of the lecture, the class going, and the communication with the students are described. In the section 4, as the results and the discussion, the survey of the lecture by the students and the results are described. In the section 5, overview and the consideration are described as the conclusion.
2. The preparation of the lecture

2.1 Structure and the flow of the class

When we make lectures, especially in the case of the students’ backgrounds are academically and ethnically varied, such as internationally circumstanced class, the teacher/lecturer needs to design the lecture contents more cautiously and properly than domestic and conventional case. To avoid the situation of misconception and/or low comprehension of the learning contents, it has to be carried out with organized and consistent flow (e.g., Caspi and et al. (2005) and Ambrose and et al. (2010)). In order to realize the organized lecture, the flow should be consisted mainly three parts: introduction, main part (subject matter), and conclusion. In the part of introduction, warming up and ice break talk should be included as the start up. After showing the contents list and outline of the lecture, the back ground and the objective of the subject are explained sufficiently, to clarify the purpose of learning the subject. At the end of the introduction part, small quiz and Q&A are also useful to simply check the comprehension and the reaction.

Next to the introduction, as a first step into the subject matter, a fundamental theory of the main theme is explained, and an example is given to understand the theory easily. To encourage the students’ interest, the example should be easy and/or familiar to imagine and figure out the problems. Using the first example of the subject, a basic and easy question is given to the students. To solve the question, the topic can be discussed with the group. If they seem difficult to figure out, giving hints is also effective. By the interactive communication with the students, finally reach the correct answer and the essential part of the theory. After the small comprehension check with Q&A and short discussion, proceed to the next level of the subject. At the second step, to accelerate and to deepen the comprehension of the subject matter’s concept, middle level (or advanced) question is provided. Using the concepts and the skill which are obtained in the first question, students try to solve an advanced problem. In this step, the combination with the former question and the concept to learn, new concept, and the related skill are given to the students. Through the communication of the comments and questions from the students, the teacher should overview and recognize the level of students’ comprehension and the interests of the subject matter. As the third part of the subject matter, advanced level of the contents are explained and displayed to make students to have wider knowledge and skill of the subject. Where needed, another quiz or assignment could be provided to step up the higher level.

As the final part of the lecture, the conclusion of the class is explained. In this part, the important and effective points of the contents should be listed to summarize the subject matter. This is also an important part to deliver the useful, practical, and essential part of the lecture. To set up these process for the lecture’s preparation, the teacher has to be aware of international sense of communication with the students, supposing the students are consisted of multi-national background. To share the concepts of the subject with the students, the delivered message should be constructed with the global mind set.

2.2 Build-up of the contents of the lectures

In order to conduct the lectures for the students of three institutes in Malaysia (PTSB, PSP, and USM), fundamental theory and basic skills of image processing have been applied. At the step of the preparation, the students’ academic profile, such as the learning background of mathematics, physics, and engineering was previously informed. The target students belong to mechanical engineering, electric/electronic engineering, and computer science departments. Addition to that, the age-group and the students’ attitude (e.g. quite positive and/or shy), are also useful as a prior information, to make a good matching with the contents and the students. The contents is mainly based the software part of the technology, and specially oriented to apply the field of production engineering such as plants and factories. To keep the good quality of the product which are assembled on the production line, quality control is crucial and essential. As one of the solutions to realize the quality control, image processing technology is very practical to detect the defects and problems of the products on the production line. On the other hand, the demands of the engineer who has the skills of image processing are rapidly growing, especially in the field of factory and logistics engineering (e.g. Industry 4.0). As we know, East and Southeast Asia regions have big potential as markets and manufacturing bases. To respond the potential also, the learning the basic of image processing for the industry is quite effective and useful.

To start the introductory learning for the image processing technology, the color image structure, the color decomposition, threshold process, and size-selection are introduced. As one of the color structure of digital imaging technology, RGB (Red Green Blue) is widely known and used. The conceptual scheme is shown in Figure 1.

![Figure 1: Color decomposition and three primary colors](image)

Each color component’s intensity is numerically digitized in the range of 0 to 255, from darkest to brightest i.e. 256 levels. A color which is displayed in digital imaging, are combined with the three color-components. The combination number is numerically calculated as shown below:

\[
256(R) \times 256(G) \times 256(B) = 16,777,216
\]

That is to say, digital imaging color is able to theoretically display 16,777,216 colors.
As the next step, one example is given. That is supposing we are the engineers to manage the quality control of a production line of a factory. The products are toys, so that the students can tackle the problems in familiar way. The mission of the engineer is to check the quality of the products from the image of the product inspection. The concept of the production line is shown in Figure 2.

![Figure 2: The concept image of the production line](image)

As shown in the figure, a camera for the products inspection is installed above the belt conveyor. The aim of the lecture is to learn the function and the algorithm to detect a standard and/or defective item in the image for the product inspection. To correspond with the three primary colors components, products are designed, as shown in Figure 3. They are Red Robot, Green Car, and Blue Submarine.

![Figure 3: The reference objects' image](image)

These three objects are the standard products, and these are the reference images to compare with objective images. Each product has each color, shape and size. These factors (color, shape, and size) are the key to differentiate with other standard and/or defective items. The concept is the precondition for the introductory learning of fundamental and basic of learning image processing. The next section describes the implementation and the related matter of the lecture.

### 3. Implementation of the lecture

After the preparation as described in the previous sections, the implementation of the lectures is carried out. In the part of introduction, the industrial needs, importance of image processing were explained, as the background, and the direction of the lecture which is introductory learning of image processing. As the next step, the basic concept of the lecture which is described in the section 2.2 was presented in detail. In order to display the process of color-decomposition which is shown in Figure 1, an example image is decomposed in each color. Using the image processing software, the color-decomposition process is demonstrated in front of the students. The reference image (Figure 3) is decomposed as shown in Figure 4.

![Figure 4: Color-decomposition of the reference image](image)

(R) Red-component image,  
(G) Green-component image, and  
(B) Blue-component image

As shown in the Figure, Red Robot is brightest in the Red-component (R), Green Car is brightest in the Green-component (G), and Blue Submarine is brightest in the Blue-component (B) image. It tells us the relationship between each reference product’s color and the color-decomposition result. As a common rule, “brightest part is the target” to detect the standard object (reference image) in an image area. In other words, to detect the red object, red-component image should be chosen, to detect the green object, green-component image should be chosen, and to detect the blue object, blue-component image should be chosen.

#### 3.1 The first step for the basic problem solving

As the next step, a basic question is given in the class. The image of the question is shown in Figure 5. The question is as follows:

![Figure 5: The image of first question](image)

“To detect the standard item, which color-component would you choose, red, green or blue?”

As shown in the figure, one item (green fruit) which is not a standard item (wrong object) is displayed. The aim
of the question is to choose the correct color-component image to detect the standard object i.e. Red Robot in this case. The selection of color-component of the image is important and practical for the detection of the target object in color. Thus the color-component selection is asked as the first question. After the question is given, the students had several minutes for the discussion among them. The color of the standard item (target object) is red, so the red part of the image has to be the highest intensity (brightest) in the component image. After the discussion, let them choose and raise their hand for the correct option, from red, green, or blue component images. And several students are asked why they chose the color-component image. The reaction and the comprehension of the lecture can be checked by the discussion. As previously described, the red object is brightest in red component image. After their choice, color-decomposition process is demonstrated in front of the students. The image of the result is shown in Figure 6.

As we see from the Figure, the red-component image has a brightest part at Red Robot. Therefore, the correct answer is (R) Red-component image. By the thresholding process to search and mark the brightest part in the image, the question which is searching the standard item in the image can be solved. The result of the software performance is shown in the Figure 7.

As shown in the figure, Red Robot part is bordered with light-blue line. By the detection of Red Robot in the image, the shape, size, and the location are also obtained as the numerical value. Through the solving the problem, students can learn the concept of color-decomposition of the image and thresholding process.

3.2 The second step for the further level problem

As the further step, another problem is given. The image of the question is shown in Figure 8. The question is as follows:

Figure 8: The image of second question

“To detect the defective item and wrong object, which color component would you choose, red, green or blue? (You can choose 2 components)”

To avoid confusions and misconceptions, the options are listed.

A) Green & Red
B) Red & Blue
C) Blue & Green

As shown in the figure, one item (reddish cake) which is not a standard item, is displayed as a wrong object. Addition to that, a broken submarine is seen in the left hand side. The aim of the question is to figure out how to choose the correct components combination to detect the cake as the wrong object, and the broken submarine as the defective item. To solve the problem, several steps are needed to find out the wrong object and the defective item. As we did in the first problem which is described in the previous section, the color-decomposition is done as the first step. The image is shown in Figure 9.

As shown in the figure, all of objects are not bright in the figure (G), and that suggests the Green-component image is not suitable for the detection of the target images which are red and blue objects. That is to say, the correct image is either (R) Red-component image or (B) Blue-component image.
The answer of the question is the option B) red & blue. In order to find out the two targets (red cake and broken blue submarine), two steps of image processing are applied. At first, the red cake which is wrong object is detected by the thresholding process in the Red-component image (Figure 10).

Figure 10: The detection of target image (red cake) by thresholding process in the red-component image

As the second step, thresholding process is applied to the Blue-component image. As shown in Figure 11, both of broken and standard submarines are detected.

Figure 11: The detection of broken and standard submarines in the blue-component image

As the third step, size-selection processing is applied after the thresholding. Based on the size of reference object (the standard product), smaller size of the object is selected as the target object (defective product). The result of the processing is shown in Figure 12.

Figure 12: The detection of broken submarine by the size-selection processing

As the final step, combining the process results for the Red-component and the Blue-component images, the target objects are detected and displayed as shown in Figure 13.

Figure 13: The detection of defective product and wrong object

The step of solving the question was also demonstrated by the software’s performance, and the students could realize how the image processing works for the product inspection. After the Q&A and discussion, the practical concepts are explained as the summary. Through the lecture, students have learned practical image processing methods (color-decomposition, thresholding, and size-selection) for the production engineering.

4. Results and Discussions (The evaluation of the lectures)

At the end of the lecture, the survey of the class has been conducted, to evaluate the quality of the lecture and the class going. The contents of the survey is as follows:

The evaluation of the lecture
1. Organization
2. Interest level of the topics
3. Comprehension level
4. Satisfaction

The lecturing skill
5. English skill
6. Attitude of the teacher (gesture, posture and eye contact)

Each item’s evaluation is ranged from 1 to 5. Higher number is, higher the evaluation is. Totally five lectures were carried out in three institutes, and every class is surveyed for the evaluation of the lecture. As one of the result, the evaluation which was surveyed in USM is shown as radar chart in Figure 14.

Figure 14: Evaluation of the lecture in USM
The class has 54 students, the ratio of boy and girl students was roughly 50% and 50%. They belong to Sixth semester (Third grade) of the Electric & Electronics Engineering Department. They were good attitude, positive behaviour, and well concentrated to the lecture. Their reaction and response to the questions were good, and the discussion with the students was also active. These students’ reaction, similar good evaluation results were obtained in PTSB and PSP as well. These results imply that the learning motivation of students in polytechnics and universities in Malaysia have quite positive and high feasibility of further level of learning in the field of advanced image processing technology and quality control engineering for the practical level of the industry.

Figure 15: Breakdown of each item of the evaluation

As shown in the figure, the variation of the data is not so high, and it suggests that most students could learn and understand well about the main theme of the lecture. Addition to that, similar good evaluation results were obtained in PTSB and PSP as well. These results imply that the learning motivation of students in polytechnics and universities in Malaysia have quite positive and high feasibility of further level of learning in the field of advanced image processing technology and quality control engineering for the practical level of the industry.

5. Conclusion

In order to realize the implementation of engineering lecture in the international circumstances, Global Faculty Development project has been carried out. The author has joined the project in 2017, teaching and communication skill in English has been reinforced in TUT and CUNY QC. For the implementation of actual and practical lecture of engineering, the introductory learning for the image processing of the production engineering is designed. It is oriented to teach to the students of engineering such as mechanical, electric & electronic, and computer science. The implementation of the lectures were evaluated by the participated students in three institutes in Malaysia. The evaluation results have been feed backed, and considered. And the further steps for the global engineering education will be carried on. To maintain the global connection and the network of engineering education, international exchange of teachers and students will be more important and should be more developed world wide. Trials as described in this paper may be a part of the realization of the movement. However, the activities are hoped to be more spread and developed in the educational institutes of the world.

Acknowledgement

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INTRODUCTION OF ONE DAY EXPERIENCE OF KOSEN CLASSES
- A NEW PROGRAM FOR INTERNATIONAL EXCHANGE ACTIVITIES
AT NIT, NAGAOKA COLLEGE -

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Abstract

National Institute of Technology, Nagaoka College (Nagaoka KOSEN) has been actively implementing international exchange programs for more than ten years. For the past decade, Nagaoka KOSEN has sent a great number of students to the overseas institutes with whom it has academic exchange agreements and this number has been steadily increasing year by year. As of today, however, Nagaoka KOSEN has not received the same number of students from the overseas institutes, and thus the student exchange program is not well-balanced. There are several reasons for this unbalanced student exchange such as focusing only on specific engineering educational programs such as LEGO Robot programming, which restricts only particular teachers involved and leads to less participation of teachers from the Division of General Education.

In order to increase the number of students from the overseas institutes with academic exchange agreements for their short-term study at Nagaoka KOSEN, one practical solution would be to devise a new program for international exchange activities at the Division of General Education. By doing so, more professors belonging to the Division of General Education can also participate in the international exchange, which might lead to increasing the capability of accepting international students. In March 2018, a group of twenty-two consisting of twenty students and two teachers from an institute in Singapore visited Nagaoka KOSEN for one week. As a first attempt, a new program was created by the Division of General Education, called One-Day Experience of KOSEN Classes. This one-day program including a math class (titled as Fastest Finger First Quiz), a chemistry experimental class (titled as Neutralization Titration), and a physics experimental class (titled as Swing of Pendulum) was added to a whole one-week-program. In order to assess the effectiveness of the program, a questionnaire was given to the visitors. In the questionnaire, a four-point Likert’s scale was used to evaluate the effectiveness of each program held in the one-week program.

Keywords: Active Learning, International Exchange Program, One-Day Experience of KOSEN classes, ice-breaker activity, Fastest Finger First Quiz, Neutralization Titration, Swing of Pendulum

Introduction

Global education has been actively implemented worldwide these days. National Institute of Technology, Nagaoka College (Nagaoka KOSEN), has its history of international students exchange for more than a decade. Nakamura (2016) has summarized the recent achievements of international exchange activities at Nagaoka KOSEN in his report. The reason for tackling such an international exchange activity at the institute is to meet the requirement from the society which advocates that the academy should foster students in order to possess broader views of globalization. Nakamura (2016) states that the first students’ overseas program was held in the Heisei 17th year or 2005. Since then students in Nagaoka KOSEN have experienced their studies aboard in Asian countries such as China, Malaysia, Thailand, Vietnam, and Singapore.

Not only have the students in Nagaoka KOSEN studied abroad at overseas institutes which have academic exchange agreements with the institute, but also students from these overseas institutes have visited the institute. In April 2009, in order to promote international exchange activities, International Affairs Center has been launched at Nagaoka KOSEN. The main functions of this Center are the following three: to exchange and conclude an agreement with overseas institutes, to plan students’ overseas program as well as to help support Japanese students who wish to study abroad, and to help support non-Japanese students who enter from the 3rd year and study at the institute.

There was, however, an unbalance of the gap in the number of students between those sent to overseas and received from overseas. As a matter of fact, it was found that the number of students visiting the overseas institutes...
from Nagaoka KOSEN has been steadily increasing since 2007, while that of the receiving students ten years ago was none and has just started increasing in the past few years when the first author conducted researching the past international exchange activities in Nagaoka KOSEN. The limitation of program availability when receiving students is thought to be one of the main reasons why this unbalanced student exchange occurs.

Nakamura (2016) has mentioned that LEGO Robot Program has been mainly utilised at the time of both sending and receiving students at Nagaoka KOSEN. Taking for example, Nakamura (2016) explained that when eight lecturers from ADTECK Melaka and 3 teachers from Mongolia KOSEN visited Nagaoka KOSEN for a month in May and September 2015 respectively, the programs applied were 3D CAD training for the first two weeks and LEGO Robot program for the last two weeks. Since these programs require certain skills with the basic knowledge of CAD and/or computer programming, only a limited number of teachers from engineering departments can conduct and participate in it. Whereas teachers and professors who belong to the Division of General Education are less likely to, due to the fact that they teach the subjects of liberal arts, and therefore have less chance to make use of the engineering educational tools like 3D CAD or LEGO Robot programming.

In order to be able to increase the capability of receiving students outside Japan for their short-term study at Nagaoka KOSEN, one practical solution would be to devise a new program organized by the Division of General Education. By doing so, unlike specific engineering programs like LEGO Robot Programming, more teachers and professors of the Division of General Education can also be involved in the international exchange program at the institute. In this paper, the new program called One-Day Experience of KOSEN Classes was implemented.

The main participants of both parties during the six-day program are as follows: a group of twenty-two (two teachers, three female and seventeen male students shown in Figure 1.) from the Mechanical Engineering Division, Engineering Department of Ngee Ann Polytechnic in Singapore, three 2nd year and seven 4th year students, three teachers from the Division of General Education, one teacher from the Department of Electrical and Electronic Systems Engineering, and two staff from International Affairs Centre of Nagaoka KOSEN.

Students Exchange Schedule in Nagaoka KOSEN

For the preparation of receiving visitors from Ngee Ann Polytechnic in March, the conventional student exchange program called LEGO Robot program was utilised for one-and-a half day, followed by, as a first attempt, a new one-day program, called One-Day Experience of KOSEN Classes, was installed. After that, a one-day excursion including a visit of museums and manufacturing companies in Nagaoka City was conducted.

In early March 2018, a group of twenty-two from Ngee Ann Polytechnic in Singapore visited to Japan. The main part of their itinerary was to visit Nagaoka KOSEN for six days, hence, in preparation of receiving them, the International Affair Center at Nagaoka KOSEN mainly steered the program. The schedule during their stay in Nagaoka KOSEN is as shown in the Table 1. As it can be seen in Table 1, they arrived at Nagaoka KOSEN at midnight on Sunday March 4th, and checked-in at the student dormitory which is located on the campus of Nagaoka KOSEN. The educational program immediately started on Monday morning, the day after their arrival. After the completion of the campus tour, one-and-a half day LEGO Robot Programming activity was conducted until the evening of Tuesday March 6th, followed by a One-Day Experience of KOSEN Classes.

Table 1. Schedule of Ngee Ann Polytechnic in Nagaoka KOSEN

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Mar</td>
<td>08:30</td>
<td>Breakfast</td>
</tr>
<tr>
<td>4 Mar</td>
<td>09:30-10:20</td>
<td>Welcome (Meet president and take commemorative photo)</td>
</tr>
<tr>
<td>4 Mar</td>
<td>10:30-11:10</td>
<td>Tour (EE10:20-EC11:00-M11:30-CI11:50)</td>
</tr>
<tr>
<td></td>
<td>11:20-15:00</td>
<td>Lunch</td>
</tr>
<tr>
<td></td>
<td>15:00-17:00</td>
<td>System Square Co., Ltd.</td>
</tr>
<tr>
<td>5 Mar</td>
<td>08:30</td>
<td>Breakfast</td>
</tr>
<tr>
<td>5 Mar</td>
<td>09:30-12:00</td>
<td>Welcome (Meet president and take commemorative photo)</td>
</tr>
<tr>
<td>5 Mar</td>
<td>10:30-15:00</td>
<td>Tour (EE10:20-EC11:00-M11:30-CI11:50)</td>
</tr>
<tr>
<td></td>
<td>12:10-17:30</td>
<td>Lunch</td>
</tr>
<tr>
<td>6 Mar</td>
<td>08:30</td>
<td>Breakfast</td>
</tr>
<tr>
<td>6 Mar</td>
<td>09:30-15:00</td>
<td>Welcome (Meet president and take commemorative photo)</td>
</tr>
<tr>
<td>6 Mar</td>
<td>10:30-12:00</td>
<td>Tour (EE10:20-EC11:00-M11:30-CI11:50)</td>
</tr>
<tr>
<td></td>
<td>12:10-17:30</td>
<td>Lunch</td>
</tr>
<tr>
<td>7 Mar</td>
<td>08:30</td>
<td>Breakfast</td>
</tr>
<tr>
<td>7 Mar</td>
<td>09:30-12:00</td>
<td>Welcome (Meet president and take commemorative photo)</td>
</tr>
<tr>
<td>7 Mar</td>
<td>10:30-12:00</td>
<td>Tour (EE10:20-EC11:00-M11:30-CI11:50)</td>
</tr>
<tr>
<td></td>
<td>12:10-17:30</td>
<td>Lunch</td>
</tr>
<tr>
<td></td>
<td>17:30-18:00</td>
<td>Dinner</td>
</tr>
</tbody>
</table>

Figure 1. Twenty-two Ngee Ann Polytechnic visitors (in blue T-shirts)

Pedagogy

Participants of the Students Exchange Program
LEGO Robot Program

LEGO Robot Programming activity this time consisted of three parts: ice-breaker, LEGO Robot programming and presentation. Since it is a group work activity, making use of ice-breaker techniques at the beginning of the group work is essential for better cooperation to tackle against tasks as a team. For the ice-breaker this time, the use of Origami, a traditional Japanese paper craftwork was firstly conducted. There are some reasons why Origami was selected — it is the simplest yet one of the traditional Japanese craftworks, which can be readily experienced; students are inevitably required to communicate with each other; Japanese students can demonstrate how to manufacture and Singaporean students can then copy them, which is a kind of a reverse engineering; it can let students learn how to reach the geometrical design goal logically.

In addition to this activity, business card exchanging was also implemented. Moreover, Ping-Pong Ball-Toss Game, in which balls are thrown into a paper-made basket, or in other words, an open-top hat on a team-mate’s head was applied (see Figure 2). After the ice-breaker, the lecture of LEGO Robot programming, called Line-Trace Competition, took place with thirty-two-page long slides, one of which is shown in Figure 3. After the programming activity, each team finally made a short presentation in front of the participants and audience.

Figure 2. Snapshot of ice-breaker: Ping-Pong Ball-Toss Game

One-Day Experience of KOSEN Classes

The One-Day Experience of KOSEN Classes is devised for aiming to have teachers, who belong to the Division of General Department, participate in international exchange activity. This time, the One-Day Experience of KOSEN Classes consists of the following three liberal arts classes: mathematics class titled as Faster Finger Math Quiz, chemistry experimental class titled as Neutralization Titration, and physics experimental class titled as Swing of Pendulum. Each subject had a ninety-minute class taught in English.

Math Class: Fastest Finger First Quiz

In this mathematic class, a lecturer, who took care of the class, did not apply any traditional lecture styles. Instead, the lecturer was making use of the pedagogy of Active Learning. For conducting the class, the following two things had been prepared in advance. One was an apparatus designed for the Fastest Finger First Quiz, which has 15 electric button or buzzer cases connected to each other. Each of the apparatus has two different sound buttons: one is pushed when the answer is correct, whereas the other is selected when the answer is incorrect. For instance, the apparatus is used as follows: a person who solves out a math problem has to quickly push the button in order to obtain the right to answer first. If the answer is correct, the person who sets the question pushes the correct buzzer and if the answer is incorrect, he or she pushes the incorrect buzzer or vice versa. Second, the day before the class, the lecturer asked the ten Japanese students to create and bring one mathematic quiz in Japanese to the class, and prepare the oral explanation of the quiz in English, which could be solved by average high school students, who have fundamental knowledge of mathematical problems learned within or by the end of 2nd year of high school. The rules of the Fastest Finger First Quiz are as follows:
1. Quizzes are mathematical problems.
2. Each of the Japanese group members present in turn problems in Japanese.
3. Japanese students in other groups translate the problems into English.
4. Group members (mainly Singaporean students) try to answer the quizzes. (See Figure 4)
The team that obtains the most points is the winner.

Chemistry Experiment: Neutralization Titration

As shown in Figure 5, this chemistry experiment requires the usage of several experimental equipment. Students at Nagaoka KOSEN learn this experiment when they are 1st year students. Since the educational background of students from Singapore was unknown, this fundamental experiment was selected. Rice vinegar, a Japanese traditional fermentation product was used as an acid solution in this experiment. Before the experiment, the lecturer introduced the traditional Japanese vinegar production method for the study of cross-cultural understanding, by using both a video and a slide which is shown in Figure 6. After the instruction and lecture, the chemical experiment was conducted as shown in Figure 7 and all groups successfully completed the experiment without any trouble, and then the experimental results were filled into the handout as shown in Table 2.

Physics Experiment: Swing of Pendulum

According to the lecture of this experiment, this physics experiment, i.e., Swing of Pendulum, is known as a way of obtaining relatively accurate value of gravity, even though the preparation for this experiment is simple: a working table, stopwatch, string, and clip which are to work as a pendulum. Students at Nagaoka KOSEN learn this experiment when they are 2nd year students. Therefore, as the Nagaoka KOSEN students have already tried the experiment in advance, little instruction was required to conduct this physics experiment together with Singaporean students.

After the experiment, namely, the measuring time of the swing with different lengths of string that each group decided for conducting this experiment, the presentation of each group’s measurement results was implemented, followed by obtaining the value of gravity by calculating with the formula. (See Figure 8.)
Evaluation

In order to assess the effectiveness of each activity of the students receiving program at Nagaoka KOSEN, a questionnaire was given under the cooperation of the Singaporean students.

Results and Discussion

After the completion of all the activities during their stay in Nagaoka, a questionnaire was given to the twenty Singaporean students in order to obtain their frank opinions about the activities. The questionnaire asks respondents to answer in autonym. The answering form is a four-point Likert’s scale i.e., Very Good, Good, Bad, Very Bad, followed by a free description writing space provided, which is to be written in two lines. The results of the questionnaire are shown in Table 3.

Table 3. Results of questionnaire

<table>
<thead>
<tr>
<th>Activity</th>
<th>Very Good</th>
<th>Good</th>
<th>Bad</th>
<th>Very Bad</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice-breaking (5th Mar)</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>LEGO Line-trace competition (6th Mar)</td>
<td>11</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Math Fast Finger Quiz (7th Mar)</td>
<td>9</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Chemistry Experiment (7th Mar)</td>
<td>9</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Physics Experiment (7th Mar)</td>
<td>5</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

Four students could not answer to two activities due to their sickness absence in the afternoon on March 7th in which the Chemistry and Physics experiments took place. The ice-breaker on March 5th received a 100% positive answer: 50% Good and 50% Very Good. The LEGO Line-Trace Competition also received a 100% positive feedback: 45% Good and 55% Very Good. The Math Fast Finger Quiz received 5% Bad, 50% Good and 45% Very Good. Chemistry Experiment received a 100% positive answer: 44% Good and 55% Very Good. The Physics Experiment received a 100% positive feedback: 69% Good and 31% Very Good. As the results reveal, the feedbacks from the respondents were all positive except one Bad vote to the Math Quiz. Furthermore, below are the randomly extracted free-descriptions of each activity:

- Very interesting, making new friends (Very Good: Ice-breaker)
- Fun and engaging (Good: Ice-breaker)
- Made new friends and new experience (Good: LEGO Line-Trace)
- Too simple (Good: LEGO Line-Trace)
- It was a rather cool experience but yet there are areas of improvement like allowing us to have a better understanding of the programming instead of letting us experiment: (Good: LEGO Line-Trace)
- Very fun and competitive (Very Good: Fastest Finger Math Quiz)
- Didn’t really understand some questions but I had fun nonetheless. (Good: Fastest Finger Math Quiz)
- Bad questions were all over the place. (Bad: Fastest Finger Math Quiz)
- Tasted vineger. (Very Good: Neutralization Titration)
- It was enriching as I get to learn how the rice vinegar is made here in Japan. (Good: Neutralization Titration)
- The pendulum experiment was okay but the professor’s voice was too soft. (Good: Swing of Pendulum)
- It was refreshing my memory too. (Good: Swing of Pendulum)

As it is shown in the above free-descriptions, despite scoring positive marks in the Lickerts’ scale, there are some critical feedbacks in the free-descriptions. For instance, even the respondent who marked Good in the LEGO Line Trace, he wrote Too simple. In addition to this example, the one who scored Good in the LEGO Line-Trace mentioned It was a rather cool experience but yet there are areas of improvement like allowing us to have a better understanding of the programming instead of letting us experiment.

In terms of the Fastest Finger Math Quiz, there is a negative feedback, namely, Bad questions were all over the place. To improve the quality of the questions, the following countermeasures are to be considered for the future:

- Math questions and their explanations should be checked in advance. (Note: the negative effect on the tendency of questions by examiners might be arisen in this case.)
- Collect the Math questions in advance and rank the difficulty of each and show them in order.
- As for Project Based Learning (PBL), all the Math questions should be prepared by teachers, not by students.
Conclusions

In conclusion, the idea of how teachers in the Division of General Education get involved in the international exchange program when accepting students from overseas institutes was proposed in this paper, i.e., not only applying engineering related subject like LEGO Robot programming as a standard engineering activity, but an activity like the One-Day Experience of KOSEN Classes described in this paper, which are composed of subjects taught in the Division of General Education such as Math, Chemistry, and Physics experiments can be one possible and/or practical solution. It was also revealed that even though the classes were conducted in English, the feedback from the Singaporian students were mostly positive.

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References

Abstract

NIT, Toyama College provides unique international programs to the students. As Toyama College has variety of departments, namely, four engineering departments, Department of International Business, and Department of Maritime Technology, the interests of the students are very various. The author would like to share the outlines and outcomes of these programs and discuss how to modify the programs as effective as possible with global institutions and industry including ISATE attendees.

Keywords: Internship, Research project, Foreign institutes, Foreign factory, Company

Introduction

NIT, Toyama College provides unique international programs to the students. As Toyama College has variety of departments, namely, four engineering departments, Department of International Business, and Department of Maritime Technology, the interests of the students are very various. We provide 15 programs every year to satisfy the interests.

The author would like to share the outlines and outcomes of these programs as case study for the global education.

Programs for Advanced Course Students

We provide two kinds of oversea programs to the advanced course students. One is “Academic internship” and the other is “Company Internship”.

The students, who are interested in a research project, join the former programs. We conclude agreements with five foreign universities/Research Institutes, namely, King Mongkut's Institute of Technology Ladkrabang in Thailand, Pazmany Peter Catholic University in Hungary, Budapest University of Technology and Economics in Hungary, and so on. The students stay laboratories in these institutes for a month or a couple of months, work on specific research projects, which are assigned by the supervisors in the foreign institutes.

The students, who are interested in learning advanced engineering English, join the program held in South Eastern Regional College in Northern Ireland, UK. They stay in Northern Ireland for 4 weeks and learn how to describe engineering papers and abstracts. They also join the engineering class with local students.

The students, who are interested in the internship at the companies in foreign countries, join the latter programs. Many companies, whose head office is near Toyama College, have factories in Asian countries. Three companies in these companies cooperate with us. They have factories in Thailand or Malaysia and provide the opportunity for the students to experience in the factories for two weeks. In one program in Thailand, we also collaborate with the local college near the factory (Lamphun College of Agriculture and Technology). A Japanese student and a local college student participate the internship program as a pair. The Japanese student stay in the student dormitory of the local college. They live together with the local students and can experience daily life if they work in foreign countries. In this framework, all the members have merits. The company can make a connection with the local college through this program. The company do not worry about providing accommodation. The local college make a connection with the company. The students in the college can experience the internship in the company, and touch with Japanese culture. The Advantage for Toyama College is described above. I believe that this so-called “win-win” relationship makes the program continue.

Programs for Associate Degree Course Students

We provide unique programs for the students in associate degree programs. We prepare the programs for learning foreign languages, such as Engineering English, Business English, Russian, Chinese, and Korean. They stay in Hawaii, Canada, Russia, Taiwan, and Korea, respectively, for 2 to 3 weeks. They also learn the culture, history, customs in each country, because not only the language itself but also knowledge above is important to talk with foreign people.

We also have a program for cultural exchange for maritime students. I will report this program in the other paper in this symposium.

Short-term International Students

We accept short-term international students every year. We concluded agreement with KMITL in Thailand, Nanyang Polytechnic and Temasek Polytechnic in
Singapore. 20-25 students of these institutions in a year come to Toyama College. They stay in Toyama College for two or three months. During their stay, they work on research projects assigned by supervisors of Toyama College. We ask their interest and request based on “Researchers List” of Toyama College in advance and match as possible. They work on their research projects with Japanese students, 5th grade of associate degree course or 1st or 2nd grade of advanced course. During the collaboration, Japanese students also learn a lot from the international students. At the end of the stay period, they give us presentations about their research project in English. Figure 1 shows a picture of this presentation. The Japanese students attend the presentation, and give some questions in English. They live in student dormitory. Japanese students can know the cultural background. Unfortunately, not all students can go abroad, because it costs a lot. However, if we accept international students as much as possible, all Japanese students can have the opportunity to contact them. From this point of view, we initatively accept short-term international students.

CAST (Conference for the Advancement of Studies in Technology)

We host CAST every year. In this conference, advanced course students of 3 or 4 Kosen give presentations in English. We use teleconference system and the 3 or 4 Kosen students can attend the presentation. We invite up to 4 professors from foreign countries to ask questions or give the speaker some comments in English. The Japanese students can know the international conference from this opportunity. Figures 2 and 3 are pictures of this conference.

Conclusion

These programs obviously affect the students’ life plan. Some of the students choose the job as an engineer in foreign countries. We would like to modify the programs as effective as possible based on the discussions with global institutions and industry including ISATE attendees.
A STUDY OF STUDENT EXCHANGE PROGRAMMES
BETWEEN SINGAPORE & JAPAN

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Abstract

In this era of globalization, it has become imperative for exposure beyond national boundaries. Student Exchange Programmes have gained much popularity of late, and in order for the workforce to have an international outlook, the learning must start, preferably during impressionable student years. This study examined the effect of Student Exchange Programmes on the participants’ personal growth from participants’ perspectives. Moreover, this study examined factors that affected their perspectives on their personal growth through Students Exchange Programs. This research utilized quantitative research in order to get generalized data across groups of the participants, then utilized qualitative research, in order to get in-depth information at the micro level, closely focusing on individual exchange programme experience. Data was collected through survey questionnaires that were distributed to the participants of three such programmes: (1) 30 students on the Student Exchange Programme from National Institute of Technology, Hachinohe College, Japan, to Temasek Polytechnic, Singapore, in Fall 2017, (2) 20 students on the Student Exchange Programme from Temasek Polytechnic, Singapore, to National Institute of Technology, Tsuruoka College, Japan, in Fall 2017 and (3) 18 students on the Student Exchange Programme from Temasek Polytechnic, Singapore, to Ishikawa Prefecture, Japan, in Spring 2018. The qualitative data comes from interviews of these participants on their expectations and experiences in Singapore and Japan respectively.

The data revealed that Student Exchange Programmes may be one of the most beneficial experiences for the students in their late teens and early twenties (high school, college level and polytechnic students): (1) Global and cultural awareness: after the programme, the participants have a deeper awareness of global issues & trends, and greater sensitization towards understanding of different cultures and various world views. This exposure has a dual positive impact – it not only enhances their knowledge of cross-cultural values through interaction with foreign counterparts, but also increases awareness of their own cultural values, as they compare and contrast the differences, (2) Intercultural communication skills: they are motivated and provided the opportunity to improve intercultural communication skills such as foreign language proficiency, (3) Personal Growth: they perceive their own personal growth such as self-confidence, responsibility, independence, a spirit of curiosity & challenge, of taking leadership, problem-solving skills and the ability to take action, and (4) Professional Development (future career) in the long-term goals: they perceive future career in the world setting, expanding their geographies from the familiarity of only their own town / city / country , to an international arena across political boundaries. They view their career and their life with a broader vision, and beyond the immediate, many are encouraged and inspired to look at their medium to longer-term goals. In addition, this study found that Peer Interaction in the counterpart country, during these exchange programmes, is an important factor that encourages students of that impressionable age, to review themselves in their own cultural setting, and compare & contrast it with world settings in a positive way for a richer outcome. The findings suggest that International Student Exchange Programmes have an overall positive effect on young students’ growth – personally and professionally – and promote Global Citizenry for the immediate and foreseeable future.

Keywords: Student Exchange Programmes, Global exposure, Global Citizen, Cross Cultural Communication.

Introduction

Japan and Singapore established formal bilateral G2G relations in 1966, 52 years ago, and have steadily worked towards collateral exchanges in multiple areas
This study is a combination of quantitative and qualitative insights into the reasons for the participants choosing Japan or Singapore respectively, as a choice destination for Student Exchange Programmes; the opportunities and challenges they perceive of study trips to these destinations; and the learning gained through the cross-country exposure. In addition to areas mentioned above, they were also surveyed and interviewed about pre-trip and post-trip knowledge and preparedness status, perceived advantages and disadvantages, and change in outlook (if any) towards consequent and potential future interaction with the counterparts.

The sample pool for this study is currently restricted to those students from the National Institute of Technology, Hachinohe College, in Japan, and Temasek Polytechnic in Singapore, who went on these three specific exchange programmes over Fall 2017 and Spring 2018. They age between 15 – 19 year old Japanese students and 17 – 22 year old students from Singapore. They include both male and female students for a more balanced study.

The sample size of this study was a total of 30 Japanese students from the National Institute of Technology, Hachinohe College, in Japan, and 38 students from Singapore, studying various courses at Temasek Polytechnic.

There are several reasons for choosing participants of these exchange programmes for this study. They came from diverse backgrounds in terms of area of study as well as professional and personal aspirations. They had different levels of prior global exposure, as well as varied depth of knowledge and experience of Singapore and Japan. This gave us a more generic and holistic view of participant responses, without biases that could potentially stem from singularity of area of study and exposure. Another reason for selecting this sample pool was due to the observation over time and multiple runs, that these particular programmes are over-subscribed and where possible, have grown in numbers. This observation does not suggest that other such programmes have not seen similar enthusiasm and participation growth.

In terms of location, this study was conducted in both Japan and Singapore. It was carried out in the home-country after the students had returned from the trip and after giving them time to settle from the initial exuberant emotions that may cloud judgment and may result in bias in responses.

The data collection was carried out from the following sources: (1) A questionnaire for all the Japanese and Singaporean students who participated in three different Student Exchange Programmes: English and Cultural Exchange Programme for Japanese students held at Temasek Polytechnic in Singapore; Global Citizenship trip for Singapore students held at National Institute of Technology, Tsuruoka College, Japan; and Ishikawa Japanese Study Programme for Singapore students held at Ishikawa Prefecture in Japan, to glean their perspectives on the learning outcomes of the various programmes; and (2) Interviews (open-ended interviews and semi-structured interviews), in order to examine the factors that affected their perspectives on their growth, with six Japanese and six Singapore students selected...
from the sample pool. The combination of data collection methods is important in order to understand deeper perspectives from the participants’ viewpoint and in order to enhance verification of the findings. This study explores the viability and usefulness of such exchange programmes from the learner-participants’ perspectives, and hopes to makes suggestions for enhancing these programmes. It also hopes to justify the rationale for continuing such positive exchange programmes in the future.

**Results & Discussions**

The participants’ perspectives on their personal and professional advancement through the intended learning outcomes for these Student Exchange Programmes was studied via a Survey Questionnaire.

**Survey Question 1a (to Japanese students): Highlight 2 main reasons that encouraged / attracted you to participate in the Student Exchange Programme to Singapore.**

- To improve their English Language & Communication skills - 87% of the participants
- To learn more about Singapore Culture, Lifestyle & Cuisines - 50% of the participants
- To make friends with Singapore peers and fellow students - 59% of the participants
- Others / Undetermined - 4% of the participants

**Survey Question 1b (to Singapore students): Highlight 2 reasons that encouraged / attracted you to participate in the Student Exchange Programme to Japan.**

- To improve their Japanese Language & Communication skills - 24% of the participants
- To learn more about Japanese Culture, Lifestyle & Cuisines - 100% of the participants
- To make friends with Singapore peers and fellow students - 55% of the participants
- Others / Undetermined - 21% of the participants

**Discussion:**

It is interesting to note that whilst 87% of the Japanese students see Singapore as a destination for improving (English) Language and Communication Skills, only 24% of the Singapore students choose to go on these Student Exchange Programmes with improving (Japanese) Language and Communication Skills as their goal. There were responses like “As I don’t like English, I’d like to conquer it,” “I would like to see and understand different cultures that I cannot experience in Japan,” “I would like to make foreign friends and establish friendship”.

The large number of Others / Undetermined Singaporean participants – 21% - are attracted to Japan to experience her varied Nature, Cool Temperatures and Small City Destinations and Countryside. These are not available in Singapore, and are thus fascinating for the Singapore students. 100% of the Singapore participants want to go to Japan because of the Japanese Culture, Lifestyle and Cuisine that they have been introduced to in Singapore itself, because of the popularity of J-Pop, Manga, Anime and Japanese cuisine in Singapore.

**Survey Question 2a (to Japanese students): What were most significant things that you learnt or got from this student exchange programme to Singapore?**

- New Friendships from Singapore - 93% of participants
- Understanding of different cultures, values & ways of thinking - 87% of participants
- Broader Vision of World Views and greater Open-Mindedness - 87% of participants
- English Communication Skills – 80%
- Confidence, Independence, Self-Reliance, Responsibility – 60%
- Caring for Others & Environment – 2%
- Others – 4%

**Survey Question 2b (to Singapore students): What were 4 most significant things that you learnt or got from this student exchange programmes to Japan?**

- New Friendships from Japan - 92% of participants
- Understanding of different cultures, values & ways of thinking - 100% of participants
- Broader Vision of World Views and greater Open-Mindedness - 95% of participants
- Japanese Communication Skills – 22%
- Confidence, Independence, Self-Reliance, Responsibility – 74%
- Caring for Others & Environment– 10%
- Others – 7%
Discussion:

Singaporean students commented that they felt that the exposure to a new culture and surroundings helped them push their boundaries, become much more confident and find solutions to challenging situations. The concept of Punctuality and appreciation of Time within the Japanese culture was an eye-opener for them. The Onsen experience, though intimidating initially, helped them overcome their inhibitions and become much more open-minded. Interaction with students or even host families in Japan found them new friends for the long run. Some are even hosting their friends and host families from Japan, in Singapore. Independence and self-reliance were big learning areas for Singapore students, especially for students staying with host families for the IJSP. They had to learn to communicate without proficient Japanese language skills. “I learnt that the world is a bigger place than I had thought earlier. It has broadened my mind and encouraged me to be open-minded”. “During my homestay, I experienced Japanese hospitality and saw how caring they are.. I learnt that I must care for others too, for a better society.”

For the Japanese students who had essentially wanted improvement in English language skills and Cross-Cultural exposure as their main take-aways, found that they achieved those goals. In addition, there was personal development and self-reflection throughout the exchange programme. The growth in their confidence, self-reliance and independence spilled over to other tasks they consequently undertook, even after the return to Japan. “I would like to broader my values, and integrate good points of Singaporeans into my life”. The fear of unknown situations and new surroundings was much reduced due to these Student Exchange Programmes.

Survey Question 3a (to Singapore students): What were your 2 biggest challenges on this student exchange programme to Japan?

- Language and Communication Barrier - 88% of participants
- Culture Shock - 65% of participants
- Lack of Knowledge of Host Country – 26%
- The need for Self-Reliance and Problem Solving – 16%
- Others – 5%

For Japanese students, one of the biggest challenges was also Language and Communication. Even those more fluent in English may struggle initially with the accent, as they are used to the American accent. In addition, Singlish, with various local expressions and terminology from dialects, is popular in Singapore and spoken by most of the Singapore poly students. These could be further distractions in the communication. Another challenge that was evident from the study, was for participants to remain positive and gung-ho despite struggling with the weather in Singapore and the Culture Shock.

Survey Question 3b (to Singapore students): What were your 2 biggest challenges on the student exchange programme to Japan?

- Language and Communication Barrier - 88% of participants
- Culture Shock - 65% of participants
- Lack of Knowledge of Host Country – 26%
- The need for Self-Reliance and Problem Solving – 16%
- Others – 5%
Survey Question 4a (to Japanese students): Has this student exchange trip encouraged you to interact more with Singapore students / people post programme?

- “Yes” – 90%

Japanese students shared that the trip had certainly encouraged them to interact more with Singapore students and they kept in touch via social media app - Line. They also expressed that the programme had encouraged them to visit Singapore again and to interact with friends made here.

Survey Question 4b (to Singapore students): Has this student exchange trip encouraged you to interact more with Japanese students / people post programme?

- “Yes” – 95%

Singapore students shared via the survey answers that they continued to keep in touch with their peers / counterparts and host families even months after the programme, mainly via social media like Line. Apart from people they already had interacted with in Japan, they also shared that their overall inhibition in communicating with the Japanese had gone down. Japanese language skills had improved thanks to the programmes. That aside, they felt confident overall, in communicating with the Japanese, even if their Japanese Language skills were entry level. In fact several had helped in the hosting of other Japanese Student Exchange Programmes and felt much more confident when interacting with the Japanese students in these programmes than before they had embarked on their own exchange programme.

Post-Trip Evaluation for Japanese students:

Achievement of intended outcomes for Student Exchange Programme: 97% of the participants said that they were successful – (23% Strongly Agree & 74% Agree), whilst 3% were Neutral.

Satisfaction of the Content of the Students Exchange Program to Singapore: 80% of the students answered Very Satisfied, 13% Satisfied, 7% Neutral.

Discussion

Factors affecting participant perspectives on the learning outcomes of student exchange programmes were examined through interviews that were held separately with 6 Hachinohe students and 6 Singapore students.

The data revealed that Student Exchange Programmes are probably one of the most beneficial experiences students in their late teens to early twenties could have, when they are at high school, college or polytechnic.

(1) Global Citizenship and Cross-cultural Awareness: the participants have a deeper global and cultural awareness and understanding of different cultures and
different views after the student exchange programme. As they are exposed to behaviours, norms and values different to theirs, they gain better understanding of their own preferences, and thus can respond more appropriately in cross-cultural settings. It was evident from the survey findings of this study that Cross-Cultural Exposure and Competence was high on the goals as intended outcome for the programmes, as determined by the participants. This goal was successfully achieved through the programmes.

This development of Global Citizenship amongst the participants, sensitizes them more to environmental responsibility and enhanced awareness of Global Issues. Some Singapore participants felt that they were much more competent in understanding Japanese culture and thus consequently 4 participants wanted to do their internship in Japan and 3 have also expressed the desire to work there in the future.

(2) Intercultural Communication Skills: One of the major goals for Japanese students on these exchange programmes is to learn English leading to more effective cross-cultural communication. For the Singapore students it is not only about understanding the Japanese language, but also understanding the unsaid and unspoken nuances, below-the-surface messages.

(3) Personal Growth: These overseas Student Exchange Programmes see tremendous contribution in this area - participants perceive their own personal growth such as self-confidence, responsibility, a spirit of challenge and problem solving, leadership and teamwork, ability to take action and feeling empowered. Singapore students commented that they would like to imbibe qualities like humility, hospitality, generosity and caring as they had witnessed from their Japanese peers and hosts. Japanese students admired the independence and assertiveness they had seen amongst the Singaporean students and wanted to adopt it for their future personal growth.

(4) Professional development (future career) and long-term goals: Participants perceive future careers in the world setting, expanding the working location from their own country to foreign countries, and view their career and their life with a broader vision. This then encourages them to think about their longer term goals as well. They start with participative opportunities in more such Student Exchange Programmes and also look for Internship opportunities overseas. The unknown does not appear as daunting as they have progressed in Self-Reliance and Independence.

Conclusion

Student Exchange Programmes have gained much popularity in recent years with more student participants than ever before. Endorsement by various agencies and institutions via funding granted also helps students undertake these overseas trips. This encourages young adults to leave their comfort zone and acquaint themselves with cultures beyond their own. The knowledge gained, creates a sense of familiarity, reduces the fear of the unknown and thus paves the way for opening up minds to further exploration. This in turn instils in them a sense of adventure and encourages them to be willing, and more able, to take seemingly perceived risks in order to accomplish cross-border connections.

Japan and Singapore are natural counterparts for such student exchanges. Common factors like safety, efficient infrastructure, long-standing connections and a mutual fascination with the other are reasons participants are eager to go on these programmes.

This study has highlighted the numerous benefits of such overseas programmes for the participants – both personally and professionally. Participant perspectives in this study have validated the success of the intended learning outcomes for these Student Exchange Programmes. Whilst the challenges faced by them initially, build grit, determination, a spirit of adventure, calculated risk-taking and problem solving skills, there is the potential of further training for preparedness prior to these trips.

Acknowledgements

We sincerely appreciate for faculty and staff members who have been involved in these student exchange programmes, both in Japan and Singapore. They have been wonderful mentors and support for students as they go through their learning journeys. These programmes would not be able to continue without their buy-in and belief on the positive impact these have on the students’ personal & professional growth.

References


E-ASSESSMENT OF COMPUTER PROGRAMMING

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Abstract

This paper demonstrates how we have used Dewis, an algorithmic open source e-assessment system, to automatically assess programming skills, in particular, in the C programming language. Teaching and assessing programming skills is challenging; prior to the implementation of this automatic assessment system, computing assessments were marked manually and this proved unpopular with students and academics due to the delay in marking and providing feedback. This new approach enables students to submit their computer code online through a link on their Virtual Learning Environment. From a student’s perspective the marking process takes a matter of seconds before the student is provided with a mark and feedback. A number of pre-submission and post-submission checks are performed on the student’s supplied code. These are essential to ensure that the student’s code satisfies certain operational and security requirements before running on the system. Typically, the e-assessment system executes the student’s supplied code a number of times with different input sets and the student’s code is evaluated based on their code’s resulting output. Prior to execution, the student’s code may be augmented by Dewis-specific code to facilitate deeper analysis of the student’s code. The analysis of the code’s output enables the system to respond to the student’s submission with ‘intelligent feedback’. This feedback explains to the student, where appropriate, reasons for their submission not scoring full marks. There are also in-built detectors for ‘common student errors’ which, when triggered, further enhances the intelligent feedback. In their first few weeks at UWE Bristol, students are presented with a number of mini-tasks involving assessing C competencies with Dewis. These tasks are purely formative, support is given to students in computer lab sessions and students may submit as many times as they wish. Later on in their first year, students are given more significant programming projects (e.g. the n-Queens problem, path-finding problem), the assessing of which is summative. Results show that this innovative work is making a positive impact on students.

Keywords: C programming, e-Assessment, intelligent feedback

Introduction

The use of e-assessments in the Department of Computer Science at the University of the West of England (UWE) is well established both for formative assessments and for examinations. These assessments have been designed to primarily assess the students’ knowledge of computer science principles as opposed to computing in practice. Further, with most of these assessments being of the form of multiple-choice questions, there is limited scope for ‘intelligent feedback’ in response to the students’ input. We do make extensive use of Blackboard ‘tests’, which provide a range of different question styles, and considerable scope for bespoke feedback attached to different correct/incorrect responses. These have proven highly successful for summative and formative assessments, and provided useful cohort-level analysis of different questions. Some of this work was supported by external funding (e.g. UK Higher Education Authority grants) and these resources have been made available for sharing by the community. However, assessing more than simply ‘recall’ requires considerable expertise in question design to test higher level skills in problem analysis and reflection. The success of these e-assessments led to the consideration of whether e-assessments could be applied to test students’ ability in the practice of computer programming. At the start of this project we undertook a review of available systems for providing automated teaching and assessment of coding. While there is a body of materials available for interpreted languages such as Python (such as the courses in Codeacademy.com) there was nothing available for languages which require code to be compiled and run (e.g. C, Java/C++) because of the security implications and difficulties in providing bespoke feedback related to specific learning activities.

In previous years, the summative assessment of computer programming in the module Artificial Intelligence on the Computer Science award at UWE, took the form of students submitting computer program solutions to set assessments via a VLE with the academic marking each submission by running the code and assessing the output. The main disadvantage of this process was, with a large number of student
submissions, the turnaround time it took for the academic to mark the submissions and provide feedback. To some extent this can be ameliorated by arranging for students to provide in-class ‘walkthroughs’ of their code, which provides great scope for immediate feedback and discussion, but this creates significant timetabling issues on large modules and it can be hard to automatically capture face-to-face feedback for students to reflect on later. With UWE having their own algorithmic e-assessment system (Dewis) running on a Linux web-server, it was decided to develop that system to e-assess these computer code submissions.

Dewis is an e-assessment system created in 2006 at the UWE’s Mathematics department (Gwynllyw and Henderson, 2009; Dewis Development Team, 2012). The primary purpose of the system was to provide algorithmic and intelligent e-assessments in numerate based subjects. In addition, the system was designed to be data-lossless so that all data for all assessment attempts is kept on the system’s server. The question-editing mechanism on Dewis allows significant flexibility in the design of the question and includes coding the assessment on the server side (primarily using Perl) and on the client side (using html, css and javascript). The Dewis system is used extensively at UWE Bristol, and its satellite colleges, across several subject areas including Mathematics and Statistics, Engineering, Computing, Accounting, Science, Nursing and Business Studies. It is also used at other UK HEIs. The system is designed to support both formative and summative assessments and also has an ‘examination setting’ designed specifically for e-assessments in controlled conditions. The success of the system, its flexibility in the question authoring and its data-lossless storage made Dewis a natural consideration for hosting the e-assessment of computer programming at UWE. In addition Dewis had already been used to communicate with other programming environments. For example, Dewis has used system calls to Python/Sympy to implement a computer algebra system and it has also been used to interact with R to produce statistics e-assessments (Gwynllyw, Weir, and Henderson, 2015; Weir, Gwynllyw and Henderson, 2015).

The Dewis system was modified to allow for students to submit computer code, concentrating initially on submissions of the C-programming language. Two projects were started in 2015 which we will refer to as project-F (formative) and project-S (summative) for the purposes of this paper.

**Project F (Formative e-Assessment)**

Being able to program in C is not an entry requirement of the Computer Science award at UWE but it is highly desirable that students learn the basic C programming syntax at an early stage. Depending on the award taken, students at UWE may learn C (BSc Robotics), Java (BSc Computer Science) or C++ (BSc Games Technology), but in the early stages C is a good choice as it avoids the issues of object orientation and the syntax is common to these (and other) languages.

Retention on Computer Science and related awards is a national problem and, although UWE does well in this regard compared to other UK HEIs, it is still highly desirable to increase the retention rate. One contributory factor to low retention is that some students have particular problems with programming and it was recognised that such issues need to be identified and addressed as early as possible. Further it was recognised that a large number of computing students are activist learners and thus it is desirable to support their learning by supplying formative computing tasks to aid their learning. Providing such computing tasks with manual marking and fast feedback is infeasible due to the large number of students and the lack of staff time on the award. In a previous year, first year students were invited to email their tutor with their solutions to a small programming task. Take-up on this invitation was high which lead to excessive delays in feedback and a negative student experience.

Following a ‘works in principle’ period with the e-assessment of C computer code, it was recognised that automated assessment could support a 3-week introductory course in programming starting in induction week. This course was aimed to remove some of students’ fears about programming by enabling a sense of recognised achievement. It was also aimed at facilitating a rapid understanding of basic C programming syntax, especially in the use of conditional statements and loops. The course provided computer laboratory sessions but students were told they also had to commit a significant amount of self-study hours (the pace of delivery was aimed to require approximately 4 hours per week) and to become used to the habit of using other resources such as the Faculty’s drop-in ‘expressoProgramming’ sessions. The use of e-assessments accommodated for the different work patterns that students employed and provided instant feedback on the students’ submitted work, thus enhancing the student’s experience of the course.

An important part of this project was the monitoring of student engagement. Students’ engagement with these e-assessments was monitored through the e-assessment system’s performance reporter; this monitoring was in addition to the traditional engagement measure of attendance recording. Non- or low-engagement students were emailed directly by the module team in addition to passing engagement information on to a dedicated retention monitoring team.

With regards the e-assessment’s specific contribution to this short course, eleven formative tasks were identified by academics to teach basic computer programming constructs. These C-programming tasks were as follows:

**Task 1**: Print out a specified string and then wait between 5 and 10 seconds, and then terminate. This assesses the ability to combine and modify simple code snippets.

**Task 2**: Print out a specified string and then wait for an input character from the user. Echo that character back
and terminate. This assesses simple i/o and the use of ‘print and pause’ constructs useful in debugging.

**Task 3:** Perform the addition of two floating point numbers that are read interactively during run time from the keyboard (via scanf). Output the resulting addition if both the two inputs are numbers, otherwise output ‘invalid input’. This assesses simple interactive conditional flow.

**Task 4:** Same as Task 3 except that the inputs for the program are taken at the start of the run process - provided via the command line (via arg).

**Task 5:** Similar to Task 4 except the requirement is for the calculation of the quotient of two floating point numbers. If the second number is a zero then output ‘invalid input – division by zero not allowed’. This assesses simple conditional flow.

**Task 6:** Read an operation from the command line of the form $x \circ y$ where $x$ and $y$ are expected to be numbers and $\circ$ is expected to be one of ‘+’, ‘-‘,’$\times$’ or ‘$\div$’. If the input is not as expected, then output ‘invalid input’. If the calculated output is not a number then output ‘invalid output’. Otherwise, output the numerical value. This assesses more complex conditional flow (e.g. embedded if/or switch constructs).

**Task 7:** Modify Task 6 to include the option of a ‘running total’ whereby the code accepts, as input, a file containing a sequence of operations of the form $x \circ y$. In addition, if the character $p$ appears in the place of an expected number, then the $p$ assumes the number in the immediately preceding calculation. This assesses the use of mechanisms for storing state/history.

**Task 8:** Similar to Task 7 but the reading of the input and its validity testing is done using a call to a function called ‘read_and_validate_input’. Further, the implementation of the numerical operations should be done using calls to functions ‘addition()’, ‘subtraction()’, etc., implemented using signatures supplied to the student. This assesses the use of modularisation and code re-use.

**Task 9&10:** Print out an 8×8 checkerboard containing o’s and x’s generated using two nested ‘for’ (Task 9) or ‘while’ (Task 10) loops with each execution of the inner loop producing exactly one character. These two tasks assess the use of iteration.

**Task 11:** Read a string via the command line and output eight strings on different lines, with each output containing the input string but with the final character replaced by the loop count (1..8). This assesses the use of more complex data types such as arrays.

It was an essential requirement of the construction of these 11 e-assessments that the student experience was a positive one. This included consideration to the ease of the student submitting their solutions and the efficacy of the feedback in the case of a student’s submission being rejected (e.g. their code containing illegal content or not compiling) or their submission being incorrect in that their code does not satisfy the assessment criteria.

The process of submission of C-code involves the student accessing the relevant module’s web page on the university’s VLE and, from there, accessing the assessment task’s specific Dewis page via an LTI link (such a link allows for Dewis to pass back the student’s attainment mark back to the VLE’s Grade Centre). The Dewis system then prompts the student to submit their C-code. Such a prompt, for Task 1, is shown in Figure 1.

![Figure 1: Dewis prompt for the student to submit their code for Task 1.](image)

The submission process involves Dewis eventually running the student’s C-code on the Dewis server. This action has significant security implications and hence there are a number of checks the Dewis system makes to ensure that the student’s code cannot be malicious. A result of this is that there are a number of commands that Dewis prohibits from being submitted in the student code. These commands include, for example, potentially malicious system calls and the inclusion of undesirable header files. As part of ensuring a positive student experience of the process, these security checks are made on the student code when they link their C-code to their web browser. That is, these checks are made prior to the student submitting their code to the Dewis system. On detecting prohibited content, the student is informed immediately that their submission cannot proceed together with the reason for the barrier. Text on the VLE page for each task provides more help in these cases.

Having submitted the code, the next stage is for Dewis to compile the code. If the student’s code fails to compile, the system will echo back to the student the compilation error. In the case of a common compilation error being triggered, the system will aim to supply suggestions to the students to address the error. A compilation error can be construed as detrimental to the student experience and, in the case of a student preparing their code on a different operating system to that of the Dewis system (Linux), a compilation error may not have been anticipatable by the novice programmer. Because of this, most Dewis assessments of this form have an associated ‘compiler check’ assessment whereby students can check their programs for compilation on the Dewis server without foregoing an assessment attempt.
For some of the assessment tasks, prior to executing the student’s submitted code, the Dewis system will augment this code with additional code to facilitate the marking process. For example, for Task 9, augmented code is used in order to ensure that the correct number of nested for-loops are used in the construction of the required output.

An example of the Dewis system detecting a code submission on this assessment task not satisfying the criteria is given in Figure 2. The feedback informs the student as to the reason why their submission was deemed incorrect. In this example, the student used only one for-loop (1..8) with each execution producing complete lines in the grid (‘oxoxoxox’ or ‘xoxoxoxo’).

Following the feedback in Figure 2, this student subsequently submitted an entry which was unaltered except that it contained a ‘null’ inner for-loop (1..8) which produced no output. Again, the Dewis system informed the student that their submission did not satisfy the criteria. This later student submission was presumably an attempt to trick the Dewis system. It was encouraging to note that the student did eventually submit code that satisfied the task’s requirement.

Impact

Student uptake on these tasks has been encouraging. For example, Table 1 shows the uptake results for the 2017/2018 academic year.

<table>
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<tr>
<td>11</td>
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<td>135</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 1: Engagement statistics for the eleven summative tasks. For each task, the 2nd column lists the number of students that submitted their C code, the 3rd column lists the total number of submitted attempts, the 4th column lists the number of students who fully achieved the tasks’ criteria.

Since these tasks were formative, there was no limit as to the number of attempts for a student to attempt these tasks. In most cases the students had several attempts at each task, seeking targeted help in response to the system’s feedback and worked through their code to eventually produce code that met the assessments’ criteria. For example, from Table 1, we see that 171 out of the 189 students that attempted Task 1, succeeded in submitting C-code that satisfied the task’s requirement. This level of engagement is mirrored by the volume of emails, and hence staff-student interactions generated. Notably, as we have refined the system over 2-3 years, the volume of emails, particularly regarding later tasks, has been reduced without the patterns of engagement changing. The process of identifying recurring issues in emails and error logs, and then amending the system to recognise and respond to those cases, has been successful in moving from manual to automated feedback. The system is transparent enough for students to ‘learn how to learn’ – taking more time to use the automated feedback.

The drop-off in the number of submissions reflects to some extent the different rates of progress that students were making on their ‘standard’ programming modules. Anecdotal evidence via students emails and anonymous end-of-module feedback also suggests that some students engaged less if they felt that the system was ‘overly restrictive or strict’ in terms of the constructs allowed and the way that exact output formats are required (e.g. use of capitalisation, spaces etc.). Capturing this feedback has been invaluable for staff, and we now pay considerably more attention in-
class to pointing out that the days of the ‘lone developer’ are largely over, and that all code should be designed for a specific purpose and tested to meet specific requirements and interfaces. Being able to pull specific (anonymised) examples of code that ‘looks right but does not meet the specifications’ is invaluable in providing concrete examples of more abstract ideas.

These formative tasks are now being used on several different modules across various awards and being used in level two to help students refresh their C-skills as a form of pre-requisite test.

Anecdotal evidence of the success of this was an improved performance in the summative assessments discussed in the next section. Since the introduction of this system, tutors in-class have noted a significant increase in the proportion of students discussing algorithmic issues in more advanced problems as opposed to programming syntax issues. E.g. students were more comfortable with writing out algorithms in pseudo-code to discuss functionality as opposed to syntax.

A highly positive outcome has been that by the fourth week of term we are able to get students collaborating in-class to work on pseudocode designs and mechanisms for simple algorithms – valuable learning activities that had not previously been possible. Familiarity with basic programming constructs means that, from far earlier in the module run, lectures can include pseudo code and code snippets to demonstrate search and machine learning algorithms. For many of our students this helps demystify the abstract definitions.

Other staff who used some of the first activities during induction week have also commented that these provided a useful ‘icebreaker’ mechanism to get students collaborating and problem-solving.

Project S (Summative e-Assessment)

Dewis was also used for the e-assessment of C-programs in a summative environment in the module ‘Introduction to Artificial Intelligence’, part of the Computer Science award. There are two such assessments on this module and initially they were quite low stakes (each accounting for 12.5% of the total marks for the module). Although the two assessments seem quite different, they are closely related in that they both require the student to produce C-code that solve problems involving search algorithms. The two problems are:

- the 8-Queens problem, solved using Depth-First Search;
- the shortest path problem (SPP) using Dijkstra’s algorithm on a map modelled by a square grid.

These two problems are both ‘search’ problems, and use a common code framework (written by the academic) provided to the students and used for earlier tutorial work. One of the intended learning outcomes is to see how a framework can be used to (i) implement different algorithms and (ii) tackle very different problems, with only very minor changes (typically a few lines).

In previous years, students were given a tool written in Netlogo that involved PacMan searching a maze (Smith, 2009). Switches allowed students to choose policies to apply whenever a junction was made, and these effectively implemented different algorithms. The students were then asked to write down their results and to submit their solutions via the VLE for manual marking. However, while providing a nice visual interpretation of the effects on a toy problem, the module leader wanted the students to implement the algorithms in actual code with the aim of ensuring a better understanding of the functionality of the algorithm.

For the assessment of these search algorithms, the Dewis marking process will be two-fold, namely:

- the solution is checked for correctness;
- the number of candidate solutions considered is consistent with the method of search.

The latter criterion was included to ensure that the student’s code implemented the correct method of search. Full marks are awarded to the student’s submission if, and only if, both these criteria are met.

For both types of problems, the student’s code was executed a number of times for different inputs. The inputs for the two problems are as follows:

- 8-Queens: the position of the Queen in the first row of the chessboard;
- SPP: the start and end point of the path on a square grid, together with the location of the obstacles on the grid.

In the case of the ‘number of candidate solutions’ considered being incorrect, the marking algorithm would attempt to identify a pattern in the number reported by the student’s code. For example, some students’ code consistently produced a numerical value one higher than the correct solution. In such a case, the student would be informed of this, together with stating common reasons that code consider one more candidate solution than is required.

The two current metrics effectively perform black box testing of the supplied code, therefore test problems have been designed to ensure that different algorithms give different results. For the next academic year, the code has been further refined to perform ‘white-box testing’, via checking of values that student’s code passes as parameters to supplied functions.

For these summative e-assessments, the student was only required to provide the ‘main’ function call for solving the problem. As part of the student’s development of their code, their code would be built with pre-supplied code (written by the academic), and they are told what a subset of the intended results should be (i.e. for one starting queen position or map).
The student would submit, to the Dewis system, only the ‘main’ part of the code. That is, the pre-supplied code that is part of the build, already resides on the Dewis system. The version that resides on the Dewis system keeps track of the number of candidate solutions considered in the search process as well as the final solution obtained in the search process. As such, the Dewis system does not depend on the student’s code telling it the solution nor the number of candidate solutions. This ensures that the correct solutions are not obtained artificially (e.g. hard coded in the student code).

Results

Quantitatively, any difference in the coursework pass rates is smaller than the annual fluctuations seen on any course. Qualitatively, feedback from students has been that they appreciated the opportunity to submit in their own time – giving them the chance to manage different demands on their time safe in the knowledge of the marks they would get.

Following the success of the phase one project, the assessment regime of the module has been changed to incorporate a further two exercises (again each worth 12.5%). In the third task, students submit a text file containing the knowledge base for a chatbot in AIML. The Dewis system marks and provides feedback by running a java programme that exploits the file handling and output-interpreting mechanism developed. Students are told the ‘questions’ in advance, and marks are awarded according to how well their knowledge base exploits different language features.

The final task requires students to submit a C code implementation of the machine learning algorithm of their choice, which is assessed via its predictive accuracy on a number of datasets designed to test aspects such as handling duplicates, class imbalance etc.

The impact of these two more ‘open-ended’ pieces of coursework, where competition has been encouraged, has been incredibly positive. In both the last two years an ‘arms-race’ has developed with students contributing specific ideas to discussions of how the tests could be made harder/ more discriminating – via different chatbot questions, or datasets with different characteristics. In the machine learning task some students implement simple algorithms such as K-nearest neighbours, but we have seen example of Bayesian networks, Rule Induction algorithms, and Multi-layer Perceptrons being submitted.

As we have said previously, many of our students self-identify as being predominantly activist or pragmatist learners and many are more likely to submit credit-bearing work. Dewis’ ‘instant marking and feedback’ means that the depth of insights displayed during in-class discussions about the merits of different approaches has been raised to new levels by the provision of learning activities more suited to our students’ styles of learning.

Discussion

The success of the approach described in this paper, which allow students to “self-learn” programming skills, has led us to develop the system further. Competence in programming is desirable in many academic disciplines, not just for Computing students. Indeed Bond (2018) recommends that computer programming becomes a core part of mathematics degrees. In the forthcoming 2018/19 academic year, the e-assessment of computer programming will be extended to Level 3 Mathematics students using Python on the Numerical Analysis module at UWE Bristol. Students will be required to write numerical methods in the Python programming language and this will be assessed automatically using Dewis.

Previously, a manual marking process was employed for the Numerical Analysis module but the workload involved in processing these student submissions resulted in difficulties in producing appropriate and timely feedback. The cases whereby the feedback was delayed resulted in negative student feedback about the process. The previous deployment of Dewis to e-assess computer code in C means that the development time required for Dewis to e-assess Python was significantly reduced.

The success of this extension to the project will be evaluated using student feedback via the module evaluation process and a comparison of student performance in their programming competencies.

References


NURTURING PRE-PROFESSIONALS BY SCAFFOLDING 21ST CENTURY BUSINESS LITERACY SKILLS THROUGH AUGMENTED REALITY

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Abstract

Foundational literacy skills in critical reading and writing can impact pre-professionals' employability and career prospects. Classroom instruction alone is often insufficient and self-directed learning is essential for mastering literacy skills for future business success. This is because practice must extend beyond formal instructional hours for skills mastery. Few studies have specifically explored the issue of literacy skill attainment in business studies using new technologies. Most studies focus on language acquisition or content knowledge rather than literacy as a skill. For preparing 21st-century professionals, a technology-integrated approach is just as essential as workplaces become increasingly digitalised. This study explored how augmented reality (AR) could improve digital business literacy skills so that pre-professionals gained a future career advantage. AR holds the potential for the contextual embedding of literacy instruction scaffolds. An AR learning app was thus developed to provide self-directed learning using Vuforia and Unity 3D. The developed AR learning scaffolds included three types of contingent or just-in-time learning interactions, which learners could trigger – displayed explanations, guided instruction, and self-assessment. A randomised controlled trial with pre- and post-proficiency tests was used. The experimental group used AR while the control used printed materials. It was found that the experimental group significantly improved their literacy skills compared to the control groups. It is thought that the experimental group achieved higher literacy proficiency due to AR being more intuitive and the different scaffolds allowed for a greater immersion into logical and critical thought. The learners who benefitted the most were those who achieved lower proficiency scores in the pre-tests. Contingent AR scaffolds enable learners to quickly and intuitively receive digital content, which facilitates skill development for self-directed literacy improvement. The triggered just-in-time access to visual information and instructions supplemented with text, guided learners towards higher proficiency attainment. AR shows promise as an emerging educational technology. This is significant because integrating new technologies like AR can help prepare pre-professionals who are increasingly differentiated at the workplace by their ability to communicate and work with digital information.

Keywords: Augmented reality, Business literacy, Critical reading, Critical writing, Scaffold, Self-directed

Introduction

Both the World Economic Forum (2016) and OECD (2016) reported that higher foundational literacy proficiencies are linked to better wages and lower unemployment in the knowledge economy. It is often not disciplinary technical content attainment that usually holds learners back. Rather, it is their ability to read and write critically that failed them. Thus, learning how to improve business-related literacy skills independently can lead to improved career outcomes (Bentham, 2015). In order to succeed in the modern digital workplace, numerous studies have also found that self-directed learning for business achievement is strongly related to mastering literacy skills (Akhras, 2012; Abram, 2006; Leu et al., 2017; Storksdieck, 2016; Tompkins et al., 2014). Rapid technological advances in the future workplace have also led to the rise of 'digitalised literacy' and the much sought-after ability to work productively with digital information. Literacy instruction, as more researchers now attest, not only need to be embedded in sociocultural business practices and learnt contextually, but must also now be integrated with technology and Web 2.0 to be effective (Ali & Katz, 2010). To prepare future-ready pre-professionals, it holds that developing literacy skills must involve technology that can scaffold self-directed learning. In doing so, it achieves the dual goals of learning about and working with technology. As such, this study's core purpose is to explore how augmented reality (AR) can improve digitalised business-related literacy skills so that pre-professionals gain a future career advantage. AR is recognised for its ability to provide on-demand self-triggered learning scaffolds. The focus is on understanding how contextual, just-in-time AR learning scaffolds can lead to increased literacy proficiencies. The study has two hypotheses:
H1: Learners using the AR-learning app will exhibit higher literacy proficiency in critical reading and writing due to self-directed contingent scaffolds.

H2: AR can assist learners of different starting initial proficiencies to achieve higher literacy proficiency attainment in critical reading and writing.

Few studies have specifically explored the issue of literacy attainment in business studies. Moreover, AR holds the potential for the contextual embedding of literacy instruction scaffolds into disciplinary content. Thus, this emerging educational technology requires further research to guide pedagogical practice.

AR and Literacy

Literacy underachievement is thought to be a result of disengagement with the learning content, which learners perceive as uninteresting. This can be linked to the rise of digitalised text as more recent literacy technologies have reshaped how text is generated and consumed and has subsequently changed learning preferences (Chun et al., 2016). A closely related emerging theme is the need for contingent scaffolding in literacy instruction. Scaffolding should ideally promote greater learner autonomy as it is essential in promoting academic and literacy competence (Meichenbaum & Biemiller, 2017). Contingent scaffolding provides on-the-spot interaction, just-in-time feedback and just-enough support (Daniel et al., 2015). The same researchers also emphasise the need to incorporate new technologies into literacy instruction. This leads to a growing recognition that literacy is shifting away from behaviourism towards constructivism and the goal is to support greater independent learning to build fluency (August et al., 2014; Gunning, 2013; Tompkins et al., 2014). It is perceived that independent or self-directed learning can be achieved using self-supportive scaffolding. It is believed that mobile computer-assisted learning can be used to achieve this.

Coupled to the rapid adoption of digital text is the rise of augmented reality (AR) which has the potential to provide immersive, experiential, contextual learning for learners mastering skills. AR confers the capability to trigger overlays of rich media onto the real world through web-enabled devices, thereby reducing cognitive overload by providing students with "perfectly situated scaffolding" in real-time. (Bower et al., 2014). In this respect, AR can be utilised to help learners who require timely guidance to improve their literacy proficiency while concurrently developing digital literacy. The opportunity to address a literacy gap with an emerging technology has immense forward-looking value for education. It addresses the demand to prepare tertiary students for the digital age that leverages their preferred use of technology for learning.

Methods

An AR learning app with self-directed learning scaffolds was developed for mobile devices using software, Vuforia and Unity 3D. The developed AR learning scaffolds included three types of contingent or just-in-time learning interactions, which learners could trigger. These were namely: i) Displayed Explanations, which was a pop-up information layer providing basic literacy explanations; ii) Guided Instruction, which was a layer showing how inferences and insights are connected and derived in a visual manner, and iii) Self-Assessment, which was a feedback layer that allowed the comparison of completed assessment exercises with the model solution with explanations.
and used the AR learning app for critical writing and reading for 45 mins. The randomly selected control group of 20 learners used a print-only text with call-out boxes and answers at the end, for 45 mins. The learning content were identical and covered the principles of critical writing and reading with self-assessment exercises. Pre- and post-proficiency tests involving performance tasks were used. In the first part, the performance tasks involved a critical reading scenario where learners were tested on the ability to spot critical reading principles and to make insights and inferences. The first part had 10 multiple choice questions. In the second part, learners were required to review a 100-word paragraph to identify critical writing principles. They then wrote a short paragraph based on a given topic. The second part had five fill-in-the-blanks and one free-writing exercise. The proficiency tests were online tests which learners completed in a computer lab within 45 mins. The proficiency tests were based on the OECD Programme for the International Assessment of Adult Competencies (PIAAC) literacy frameworks (OECD, 2016b).

**Results and Discussion**

The study sought to determine if learners using the AR-learning app would exhibit higher literacy proficiency in critical reading and writing due to self-directed contingent scaffolds. It was found that the experimental group significantly improved their literacy skills more than the control group for the post-tests (t-test 2.37, p=0.023) compared to the control group in the post-test. Critical writing was not significantly different (t-test 1.82, p=0.244) for the AR experimental group in the post test.

While both groups exhibited improvements, it was the AR experimental group (23.05/30 (76%)) that outperformed the control group (20.50/30 (68%)) in the post-test. It is thought that the experimental group achieved higher literacy proficiency due to AR being more intuitive and the different scaffolds allowed for a greater immersion into logical and critical thought (Chiang et al, 2014).

Further comparisons between the AR experimental and control groups produced mixed results. The AR experimental group was statistically significant for critical reading (t-test 2.30, p=0.029) and for free-writing (t-test 2.37, p=0.023) compared to the control group in the post-test. Critical writing was not significantly different (t-test 1.82, p=0.244) for the AR experimental group in the post test.

<table>
<thead>
<tr>
<th>Group</th>
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**Table 2 Comparisons of Critical Reading, Writing and Free-Writing Test Components**

The increased performance in critical reading and free-writing could be explained by the AR scaffolds used. Triggered explanations with displayed pop-outs illustrating key critical reading concepts like previewing, scanning and keywording helped learners master key strategies to improve reading comprehension. Guided instruction further assisted learners in training their eyes and minds for critical reading. Guided instructions were helpful for developing free-writing as it provided AR prompts that showed learners sequentially on the type of evidencing and sentences needed for developing topically sound paragraphs. It would also seem that the current AR learning scaffolds used were less effective for developing reviewing and evaluating literacy skills. In critical writing, learners were taught to differentiate between descriptive, analytical and argumentative/positional writing. The nuances were harder to bring forth with the current AR scaffolds used. Therefore, a rethink is necessary to redesign AR learning experiences to develop this particular literacy skillset. AR self-assessment scaffolds were also insufficient to develop reviewing and evaluating skills. In hindsight, the AR scaffolds for reviewing and evaluating required comparative layers illustrating key differences between different writing styles so learners can overlay for comparison to better visualise the nuances. AR allows for multiple layers of content to be presented separately or all at once.

The study also sought to determine if AR could assist learners of different starting literacy proficiencies to achieve higher literacy proficiency attainment in critical reading and writing. The AR experimental group was clustered into different literacy proficiency tiers of high (>80%), average (70%-79%) and low (<69%) based on their pre-test scores. The post-test performance of each clustered subset were compared against their pre-test scores. The learners in the AR experimental group that benefitted the most was those who achieved lower proficiency scores in the pre-test. Learners with average or higher initial literacy proficiencies had less significant differences comparatively. The lower literacy proficiency attainment scores in the control group can be attributed to a lack of interest in using printed text. Learners were noticeably less enthusiastic reading the printed text. Digital nativity might be at work here.
It is believed that contextual and contingent scaffolds benefitted weaker students more as they were able to review and revise learning content repeatedly at the point where immediate clarification was most needed. This immediacy led to better retention and thus, bridged the learning pathways to higher order proficiencies. In other words, AR demonstrated the ability to facilitate the learning pathway necessary for better literacy performance when working with digital information. Learners with weaker proficiencies shared that they were able to grasp the concepts more readily as they could access learning instruction at the point of need and application. They also favoured using the AR self-assessment scaffolds as it allowed for repeated attempts. For the weaker learners, repeated drills and practice might be necessary for skill development. It is recognised that learners were using AR for literacy for the first time. They have experienced AR in other disciplines and in personal contexts like games and social media before. While learners are not new to AR, the element of a novelty still exists. This might have prompted greater initial engagement.

**Conclusions**

This study investigated whether learners could achieve improved business-related literacy skills through the use of AR, especially for preparing pre-professionals who must now cope with a digitalised form of literacy in the modern workplace. It also sought to explore if learners could improve literacy skills independently, without the need for an instructor-led face-to-face facilitation as lifelong learning is necessitated by self-directedness. It can be concluded that contingent AR scaffolds enable learners to quickly and intuitively receive digital content, which facilitates skill development for self-directed literacy improvement. The triggered just-in-time access to visual information and instructions supplemented with text, guided the learners toward higher proficiency attainment. It is interesting to note that AR scaffolds have the potential to allow weaker learners to catch up with stronger learners by providing contingent or just-in-time learning support and this is critical in ensuring more learners attain the desired competency proficiency levels. AR thus, can have an equalising effect on skill achievement.

AR shows promise as an emerging educational technology. It can be used effectively for business and soft skills and this is significant because pre-professionals are increasingly differentiated at the workplace by their ability to communicate and work with digital information. This study recognises that the controlled trial was modest in scale and was designed more to probe specific hypotheses to better understand the nature of AR scaffolds. A pilot is necessary as it avoided costly trial and error. Also, as research in AR use for business literacy skills is limited, a pilot exploratory study provides critical guidance. The controlled trial pointed to the opportunities AR presents for technology-integrated learning beyond STEM applications. A future research direction is to conduct a broader study with a large participant size. The key learning points from the controlled trials can help facilitate such future studies of scale.

**Acknowledgements**

The authors would like to acknowledge the Ministry of Education (Singapore) Tertiary Research Fund (MOE TRF) for funding this work. Participation at this conference is also made possible as a result of funding by the MOE TRF. The support and guidance from Nanyang Polytechnic's School of Business Management's senior management is also gratefully acknowledged.

**References**


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**Table 3 Performance Improvements within the AR Experimental Groups**

| Literacy Proficiency | Group | Pre-test Mean Score (100%) | Post-test Mean Score (100%) | Change (%)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High Proficiency</td>
<td>Control</td>
<td>85.0</td>
<td>81.7</td>
<td>-4.1%</td>
</tr>
<tr>
<td></td>
<td>Exp.</td>
<td>86.7</td>
<td>90</td>
<td>3.7%</td>
</tr>
<tr>
<td>Average Proficiency</td>
<td>Control</td>
<td>73</td>
<td>72.6</td>
<td>-0.6%</td>
</tr>
<tr>
<td></td>
<td>Exp.</td>
<td>72</td>
<td>80</td>
<td>9.8%</td>
</tr>
<tr>
<td>Low Proficiency</td>
<td>Control</td>
<td>52.2</td>
<td>61.9</td>
<td>14.6%</td>
</tr>
<tr>
<td></td>
<td>Exp.</td>
<td>47.1</td>
<td>66.7</td>
<td>29.2%</td>
</tr>
</tbody>
</table>

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ACTIVE LEARNING CLASSROOM APPLICATION FOR ENGINEERING

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Abstract

Nowadays, the technology has been rapidly changed. Traditional teaching platforms cannot be applied with students in this era anymore since the students can search for any topic by themselves easily. Active learning is one of the solutions for the teacher to stimulate a student’s attention. In this paper, a prototype application that help a teacher to assess students’ understanding is presented. The application functions consisted of two parts: a teacher mobile application and a student mobile application. In order to evaluation the proposed application’s performance, 107 students who used this application during the class were interviewed. In this paper, functions of the application are shown and the results from experiments are discussed. The result of a questionnaire-based evaluation showed that almost all the students rated the application in positive feedbacks. The negative feedbacks are mostly not related to functions in the application such as a poor Internet connection signal make it hard to submit an answer to a server.

The proposed application is one of the Classroom Response Systems (CRS) system focusing on computer engineering education. It was used by 107 second-year students studying the Web-Technology subject at Faculty of Engineering, King Mongkut’s Institute of Technology Ladkrabang in 2017. The experiment was divided into 2 parts: Practical testing and Evaluation of students’ satisfaction. The result indicated that the students are satisfy with the application and willing to use it again. The impact of the application was examined by comparing students’ score between 2016 and 2017 in the same subject. The result shows that an average class score of students in 2017 is better than those in 2016.

Keywords: Android application, Active learning, Technology enhance learning, web-base platform, teaching

Introduction

Presently, many teaching assistance tools such as Classroom Response Systems (e.g., Naismith et al., 2004), Audience Response System (e.g., Miller et al., 2003; Robertson, 2000) and Electronic Response Systems (e.g., Hall et al., 2002) are used as powerful tools for instruction in classrooms. It enables teachers to post an instant question during the lecture and students can submit their answer to the question in real-time.

Traditionally, CRS system consists of two ways communications between an instructor and students. The instructor can choose whether students can response to the question in anonymous mode or require them to fill in their identities. Penuel et al. (2004) proposed modern CRS system “Classroom Aggregation Technology for Activating and Assessing Learning and Your Students’ Thinking” (CATAALYST). The system is not only allowing students to response to the instructor’s question but also provide them opportunities to shape their critical thinking abilities.

The proposed application is one of the CRS system focusing on computer engineering education. It was used by 107 second-year students studying the Web-Technology subject at Faculty of Engineering, King Mongkut’s Institute of Technology Ladkrabang in 2017. In this subject, it requires special functions such as a laboratory queuing system to let students call for help from a teacher or TA in a good manner. The application was built with Native language to maintain a stability of system and to be able to contribute new functions in the future. The experiment was divided into 2 parts: Practical testing and Evaluation of students’ satisfaction.

Materials and Methods

Nature of the subject, Web Technology is a required subject for second year students to enroll. There are 90 and 107 students enrolled in this subject in 2016 and 2017 respectively. There is no course prerequisite in this subject. Students were divided into two sections, A and B in each semester. In 2016, enrollment in Section A was 45 students and increasing to 56 students in 2017. In 2016 enrollment in section B was 45 students and increasing to 51 students in 2017. The proposed of this subject is to introduce taxonomies, ontologies for web applications and technological issues to the students. This course was taught based on project-based learning (PBL). PBL is a
methodology for learning without exactly right answer. It provides open-ended problems and open-ended answer so the students’ learning curve are stimulated by their curiosity (Schmidt 1983; Woltering, V., Herrler, A., Spitzer K., Spreckelsen C. 2009). This subject was consisted of 2 parts: lecture and laboratory. Before a final examination, the students must be able to build one web application as an evidence of their learning outcome.

Course description: The course consisted of two hours lectures and three hours laboratory per week for a total of 75 hours of classroom instruction. To implement PBL, students were divided into a group of three to five people throughout the semester. There are three examinations: quiz, comprehensive two hours midterm, and comprehensive three hours final. There were 500 total possible points during the semester, and the students’ grades were calculated based on Criterion-referenced.

The proposed CRS environment; Traditional CRS system normally consists of a computer, receivers, and a handheld personal data transmitter (PDT) registered to each student while the proposed system requires only a smartphone with the Internet connection. The instructor can create a real-time test then edit, delete, or update it later on as shown in Fig. 1. Students can login and response to the question and keep records of their score. Computer laboratory is required in this course with approximately 50 students per one instructor. Special function was implemented in the proposed application to manage queuing problem. The application was divided into two parts: Instructor and Students. The instructor and student user-interface was shown in Fig. 2.

Instructor’s functions; (1) List all questions, delete, insert, update or add new test. The questions can be both subjective or objective but the system can automatically check for objective test only as shown in Fig. 3. (2) List all students’ scores as shown in Fig. 4. (3) Lock the quiz as shown in Fig. 5. The purposed of this function is for the instructor to control access to the questions by students. (4) Divide students into groups and view list of students calling for help as shown in Fig. 6 and Fig. 7.
Students’ function: (1) Response to the questions as shown in Fig. 8 (2) View his or her own score history as shown in Fig. 9 (3) Register a studentID to map with seat in laboratory room as shown in Fig. 10. If a student has a question to ask an instructor, he or she can select queue button to call the instructor as shown in Fig. 11.
Implementation in the classroom; In 2016, paper based teaching approach was used to teach students. In 2017, CRS was implement to students. However, course syllabus, lectures, laboratory and examination questions are all the same in both years.

Experiment and Discussion

The goal of this paper is to examine the power of the proposed CRS application. The experiment was done by comparing a learning curve between students learning with CRS and without CRS. In both 2016 and 2017, 500 total possible points during the semester was divided into 100 points for quiz, 200 points for comprehensive two hours midterm and 200 points for comprehensive three hours final. CRS was not used by students in 2016 while in 2017 students in both section was taught using CRS. The student’s scores from 2016 and 2017 were compared to examine whether this application help improve student learning ability.

Firstly, Students enrolled in 2016 and 2017 were requested to complete a pre-test about basic knowledge of web technology in a first week of the course. Figure 8 shows that from score 0 to 100, the students in both two years got the score in range 30 to 50 and average score range was 37- 40. The result indicated that the students have almost same fundamental skill in both years.

Secondly, the instructor was introduced CRS to the student in the first week. Students created their own account and practice using the application to ensure that all student understand how it works. After that, the instructor used this application as a tool to teach in every week.

Thirdly, in the last week of the course, a survey was given to all student to rate their satisfaction of the application on a scale of 1 to 5; with 5 being strongly satisfy; 4 somewhat satisfy; 3 satisfy; 2 strongly not satisfy; 1 not satisfy. One open-end question was included in this survey asking the students to express their feeling while using this application. The result of a questionnaire-based evaluation showed that almost all the students rated the application in positive feedbacks since the average satisfaction score of this application is 4.5. The negative feedbacks are mostly not related to functions in the application such as a poor Internet connection signal make it hard to submit an answer to a server. The students are willing to used it again in next semester.

Finally, total scores of the students from 2016 and 2017 were compared. The result shows that average score of student in 2017 is higher than in 2016. Moreover, Highest score in 2017 is higher than in 2016.

Conclusions

The proposed application was built with Native language to maintain a stability of system and to be able to contribute new functions in the future. The experiment was divided into 2 parts: Practical testing and Evaluation of students’ satisfaction. The result indicated that the students are satisfy with the application and willing to use it again. The impact of the application was examined by comparing students’ score between 2016 and 2017 in the same subject. The result shows that an average class score of students in 2017 is better than those in 2016.

Acknowledgements

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References


TEACHING BASIC PROGRAMMING TO PRE-UNIVERSITY STUDENTS THROUGH BLENDED LEARNING PEDAGOGY– A DESCRIPTIVE STUDY

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Abstract

Students enrolling for undergraduate programmes in Singapore would have either finished their polytechnic diploma or completed Junior College (JC) studies. Most pre-university students coming through the JC pathway are not exposed to programming as computing is offered as a subject in a very few JCs. The authors of this paper conducted four runs of an introductory programming course between 2016 and 2017 for a research project funded by the Ministry of Education, Singapore. The project named “Let’s Code!” was intended to introduce fundamental programming concepts to students and guide them to consider taking a computer-science related degree for their university education. Pre-university students who had no background in programming could enrol in one of the runs of the “Let’s Code!” programming course. Blended learning pedagogy was adopted to deliver the course content in three weeks. The purpose of this study is to gain insights into the delivery of an introductory programming course to a heterogeneous group of pre-university students through a blended learning pedagogy. This paper analyses the survey responses and the test scores of the participants who attended the course in the two runs of June and December 2017. Based on the test scores taken on the final day of the course, it was found that (i) male students performed better than the female students regardless of whether they had prior programming exposure, and (ii) students who had exposure to programming performed better than those with no prior background.

Keywords: introductory programming course, blended learning pedagogy, university education choice, computer science studies, open educational resource, student outreach.

Introduction

Students applying for undergraduate university admissions in Singapore primarily come from two streams. They are either (i) students with a polytechnic diploma or (ii) students who have completed their A-level at one of the Junior colleges (JC) (Singapore Education - Pre-University, n.d.), or students with an International Baccalaureate diploma (International Baccalaureate – Programmes, n.d.). The IB diploma is considered equivalent to the A-levels in the pre-university education landscape; Bhardwa (2017) compares the two (A-levels and IB) in her article in the Times Higher Education. In most of the JCs in Singapore, “Computer Studies” is not offered as a subject. The authors of this paper hence decided to offer an introductory programming course to all JC students. The authors got funding from the Singapore Ministry of Education’s “MOE Academies Fund” for the project, named “Let’s Code!” The project’s primary objective was to expose JC students to programming by conducting four similar runs of an introductory programming course in a span of two years in order to help them consider an undergraduate degree related to computer science. The secondary objective was to create awareness about the computer science-related degree options available at the Singapore Management University’s School of Information Systems (the school the authors work at). The programming course was open to all students from the JCs, the IB diploma program, and students in their fourth year from the Integrated Programme at the secondary level (Other Programmes in Secondary School - Integrated Programmes, n.d.). This meant that the participants of the course were between the tenth and twelfth year of their school education.

The programming course was designed to cater to participants with no computing background. The focus of the course was problem solving. Only fundamental programming concepts such as variables, conditional and loop structures, functions, and arrays were covered. The Ruby programming language was chosen as the language of instruction.

The four runs of the course were scheduled in June and December (of 2016 and 2017) to coincide with the school holidays in Singapore in order to facilitate the attendance of school-going participants. Each run lasted for three weeks. The course content for the four runs of the course was identical albeit minor differences in the delivery.

A major portion of the project funds was used to pay the teaching assistants who assisted the instructors (authors of this paper) in the delivery of the course. The
teaching assistants were first or second year Information Systems’ undergraduate students and were selected by the instructors. More than 500 pre-university students enrolled to attend one of the four runs.

The course content (video lectures, assignments) was uploaded onto the Singapore Management University’s learning management system. The learning material was also made publicly available on a website created for this project (Let’s code!, n.d.). The website that had the registration page was sent to all JCs and IB / IP schools in Singapore. The teachers in the schools helped to publicise the course before the beginning of every run. The participants of this course self-registered to one of the runs.

Initial data for this study comes from responses by the registrants to the survey questions. The purpose of this pre-course survey was to collect data regarding the profile of the registrants enrolling for the course (sex of the student, which school they were from, which year of study they belonged to, subjects taken at school etc.) as well as for the instructors to understand registrants’ exposure and background in programming (Has the student experienced programming using Scratch, Alice, or other languages? What is the student’s self-assessment of his experience in programming?). At the end of the course, participants provided course feedback. The post-course feedback survey followed a modified version of FACETS (Student feedback on teaching, n.d.), a survey instrument used at Singapore Management University for collecting teaching feedback. In addition to the above two sources (pre-course and post-course survey), data collected from the learning portal through the process of participants’ course of study (online quizzes, attendance) and data from the results of the exam conducted at the end of the course (for every run) constituted the data for this study.

Although data for the four runs of “Let’s Code!” programming course was available, this study analyses the data collected from the last two runs. This is because the last two runs adopted the same post-course feedback survey instrument (FACETS); the initial two runs followed a different instrument that was too long and discouraging for the students to fill. This study attempts to find answers for the following questions:
1. How effective is the delivery of the introductory programming course using blended learning pedagogy, related to students’ learning and performance?
2. Do participants’ prior programming experience affect their results?
3. Is there any other influencing factor that affected the participants’ results?

**Pedagogy**

The participants who hailed from various schools (from 24 schools for the two runs in 2017) registered online for the programming course. All registrants were required to attend a briefing session during which the instructors briefed the participants about blended learning (BL) pedagogy adopted for this course. The instructors were well aware of the BL pedagogy (Mok, 2014). On the briefing day, the students were assigned groups; depending on the size of the group, up to two teaching assistants were assigned as mentors to each group. The students got help to set up their laptop with the programming environment on the briefing day. The briefing session also provided an opportunity for every student to know his mentors and peers.

During the briefing session, the students were given an online Multiple Choice Question (MCQ) quiz to test their programming exposure prior to taking the course as it was expected that a few students would have some programming knowledge. An almost identical test was given to them at the end of the course.

The topics covered in the course were categorized into four units and the students were advised to follow the learning material in sequence. Table 1 shows the topics covered in all the planned seven meet-up sessions of each run.

<table>
<thead>
<tr>
<th>Meet-up session</th>
<th>Topics covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Briefing and set up session</td>
</tr>
<tr>
<td>2</td>
<td>Variables, Types, Operators (Unit 1)</td>
</tr>
<tr>
<td>3</td>
<td>Decision and Loops (Unit 2)</td>
</tr>
<tr>
<td>4</td>
<td>Methods (Unit 3)</td>
</tr>
<tr>
<td>5</td>
<td>Arrays (including 2D arrays) (Unit 4)</td>
</tr>
<tr>
<td>6</td>
<td>Putting all concepts together</td>
</tr>
<tr>
<td>7</td>
<td>Debrief and exam session</td>
</tr>
</tbody>
</table>

Apart from the briefing session and the last meet-up session, that served as the exam and de-brief session, the participants were required to attend at least two of five other meet-up sessions (2 to 6) as a requirement to be eligible for a certificate of completion. During these meet-up sessions, tutorial type lessons were conducted. The first four tutorials had problems to be solved based on the new topic covered in the recent lecture videos of the corresponding unit, whereas the fifth tutorial had questions that helped students combine all the concepts taught in the previous units and also to prepare them for the exam.

Every unit required the students to watch online lecture videos, take the self-check quizzes and attempt assignment questions related to the unit. Figure 1 illustrates the learning plan recommended to the students for watching videos. The students were advised to attempt all self-check quizzes related to the unit before attempting the corresponding unit’s assignment questions. Mentors provided support to students during this period of self-learning.

![Figure 1: Recommended mode of learning](image-url)
During the tutorial sessions, more questions pertinent to the topics covered in the recent unit were given to reinforce the concepts. Figure 2 shows the sequence of activities lined up for the student for every unit.

![Figure 2: Sequence of activities per unit](image)

During the tutorial session, instructors and mentors guided students on how to approach programming questions and compared various solutions to the same question. The meet-up sessions allowed the mentors to engage with the students and assist them with their assignments.

In the first three runs, the tutorial session served as a review session and was held on Day 3 as shown in Figure 2. However, for the last run, the tutorial was held just after the students watched the lecture video to help clear students’ doubts on concepts (on Day 2) before they tackled the assignment questions. The change was implemented based on the feedback from the mentors, and our observation of students’ inability to apply the concepts learnt to the assignment questions. The authors of this paper documented the experience of conducting the course, with all the implementation details, and the changes made across the four runs in Mok & Rao (2018).

Each of the first four tutorials corresponding to units 1 to 4 and the final tutorial that consolidated topics of all units had a corresponding assignment (summing to five assignments) that was required to be submitted. The mentors’ responsibility was to provide feedback on the submitted assignments of students mentored by them.

The briefing session and the five tutorials were spread over three weeks with each week typically having two tutorials. The exam consisted of MCQs and programming exercise questions for students to solve. The students used their computers to write the solutions for the programming exercises. The MCQs were a mixture of online and paper based questions. As previously mentioned, the online MCQs were similar to those given on the briefing day. In order to earn a “Certificate of Completion”, the students had to meet attendance requirement (at least two out of five tutorials), submit five assignments, and attempt the exam. Students who fulfilled the requirements for the “Certificate of Completion” and passed the exam were given a “Certificate of Merit” in recognition of their good performance.

### Methods and Materials

For this study, the sample data comes from 266 students who enrolled in the June and Dec. 2017 runs (out of a total of 535 participants across the four runs). It was encouraging to observe that there was a good interest from female students to enrol in the course. The percentage of female students (47.4%) enrolled compared to male students (52.6%) did not show a huge difference indicating growing interest among female students to be in the STEM sector (More women working in science, engineering sectors, 2016). The interest could be attributed to Singapore’s push to become a “smart nation” (Info-communications Media Development Authority, 2015) and the job opportunities available in the technology sector (Heng, 2017; Tegos, 2017). A review of the participants’ responses to the pre-course survey question, “Describe your goals for participating in this course” asserted the above opinion. As examples, there were responses that read “I am interested in taking an IT related course in uni but I have come from a bio background since secondary 3 till JC, so I hope this course can firm my interest on IT and guide me into this path I hope to take.”, “wish to learn and understand more about coding as it has always been emphasised as an essential skill in this 21st century…”.”, “With the knowledge that Singapore is striving towards being a smart nation and that technology will definitely be an integral part of society in the future, I hope that through this course I would be able to grasp the basics and foundations of programming…”.

Table 2 reports the demographic profile of the students in the sample. Most (85%) of the 266 students were either in their 11th or 12th year of education compared to 9% in the 10th year of education.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Percentage</th>
<th>n</th>
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<tbody>
<tr>
<td>Female</td>
<td>47.4%</td>
<td>126</td>
</tr>
<tr>
<td>Male</td>
<td>52.6%</td>
<td>140</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year of study</th>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>JC1 or IB Year 5</td>
<td>33.5%</td>
<td>89</td>
</tr>
<tr>
<td>JC2 or IB Year 6</td>
<td>51.5%</td>
<td>137</td>
</tr>
<tr>
<td>IP year 4 or IB Year 4</td>
<td>9%</td>
<td>24</td>
</tr>
<tr>
<td>Graduated from JC / IB</td>
<td>6%</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prior Programming Exposure</th>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Programming Experience</td>
<td>22.2%</td>
<td>59</td>
</tr>
<tr>
<td>No programming Experience</td>
<td>76.7%</td>
<td>204</td>
</tr>
</tbody>
</table>

Although this course was catered to students with no programming experience, we had questions in the survey related to the extent of exposure the students had to programming prior to joining our course. We used a binary measure to capture participants’ prior programming exposure. Based on the students’ responses, we considered those who had exposure to at least one programming language such as C, C++, Python,
Java, JavaScript and other non-visual programming languages as having had “programming experience” whereas those who mentioned that they have tried HTML, or Alice, or Scratch with no other typical programming language experience to be having “No programming experience”. Based on this criterion, the percentage of students with programming experience was 22.2%, compared to 76.7% with no prior programming experience as shown in Table 2. Only 11.9% of the female participants had programming experience compared to 31.4% of the male participants.

Among the 266 students who enrolled for the course in 2017, 215 (80.8%) completed the course and were eligible for the “Certificate of Completion”. The attrition rate of 19.2% was considered low, as the students had no obligation to complete the course. Table 3 captures the course’ completion rate statistics by gender in the two runs.

### Results and Discussion

In order to measure the learning achievement of students, we compared the results of MCQs attempted by the students on the briefing day (beginning of the course) and compared it with their scores (out of a maximum score of 8) on the exam day when they attempted a similar set of MCQs (as on the briefing day). Data from the participants who had not attended one of the tests, pre-course or the post-course MCQ test was not considered. The mean difference between the scores before the run of the course (1.53/8 i.e. 19.1%) and after the course (6.1/8 i.e. 76.3%) was noted to be statistically significant with a p value less than 0.01 at 95% confidence level (n = 228).

In order to examine the impact of prior programming exposure of the students, we conducted the t-test again to compare the MCQ scores of participants who had no prior programming experience. Table 4 tabulates the result of paired two-sample t-test performed on the unfiltered and the filtered sample. The significant difference in the mean scores (pre-course 16.5 %, post-course 74.6 %, n = 174, p value < 0.01) for students with no prior programming background indicated that there was a positive learning achievement. The mean difference for those with prior programming experience (p value < 0.01, n=54) also seemed to be statistically significant indicating that even the group with prior programming exposure improved in their competence.

The post-course online MCQ test constituted to about 1/6th of the total exam score. We then studied the data by comparing the total exam score of all students with no prior programming experience and those with prior programming exposure. The mean score for the sample data with “no programming experience” was 46.5%, “with programming experience” was 61.0%, and the mean difference was significant at p < 0.01.

We also compared the results of the total exam score by gender. It was observed that male students performed better (mean 58.1%) than the female students (mean 41.4%) and the t-test showed that the difference is significant (p < 0.01) at 95% confidence intervals. Table 5 shows the comparison of the mean exam scores for male and female participants by their prior programming experience.

### Results and Discussion

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average exam score by students in relation to the number of tutorials attended. The correlation coefficient showed positive relationship but the strength was not very high (correlation coefficient = 0.54).

Table 6: Mean Exam Score Vs Attendance at Tutorials

<table>
<thead>
<tr>
<th>Number of tutorials attended</th>
<th>Percentage of students</th>
<th>Mean exam score of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4 %</td>
<td>41.25</td>
</tr>
<tr>
<td>2</td>
<td>4.7 %</td>
<td>51.86</td>
</tr>
<tr>
<td>3</td>
<td>16.7 %</td>
<td>47.87</td>
</tr>
<tr>
<td>4</td>
<td>28.2 %</td>
<td>44.79</td>
</tr>
<tr>
<td>5</td>
<td>50 %</td>
<td>53.37</td>
</tr>
</tbody>
</table>

The students provided data related to the average number of hours spent on the course per day during the three weeks. Putting the figures through multiple linear regression test showed that the variables - Number of tutorials attended, Sex of the student, Pre-course MCQ test score, Prior Programming Experience and Number of hours spent by the student on an average per day, determined about 34% of the variability in the exam scores. Figure 3 shows the multiple regression test result performed using Excel.

Figure 3: Multiple Linear Regression Analysis Result

Our research study was more exploratory in nature. Further study would be required to understand the differences in learning achievement between males and females. Perhaps studies that capture students’ attitudes towards computer studies, learners’ cognitive disposition, confidence level, motivation level and learners’ persistence would help to understand the differences in the results.

Conclusions

This study showed that there was a significant improvement in student’s learning based on the pre-course and post-course MCQ test. This suggests the effectiveness of using BL approach in teaching introductory programming to pre-university students. There were two findings that emerged from this study; male students performed better than the female students regardless of the prior programming exposure they had, and students who had exposure to programming performed better than those with no prior background. This could perhaps be because of the steep learning curve for those with zero background in programming. Further research is required to determine the cause of gender differences in order to address the gap.

Acknowledgements

The authors would like to thank their colleagues Ms. Fiona Lee and Mr. Timothy Chan who helped review the paper. Associate Professor Manoj Thulasidas who helped verify the statistical results, General Office staff who provided administration support, the Ministry of Education (Singapore), Hwa Chong Institution as well as the following organizations: Science Centre Singapore, IEEE (Singapore branch), Singapore Computer Society, and the Info-communications Media Development Authority, that supported this initiative.

References


BENEFITS OF USE OF FREE ACCESS TECHNOLOGY TO BLENDED LEARNING AND STUDENT MOTIVATION AT A NATIONAL INSTITUTE OF TECHNOLOGY IN JAPAN

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Abstract

The purpose of this research is to find effective and suitable methods of using technological advancements for the promotion and improvement of blended learning teaching at English as a foreign language (EFL) classes at a National Institute of Technology in Japan. The college at which the study was conducted has experienced previous unsuccessful attempts at incorporating learning management systems (LMS) specifically for EFL learning, and with near to no funding or support for implementation of newer efforts, a switch to free access technology was experimented with. A main website created on a free online provider was created without previous experience in HTML or other programming. The site was used for all communication with students outside of classes, including submitting homework, sharing documents, and providing extra content to lessons content from in class. Site traffic was monitored to see if how many students were actually using the site, as well as conducting surveys and exit interviews from randomly selected individuals on their perceptions of the effectiveness of the site. It was found that a vast majority was satisfied with the use and existence of the site, and felt that the simplicity of navigation in particular to being mobile device friendly were key factors to repeated use of the environment. Some went as far to say that it was better than other LMS-based experiences from other courses in the college. Further improvements to the site are now being tested, such as including testing options and even full classes outside of teaching hours using pre-recorded and potentially live video distance education. It is hoped that other faculty at any institution can use similar methods for non-cost enduring educational technology enhanced teaching methods, and to also create a community of online education instructors to keep up to date with various methods found effective through previous experiences.

Keywords: language education, student motivation, blended learning, mobile assisted language learning (MALL), English as a foreign language (EFL)

Introduction

The use of technology in classrooms is quite common nowadays, regardless of subject and level. Even in Japan, the use of learning management systems and blended learning classrooms are increasing, especially at National Institutes of Technology (also known as Kosen). In a previous study, a group of students were observed in their reactions to blended learning-based English as a Foreign Language classes, and results were positive (Ziemba, 2017). However, in that same study, the use of LMS that was provided freely with the course textbook was based overseas and with seemingly endless amounts of problems arising throughout the year long course, it was found that using an original, mobile-friendly site was found to be more advantageous to students due to its ease of access by mobile devices, such as students’ smart phones. An increasing number of studies emphasize the move from traditional Computer Assisted Language Learning (or CALL) to Mobile Assisted Language Learning (or MALL), which are expected to lead to greater educational benefits especially in motivation, much like what is detailed by McCarty, Sato & Obari (2017).

Surprisingly though, it is still quite common for other subjects to be taught by writing inconceivable amounts of notes on a blackboard and having students just copy down the same content in their notes in Japan (Tham & Tham, 2013). Some attempts to incorporate learning management systems in courses have been seen thanks to encouragement from the Ministry of Education (MEXT), yet most of these are only accessible on-campus or in the specific CALL classroom, leading to a lack of access from students’ homes (Ono, et al., 2015). Furthermore, with this encouragement also comes various budget cuts, especially in humanities subjects at Kosen colleges, and instructors are forced to either return to paper-and-chalk methods or turn to free-access services to keep the MALL environment running. This research will go into details of proven successful intervention methods on a previously tested group of students aged 15 to 22 at a specific National Institute of Technology in Japan for mandatory and elective English as a Foreign Language courses taught by the author of this research.
Methods

What was initially created in previous research (Ziemba, 2017) for first and second year EFL classes was now spread to all courses taught by the same instructor, including those that were not entirely taught by one instructor. One of the courses that was divided into the four existing classes at the National Institute of Technology at hand, was split into two each between themselves and another English teacher due to class limit restrictions. As shown in other studies (Lander, 2015), incorporation of blended learning environments can also help students achieve greater scores on traditional Japanese test-based courses. This was ensured through the inclusion of practice tests and access to further content and discussion available on the created website, updated at the end of the week so students had access to materials before weekends.

The classes were mostly 40 students each, with the higher grades (equivalent to second and third grade at university) being elective subjects with a lower number of participating students. These were further changed in their instruction method by including various forms of continued discussion based on in-class materials, including linking to documentary films on YouTube, or creating content-specific pages leading to writing of opinion essays or creating original media themselves.

As the current second year students had previous experience in the implemented blended MALL English class environment, they were designated as the control group, and were monitored for their upkeep of motivation and access to the website. Other students’ access to the free site was monitored and paper questionnaires were distributed with each midterm and final exam, which were open ended questions regarding their perceptions of the website, its effectiveness, and what improvements they felt would be necessary to increase learning and the online environment.

The website used for blended learning was based off Weebly, a free website making service, with an e-mail form for students to submit questions and written homework assignments in a contact box that would directly be delivered to the instructor. The benefit of this service is that some mobile providers in Japan block connections from mobile phones to PC-based addresses for security purposes, and by submitting via the website, a guaranteed submission can be confirmed.

Unfortunately, attachments cannot be provided, so in those cases it was recommended to use free file sharing services, like GigaFile, and to copy the link to the files in the e-mail form. The use of these uploading sites was also originally a source of concern for the files potentially having viruses and such but were always checked through anti-virus software designated by the National Institute of Technology.

Furthermore, site access data was analysed to see how often students were visiting the site, at what times, and from what locations, to see how useful specific pages and contents were to the students, which in combination with regular surveys, were able to further cater the contents to the students’ needs for learning.

Results

Student feedback was seen to be generally positive, especially with first year students, as seen in Table 1 below. Second year students who had first experienced the website had showed a slight decrease in their excitement of the website from the previous year, with increasing demands for customization that is not always possible with teaching workloads. Surprisingly, higher grade students (fifth and sixth graders) who were also exposed to the MALL website showed the lowest levels of satisfaction in terms of finding it very useful.

<table>
<thead>
<tr>
<th>Grade (Students)</th>
<th>1st year (168)</th>
<th>2nd year (153)</th>
<th>5th year (39)</th>
<th>6th year (30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Useful</td>
<td>82%</td>
<td>72%</td>
<td>57%</td>
<td>60%</td>
</tr>
<tr>
<td>Useful</td>
<td>18%</td>
<td>23%</td>
<td>33%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Table 1: Student feedback on site usefulness by class

The reasons for the results are seen in Table 2 below, in which free comments by the students on the midterm surveys were detailed. Like the percentages of satisfaction seen above, most comments were also seen to be along the same lines. Lower grades had more positive feedback, and higher grades had more straightforward complaints. It is important however to take into consideration that the higher grades although were also introduced to the MALL website for the first time like the first-year students, their experiences at National Institutes of Technology are much more plentiful, and have also previous experiences in other LMS, like Moodle and Blackboard, in some of their other specialized engineering courses over the years. This previous exposure may skew their perceptions of an ideal LMS blended learning experience, whereas first-year students who came straight out of junior high schools are likely to be exposed to these technological incorporations for the first time in their education.

- The website makes it easy to get information that otherwise we’d need to go see you in your office and ask for in person (1st year)
- Having everything from class available on a website that is smartphone friendly is something I wish all other classes had (1st year)
- I’m glad last year’s pages are still available even though we aren’t taking that course anymore (2nd year)
- More regular updates would be nice (2nd year)
- I understand that its useful, but taking time to check it outside of class is annoying (5th year)
- The website is hard to navigate, especially since the course titles and content are so similar for both advanced classes (6th year)

Table 2: Detailed comments from students based on written opinions from test feedback surveys
Discussion

The first and most concerning point brought up by the results was the surprising lack of confidence and satisfaction by higher level students with the free MALL website. The initial suspicion was due to comparisons to previous LMS based teachings in their other courses, which was confirmed by interviewing a few students that volunteered to partake in one-on-one discussions about the free MALL site.

Botero et al (2018) have just recently published a study on the usage and more importantly acceptance of MALL environments in regard to attitudes towards its use. Student perceptions are obviously key, but the perceptions that were initially assumed to be similar to first-time users of the EFL MALL site were not the case, due to more experienced students having greater expectations based on their previous encounters with LMS and blended learning.

To put simply, what can be seen as a trivial, beneficial tool to lower grade students is not seen to positively by their seniors, due to the seriousness of their studies and concerns with grades. A previous study by Lander (2015) also reinforces this concern with their research concluding that successful incorporation of blended learning environments are able to and are somewhat expected by students to improve their grades through online practice testing. In other words, the senior students who are most concerned with their job hunting, university entrance exams, and marks average upon graduation are sadly more concerned about the numbers achieved at the end of the course rather than the content of what is taught or how it is achieved.

The higher graded students need confirmation from the get go, or as soon as possible, that using this material will be a plus for them and be reflected likewise in their marks, otherwise they will only see the site as an obstruction to what they can find and learn themselves (Hinkelman & Gruba, 2012). It is due to these demands that further links with other sites and services, like Quizlet or other testing services are intended to be appropriately incorporated to further the positive aspects that can show benefits to the senior students while still maintaining a fun, albeit trivial perception by juniors, which is still understandable.

Potentially the most crucial, and still in discussion with the students involved in the study are appropriate forms of feedback to the students, regardless of grade or level. As previously mentioned, if there is no clear sign of benefit to the senior students, they do not feel the need to access supplementary material, whether it is freely available online, with easy to navigate environments or not, also shown by Ginn & Ellis (2007). It came as an initial shock to the developing team that what was assumed to be user friendly and beneficial to all users, could have such a polarizing result. This also displays the importance of catering the content to the needs of the students using the technology – free or not. Further improvements and updates are being planned with revisions being implemented as soon as the fall of this academic school year.

Conclusions

As mentioned by Radin (2017), implementing MALL is a lot more complex than expected, with various factors needing to be considered before successful implementation. Does the system selected suit the needs better than other options? What is the plan for the learning environment, and how will it be created and implemented? And perhaps most importantly – what kind of support is provided or available in case anything may happen? These are often overlooked.

Although most of the students that were observed in this study had previous experience with LMS-based blended learning and other ICT initiatives in their English and other classes, it was found that investments in higher-cost intervention methods were found to have been better accepted by senior students. Yet in the cases of younger students, it was preferred for the simplicity of the free technology due and their familiarity of access to use on their own mobile devices (phone or tablet).

However, there is still room for improvements with their use, especially in concerns for privacy and safety. By using free media, it is often completely open to the entire Internet, with most technologies offering a paid option for login IDs, which defeat the ideal of staying free to use. The risk of students’ personal information being used for marketing purposes is an understandable concern for school administrators, as well as parents and guardians of the students themselves. This is one concern that the college administrators are quite adamant about keeping an eye on for clear reasons.

In the case of National Institutes of Technology, licenses of Office365 are available for students and staff, but their incorporation is still not made fully available due to previous issues at various institutions. By using this, the cost for instructors to use this service is technically free, and becomes valid option, albeit proper instruction for their use has yet to be designated and confirmed. With further budget cuts projected, it is key to keep cost to a minimum, and preferably free without risking privacy. Also, considering that the school and its technical staff in the case of this free MALL implementation gave no advice or support, further improvements to these issues must be carefully planned, for risk of personal information getting into the wrong hands, or misuse by third parties unbeknownst to the students or school administration themselves.

With the increasing familiarity of students to ICT integration in classrooms, and decreases in funding for educational implementations, the use of free websites and online service to improve classes will only become more common. Open media is only growing in space and content and is also a valid option as opposed to previously published materials (Miyazoe & Anderson, 2009), which creates a wider future of learning. Probably the most important factor in keeping these efforts up to date and truly effective is the need to create a community in which educators from around the world can collaborate and discuss their intervention methods and share experiences of what works best in various situations, not just an EFL classroom in Japan.
References


Abstract

Tertiary students face difficulties in using technical modules because they rarely utilise these materials in high school. Given that they are new to this concept, including the related theories and methods of calculation, these students occasionally perform poorly in their studies, particularly in the technical modules of engineering courses. Evidently, students from engineering schools constantly encounter learning problems because of the many technical modules that they use in their respective programmes. The concepts, theories and calculations involved in various technical modules are new to tertiary students.

Civil engineering is one of the most popular but difficult programmes in Hong Kong. The increase in the number of infrastructure projects in this territory has resulted in an increasing number of high school students preferring to pursue an undergraduate degree in Civil Engineering. However, they often face difficulties whilst pursuing their tertiary study.

Video tutorial as a concept of flipped classroom is recommended in tertiary education, particularly for engineering modules. This tutorial provides a 7-day/24-hour and repeat resources to assist tertiary students upgrade and enhance their skills, particularly in technical modules. This research conducts a pilot study of a technical module titled ‘Temporary Work Design’ from the High Diploma of Civil Engineering programme. Moreover, a three-year rolling study is performed. Results indicate an improvement in the academic outcomes of students who studied under the aforementioned technical module.

A 10% increase in the average mark and passing rate was observed from academic years 2015–2016 to 2017–2018. Moreover, the number of students who obtained a grade of ‘A’ increased. The overall result of the engineering module was enhanced by using video tutorials based on the flipped classroom concept. The mean of the result, passing rate and number of students who obtained an ‘A’ were generally enhanced as well. Conclusions and recommendations were likewise provided in this study.

Keywords: flipped classroom, technical module, video tutorial, engineering, Hong Kong

Introduction

Tertiary students often encounter difficulties in using technical modules because these materials are new in the tertiary education. The syllabus of tertiary modules is completely different from those used in high school. For example, high school students who study mathematics (e.g. algebra, differentiation, integration, trigonometry, probability and logical analysis) learnt only the foundation theories and basic concepts. However, they need to apply the related concepts and theories into the technical modules in engineering. Additionally, students should apply the basic mathematics concepts into the technical analysis of engineering problems.

Civil engineering is one of the most difficult amongst various School of Engineering programmes. Particularly, civil engineering involves broad and detailed analyses. Fluid, soil and structural mechanics are basic modules in civil engineering that require substantial understanding and analyses of mathematical concepts. Students will definitely experience academic difficulties if their knowledge and skills in mathematics are limited. Consequently, their academic performance will be affected, particularly in terms of low academic results.

The current study proposes the concept of a flipped classroom. Wikipedia (2018) defined flipped classroom as ‘students watch online lectures, collaborate in online discussions, or carry out research at home whilst engaging in concepts in the classroom with the guidance of a mentor’. This concept has been applied in teach technical modules in civil engineering. The researcher introduced video tutorial to civil engineering students in the ‘Temporary Work Design’ module. Firstly, video clips on the methods of solving tutorial problems had been uploaded in the Moodle system for the tutorial class of students of the High Diploma of Civil Engineering...
programme. They were required to ‘pre-study’ for the tutorial questions and ‘re-study’ at any time. Thereafter, the researcher discussed with the students during the tutorial class, asked if they understood the discussion and encouraged them to present the difficulties that they encountered in the tutorial questions.

A three-year rolling pilot study has been introduced to investigate the effectiveness of the method in teaching technical modules to the students of the High Diploma of Civil Engineering programme. The study started in 2015 and the academic results of the Temporary Work Design module were recorded from 2015 to 2017 for analysis. An overall 10% improvement in the academic performance had been recorded using the concept of flipped classroom.

Literature review

Palmiter and Elkerton (1993) determined that a trainee often demonstrates improved results during training when using video instruction. The researchers conducted a survey that involved 59 engineering students with mean ages of 24.9 years old in their US study. They determined that the students who used video tutorials as demonstration can reply to questions faster and more accurate than those who used reading materials as demonstration. When using video tutorials, the students did not have to spend time to interpret the steps from the reading materials. Moreover, the students did not need to do referential mapping of verbal concepts in the text to objects and actions in the interface.

Leng et al. (2007) investigated the effectiveness of using video tutorials to teach medical students. These researchers determined that video tutorial classes assist students who lack clinical experience to gain knowledge on the actual process of surgery. Additionally, video tutorial classes provide definite visuals to students compared with books or texts. Furthermore, these researchers mentioned that videos facilitate good memory retention. That is, students can remember actions and procedures related to the surgery.

Lloyd and Robertson (2012) presented learning outcomes by using video tutorials in the US, in which their investigation involved undergraduate students of psychology. These researchers determined that video tutorials are an effective and efficient tool for enhancing student learning, particularly mathematics concepts.

He et al. (2012) investigated how video tutorials assist in addressing learning difficulties in chemistry. These researchers introduced video tutorials to undergraduate Chemistry students and determined that online video tutorials are a valuable, flexible and cost-effective tool to improve the learning process of students and address their difficulty in this particular subject.

Meij and Meij (2015) discussed the effectiveness of video- versus paper-based tutorials. They determined that video tutorials provide better results in terms of retention task performance for junior students, whereas paper-based tutorials cannot match those of the former. Additionally, these researchers conducted a questionnaire survey involving a group of 30 students with a mean age of 13.2 years. Their result showed that the task performance of the students is good.

In summary, researchers concluded that the trainees (i.e. tertiary students) prefer to attend video tutorials possibly because of the following reasons. (1) The new generation loves to use new media (e.g. YouTube, Internet forum, WhatsApp, Instagram and Facebook) to communicate and learn. (2) Video tutorials are 7 day/24 hour-platforms, thereby enabling students to learn and review videos anytime. (3) Video tutorials eliminate location barriers, thereby enabling students to continue studying even if they are absent from the actual class. (4) The quality and quantity of the tutorial class can be maintained. (5) A tutor is not required (although the performance of a tutor in various tutorial classes may be retained).

A video tutorial is only a one-way method for students to ‘pre-study’ and ‘re-study’. Hence, this method is a component of the flipped classroom concept.

Flipped classroom

Lage et al. (2000) defined flipped classroom learnings as concepts that ‘require human interaction’ and ‘automated through technology’ (see Figure 1):

Require human interaction

Automated through technology

Student centered learning theories
Interactive classroom activities

Teacher centered learning theories
Explicit instruction methods

Flipped classroom

Figure 1: Concept of Flipped classroom

Bishop and Verleger (2013) indicated that the concept of flipped classroom represents a unique combination of learning theories that were previously considered ineffective. The flipped classroom concept is an active,
problem-based learning method. The researchers stated that learning performance can be improved by using flipped classroom because students prefer face-to-face learnings, such as video lectures.

Roehl et al. (2013) summarised that flipped classroom is easy to use and readily accessible. This concept allows an expanded range of learning activities during class time and provides opportunities for teacher–student interaction, mentoring, peer-to-peer collaboration and cross-disciplinary engagements. Such type of learning is good for millennial students (born between 1982 and 2002) because they are ‘digital natives’. That is, they have been exposed to information technology from an extremely young age.

The researchers further suggested that the flipped classroom model could be easily adapted in different disciplines, such as textile, apparel and interior designs and nutrition and construction studies. Additionally, the researchers performed their investigation in various courses (e.g. chemistry, psychology and medical education).

In this work, the researcher conducted a pilot study to investigate the effectiveness of video tutorial for students in engineering study to improve their learning performance.

Methodology
A three-year rolling survey has been conducted starting from 2015. The Temporary Work Design module for civil engineering has been utilised for analysis. The academic year (AY) 2015–2016 is a control year. That is, no video tutorials have been provided to the students. For AYs 2016–2017 and 2017–2018, the researcher introduced video tutorials to the second year students of the High Diploma in Civil Engineering programme. Their academic performance had been recorded and analysed. Regarding the distribution of video tutorials, the researcher uploaded video clips (see Figure 2) on how to resolve the problems in ‘Moodle’ (an internal communication system between students and lecturers provided by Vocational Training Council). The students were required to ‘pre-study’ before the tutorial class. Thereafter, they were encouraged to ask questions regarding the tutorial questions after their ‘pre-study’. The students assessed the videos after the class for their ‘re-study’. The video clips were available within the entire semester. Hence, the students can ‘pre-study’ and ‘re-study’ in 7-day/24-hour learning mode. The tutor further discussed the tutorial questions and provided in-depth ideas during the class. The academic results of the three consecutive years had been recorded for analysis. The SPSS version 24 software was used for analysis.

Findings and analysis

<table>
<thead>
<tr>
<th>Year</th>
<th>Pass rate</th>
<th>% of A grade</th>
<th>Mean Statistic</th>
<th>Std. Deviation Statistic</th>
<th>Variance Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY 15/16</td>
<td>79.5%</td>
<td>0.9%</td>
<td>50</td>
<td>15.798</td>
<td>249.584</td>
</tr>
<tr>
<td>AY 16/17</td>
<td>85.9%</td>
<td>1.8%</td>
<td>53</td>
<td>13.001</td>
<td>169.032</td>
</tr>
<tr>
<td>AY 17/18</td>
<td>87.3%</td>
<td>8.5%</td>
<td>55</td>
<td>14.782</td>
<td>218.511</td>
</tr>
</tbody>
</table>

Table 1: The followings are the results from SPSS version 24:

Table 1 shows the summary of the academic result. The passing rate of the students steadily increased by 10% from 79.5% in AY 2015–2016 to 87.3% in AY 2017–2018. The students had a high passing rate when using this engineering module. A significant improvement (i.e. 10%) was obtained after introducing video tutorials to second and third year students.

An increasing number of students obtained a grade of ‘A’ (75 marks and above) in their total mark. The percentage of grade A recipients substantially increased from 0.9% in AY 2015–2016 to 1.8% in AY 2016–2017 and to 8.5% in AY 2017–2018. The video tutorials were determined to be beneficial for students to ‘pre-study’ and ‘re-study’ under this engineering module.

The mean of the academic results were increased when comparing the control mark in AY 2015–2016. A total of 10% improvement was recorded in the final mark compared with the result between AYs 2015–2016 and

The standard deviation and variance in AY 2017–2018 was narrow and concentrated to the mean value compared with those in AY 2015–2016. The results of the students were consistent.

Student feedback was positive and they were often welcome to the video tutorial setting. They appreciated the availability of video tutorial provided in the Moodle system because of the easy way to ‘pre-study’ and ‘re-study’ on their own

![Figure 3: Summary of Academic result from AY15/16 – AY17/18](image)

Figure 3 provides the boxplot graph. The outliers of AYs 2015–2016, 2016–2017 and 2017–2018 are 4, 3 and 1, respectively. The majority of the data were reliable. Moreover, the majority of data (lower quarter) was above the passing mark of 40. The mean mark slightly increased from AY15/16 to AY17/18.

**Conclusion and recommendation**

A flipped classroom is a remarkable and variable concept in learning. The concept is beneficial for millennial students because they are considered ‘digital natives’. That is, they have been exposed to information technology from an extremely young age. Additionally, this concept was determined to be beneficial in various disciplines.

The students of the Higher Diploma in Civil Engineering programme were selected for the evaluation of the effectiveness of applying the flipped classroom concept in engineering modules. A three-year rolling study was conducted and the academic results were collected for the analysis.

The flipped classroom concept is an effective idea to improve the learning performance of engineering students. An engineering module (Temporary Work Design) of the High Diploma in Civil Engineering programme was used as a pilot study. The mean of the result, passing rate and number of students who obtained an ‘A’ increased generally.

The average mark and passing rate increased by 10% from AY 2015/2016 to 2017/2018. The number of students who obtained an ‘A’ likewise increased. The overall result of the engineering module improved by using the video tutorial from the flipped classroom concept.

Further study was determined to be good to millennial students. The majority of the High Diploma students are in this age group. Therefore, the researcher recommends that the flipped classroom concept is feasible for approval in the engineering discipline. Moreover, investigating the 5Ws (i.e. What, Who, Where, When and how) must be the direction of further study.

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

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Abstract

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

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

Introduction

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

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

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

Theoretical Perspectives of Blended Learning

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

“…a language course which combines a face-to-face (F2F) classroom component with an appropriate use of technology” (Sharma & Barret, 2007, p.7).
“...the term most commonly used to refer to any combination of face-to-face teaching with computer technology (online and offline activities/materials)” (Whittaker, 2013, p.12).

“...face-to-face plus web-based learning” (Sharma, 2010, p.457).

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

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

According to Graham (2006), BL brings at least three advantages to a classroom. Firstly, it enables teachers to enhance the quality of their teaching, as BL allows teachers to combine the advantages of face-to-face teaching and WBT. For example, Enokida (2015) conducted a dictogloss activity (i.e., a type of listening activity where learners are required to listen to a passage with their partners and reconstruct the passage collaboratively) in a face-to-face classroom. Then, using the same listening material, the learners were required to practice English dictation on WBT. It is clear that Enokida (2015) utilizes WBT for listening practice.

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

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

**Case Study**

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

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

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

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

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

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

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

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

![Figure 1. An example of an instructional video.](image)

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

![Figure 2. An example of a multiple-choice question.](image)

![Figure 3. An example of a match-the-following question.](image)

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

![Figure 4. An example of a quizlet. When a study mode is changed, learners can experience a variety of activities.](image)

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

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

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

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

In comprehension tasks, the learners were required to read the sentences on heat and judge whether the sentences were correct or not (lesson 7-1 and 7-2). The
learners were also told to read the fill-in-the-blank passages related to convection and radiation, and to fill the blank spaces with appropriate vocabulary and expressions.

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

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

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

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

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

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

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

Tips for effective BL

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

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

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

Third, it is essential to consider the number of ways to distribute videos. In Fujita (2018), I basically used YouTube as a platform for providing videos to learners. However, there were some students who had difficulty in accessing YouTube due to the restriction on the use of cellular network and/or unavailability of an Internet network at home. To deal with this problem, Office 365 was used as an alternative to YouTube. Since Office 365 is contracted in almost all the NITs, the learners at the NIT, Fukui College, could use it at the time they...
were on campus. Moreover, USB drives were also used to distribute the instructional videos. This enabled learners to watch the videos offline. Distributing videos in these three ways made the learners in my classroom watch them one way or the other.

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

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

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

![Figure 6. File formats for importing question data.](image)

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

![Figure 7. The Aiken format.](image)

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

Conclusions

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

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

Acknowledgements

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Notes
References


BUILDING INFORMATION MODELLING EDUCATION IN HONG KONG

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Abstract

BIM Technology introduced to Hong Kong Architecture, Engineering and Construction (AEC) Industry for more than 12 years, and it added to the curricula of higher diploma programmes of Hong Kong Institute of Vocational Education (IVE) for nearly a decade. At the same time, the BIM technology continuously updated and extended to a much broader scope. With the introducing of BIM mandate to almost all government public works projects, there are profound changes in the competencies demand. All the above development imposed new challenges for the teaching and learning approaches to the subject.

This paper presents the current situation of Building Information Modelling (BIM) Education in IVE of Vocational Training Council (VTC), Hong Kong.

Keywords: Building Information Modelling (BIM), Education, Architecture, Engineering, Construction, Hong Kong

Introduction

In September 2016, the Buildings Department of the HKSAR Government issued the “Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers (ADV-34)” which expressly encourages authorized persons (AP), registered structural engineers (RSE) and registered geotechnical engineers (RGE) to consider adopting BIM in building projects under the Buildings Ordinance.

In January 2017, The Chief Executive of the Hong Kong Special Administrative Region (HKSAR) in the Policy Address asserted that the HKSAR Government would actively seek to require consultants and contractors to use Building Information Modelling (BIM) technology to undertaking design of major government capital works projects from 2018 onwards. The Chief Executive also urged all eligible consultants to prepare for facilitating a smooth implementation of this initiative. The message reiterated in the Policy Address in October 2017. The adoption of Building Information Modelling in Capital Works Project has been rolled out in January 2018 as scheduled.

Development of BIM in Hong Kong

BIM Technology introduced to Hong Kong Architecture, Engineering and Construction (AEC) Industry for more than 12 years, and it added to the curricula of higher diploma programmes of Hong Kong Institute of Vocational Education (IVE) for nearly a decade. At the same time, the BIM technology continuously updated and extended to a much broader scope. With the introducing of BIM mandate to almost all government public works projects, there are profound changes in the competencies demand. All the above development imposed new challenges for the teaching and learning approaches to the subject.

Literature review

Building Information Modelling (BIM) is not simply a new technology. It is not just software, hardware or a few personnel that can easily be master and become a functional business area. BIM becomes another essential business function that is crucial for every Architectural, Engineering and Civil Engineering (AEC) companies. Many AEC companies that need to introduce BIM to their business function may start by transforming the existing function department or re-training their staff to adopt BIM for their business needs. Unlike other well established AEC professional, technologists or technicians who have corresponding undergraduate courses or Higher Diplomas and Associate Degrees.

Regarding professionalism, BIM still does not have a universal recognised professional. There is no clear definition for the scope of work and job duties of the BIM personnel. Barison and Santos (2010a) identified several types of BIM job positions:

- BIM Modeller
- BIM Analyst
- BIM Application Developer or BIM Software Developer
- Modelling Specialist
- BIM Facilitator
- BIM Consultant
- BIM Researcher
- BIM Manager
BIM Manager which usually in a leading role of a team of BIM initiative of the company can further classify into:
- Project Model Manager, Modelling Manager or Model Manager
- BIM Manager at Design Firms or Chief BIM officer
- BIM Manager at General Construction and subcontractor Firms

Degree-awarding higher education institutions considered as the source of AEC professional. Employers of AEC companies expect that construction related program graduates will already have a working knowledge of BIM. There is no a BIM specific undergraduate course or Higher Diplomas BIM exists. It is even not compulsory elements for most AEC related course offered by these institutions.

Maghiar, Jain and Sullivan (2013) revealed one possible barrier that limited the availability of BIM education in the various program. Although BIM already noted as essential elements by the industry, BIM is still not formally acknowledged as the accreditation criteria of any AEC courses. Students also lack the incentive to take additional courses for BIM education that is not part of their program curricula, as far as they are not necessary to graduate.

However, with the rapid adoption of BIM over the past few years, BIM becomes the essential skill for graduates to remain competitive in the job market. Maghiar, Jain and Sullivan (2013) suggested the following important skill needed:
- Ability to apply and work with new technology;
- Basic modelling and manipulation skills;
- Ability to model detailed conditions in 3D;
- Ability to assemble and review a clash detection model;
- Ability to create 4D models using a schedule and then derives a total project estimate.

Maghiar, Jain and Sullivan (2013) concluded that “The leading instruction of this class with a few industry experts explored several areas of BIM integration and after careful considerations have determined that implementation throughout the curriculum is the most advantageous way to achieve both academic and industry”. They also opine that “the next generations of construction professionals are not the BIM experts, but they are capable of applying their BIM knowledge to their daily job tasks.” Wu and Issa (2013) study affirmed that BIM-oriented career development was still new to most academic AEC programs. Nowadays companies preferred to hire seasoned professionals instead of fresh college graduates for BIM staffing.

Barison and Santos (2010b) studied the approach to introduce BIM to the curriculum of Architecture and Engineering courses and conclude that the simple addition of a new BIM course may not fully unleash the potential of BIM. An integrative approach by spreading the BIM subject into separate courses and with attempts to collaborate with each other would need. Indeed, there was a similar framework developed by The Higher Education Academy and BAF (BIM Academic Forum) in the UK. The report “Embedding Building Information Modelling (BIM) within the taught curriculum” (2013) outlined a “BIM Learning Outcomes Framework”. The framework covers three levels of need: strategic, management and technical.

One of the key difference highlighted by Barison and Santos (2010c) is that unlike other traditional subjects, “Collaboration” is an essential component for BIM curriculum activities. It is clear that the learning experience is still rather new and the pedagogy applied is not yet been consolidated.

### Provision of BIM Modules in IVE

Table 1. List of Building Information Modelling Module offered by IVE.

<table>
<thead>
<tr>
<th>Higher Diploma (HD) Programme</th>
<th>Module title</th>
<th>Curriculum Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD in Architectural Studies</td>
<td>Computer 3-D Visualization and BIM</td>
<td>39</td>
</tr>
<tr>
<td>HD in Architectural Technology and Design</td>
<td>BIM A</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>BIM B</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>BIM for Building Services Engineering*</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>BIM for Construction Management*</td>
<td>39</td>
</tr>
<tr>
<td>HD in Building Studies</td>
<td>BIM for Building Works</td>
<td>39</td>
</tr>
<tr>
<td>HD in Civil Engineering</td>
<td>Structural Detailing and BIM</td>
<td>39</td>
</tr>
<tr>
<td>HD in Environmental Engineering</td>
<td>BIM for Environmental Applications</td>
<td>26</td>
</tr>
<tr>
<td>HD in Surveying</td>
<td>BIM and CAD</td>
<td>52</td>
</tr>
<tr>
<td>HD in Building Services Engineering</td>
<td>BIM in Building Services Design</td>
<td>39</td>
</tr>
<tr>
<td>HD in Real Estate and Property Management</td>
<td>Intelligent Building Systems &amp; BM</td>
<td>39</td>
</tr>
<tr>
<td>Enrichment Modules (Offer to all IVE HD students)</td>
<td>Introduction to Building Information Modelling</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Parametric Modelling for Building Design</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Building Information Modelling with ArchiCAD</td>
<td>26</td>
</tr>
</tbody>
</table>

The above table lists the latest provision of BIM in IVE.
In the early stage of introducing BIM to the IVE curriculum, BIM Modules only introduced to very limited Higher Diploma Programmes of the Department of Construction. With the experience gained in delivery BIM modules and through observation of the industry development, feedback from various industry stakeholders, we finally notice that the provision of BIM modules to particular Higher Diploma cannot fit the sustainable development of BIM which focuses a lot in collaboration as mentioned in previous paragraphs.

In recent years, with the popularity of BIM, more IVE Higher Diploma programmes started to introduce BIM module into the curriculum. Currently, we have 8 Higher Diploma with one or more than one BIM modules as core or elective modules of the curriculum.

**Challenges in BIM Education**

Unlike hand-drafting or Computer Aided Drafting, BIM technology is a tool that can be capable of allowing one to develop a complete set of drawings including plans, elevations, Sections, schedules, 3D views, animation. The requirement of hardware is relatively higher than that of other software. Additionally BIM software tends to upgrade annually; one of the major BIM software introduced a practice that BIM files created by newer version are not backwards compatible with the older version. We cannot stick to an older version for a prolonged period as the newer version will always have new functions and improved functionality.

With the continuous development and the maturity of using BIM technology, the scope of BIM has extended rapidly. From the number of software available to the technology adopted. Examples include the use of virtual reality (VR) in visualisation, Terrestrial laser scanning of the construction site, existing building or internal environment. The popularity of unmanned aerial vehicle (UAV) and photogrammetry in surveying. All these latest development which introduced rapidly as the norm of BIM operations added new demand from Employer and various stakeholders, yet all these new technologies require a considerable amount of resources for adapting to the curriculum.

**Conclusions**

The paper reviewed the latest development of BIM in Hong Kong. It also reviews the challenge of incorporating BIM into the curriculum and reported the latest status of BIM provision in IVE.

**References**


CONVERGENT COLLABORATIVE LEARNING (CCL) MODEL FOR ENHANCED STUDENTS LEARNING IN BIOMEDICAL ENGINEERING COURSE

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Abstract

Group project-based learning is commonly used within engineering curriculum to simulate what is expected in the real-world of engineering work – working in teams to collaborate and apply their knowledge and skills to solve real engineering problems. However, many engineering educators face multiple challenges in using group projects effectively. Some of the issues observed include team members not equally contributing fairly and equally to the work, poor student motivation due to less individual accountability, and the worry of uneven acquisition of the expected skills, knowledge, and know-how by team members. In this paper, a systematic approach called the ‘Convergent Collaborative Learning (CCL) model’ is proposed to help educators address the challenges of implementing group projects and, at the same time, build students’ interest and confidence in their own ability to learn and solve engineering problems.

The CCL model is developed by adopting collaborative learning approach but in a more structured manner to promote students’ cognitive thinking. In this model, the problem solving process involves four stages. The first stage is the Idea Generation (IG) stage where the students brainstorm and collect different ideas from the group. The second stage is Idea Organization (IO) that involves comparing, analyzing and categorizing different ideas. The third stage is Idea Convergence (IC) that necessitates higher levels of cognitive processing to synthesize the organized ideas and converge to generate solutions. The last stage is the Final Design (FD) where the students integrate and complete the design. The process can be reiterated for more complex project design. In this way, this model provides opportunity for the students to engage more in deep learning.

A pilot study of the proposed model was carried out with 83 diploma level students of the Biomedical Engineering course at Ngee Ann Polytechnic. Analysis of the results indicated that the CCL model enhances the students’ learning experience and fosters the development of technical and non-technical competencies in all team members. This approach also helped to alleviate the issues of free-riding and accountability of individual contribution by team members. In conclusion, this study demonstrated the potential of this model for use at any higher education courses to nurture students for future career and challenges in the rapidly growing economy.

Keywords: convergent collaborative learning, group projects, critical thinking, cognitive thinking, biomedical engineering

Introduction

In this decade, engineering education institutions are faced with many challenges with the decline in students’ intake and interest in engineering as key factors. Currently, students encounter difficulties in applying the knowledge and skills learnt in the classroom to industry. At the same time, many companies require that employees be skilled in teamwork and communication, so as to improve productivity. In an effort to close the gap between industry needs and academia for engineering students, Daniels et al. (2010) proposed using open-ended group projects. Open-ended group projects intend to bridge the gap by mimicking real-world scenarios and enabling the students to acquire relevant skills in addition to content knowledge. It paves a way to integrate, teach and assess non-technical competencies as well, along with technical competencies.

Group projects are not something new and have been used by educators for many decades. Many university and college level courses employ group projects to simulate real-world industry experiences in solving problems and managing resources and teams (Gamson, 1994). Group projects intend to create a simulated industry-working environment for students. As much as said, many researchers have assessed the advantages of group projects in classrooms. The main advantage was found to be fostering ‘deep learning’ and reducing ‘surface learning’ in students (Entwistle and Waterson, 1988). Group work pushes students to be active learners
by enabling them to construct and synthesize their own knowledge (Ruel et al., 2003). Group projects also provided students with experiential learning opportunities and promoted their problem-solving and decision-making capabilities (McGraw and Tidwell, 2001). Watkins (2004) had indicated that many students appreciated the holistic learning experience obtained by doing group projects.

Though there are many advantages for implementing group projects in classrooms, they posed significant challenges for teachers and students in achieving desired learning outcomes. As much as researchers agreed on the benefits of real-world scenario-based group projects for engineering students, they have also highlighted the various concerns and implementation issues that hinder the efficacy of using group projects for learning. According to the analysis by Davies (2009), for the students at tertiary level, group work promoted deep and active learning, construction of knowledge and higher-order thinking skills. It provides a pathway for students to discuss and assimilate new ideas in a social context, fostering social skills. Group project work also enables students to develop transferable skills and on-job learning attitude that meet the demands of the industry for flexible workers.

On the other hand, there are also some key concerns with the use of group project for learning. One of them is self-motivation. It can result in poor group work experience for students, when they are in groups with unmotivated students who only want to “free ride” or “social loaf” (Morgan, 2002). Another study (Isaac & Tormey, 2015) revealed that students’ perceptions of learning in groups change during the course of the project and reported more positive group experiences with increased lecturer guidance and intervention. The students were also concerned about time as they found it difficult to meet with group members to discuss their project or meet up with their lecturers. These challenges add pressure to their learning experience and negatively impact students’ learning when working in group projects.

To address these issues of group projects, various collaborative learning pedagogies were proposed in the literature. The study by Persico et al. (2009) suggested that more structured activities during collaborative learning results in better learning outcomes and experiences. But researchers like Dillenbourg (2002) have cautioned that over-guiding of students by instructors during collaboration activities tend to cause loss of flexibility and failed to nurture students’ creativity and abilities to handle unforeseen circumstances. Hence it is important to strike a balance and nurture creativity in students even with structured activities. With this objective, we have proposed a new enhanced collaborative learning model referred to as the Convergent Collaborative Learning (CCL) model to facilitate group projects for engineering courses in higher educational institutions. The proposed CCL model provides a structured approach for collaboration that allows learners to develop both technical skills and 21st century competencies. A pilot study of the CCL model was carried out with students in a biomedical engineering course with the aim to evaluate the effectiveness of the proposed CCL model in facilitating group projects and its impact on learners.

**Methodology**

The CCL model is underpinned by the social constructivist learning theory developed by Vygotsky (1978). According to Vygotsky, social interaction aids to build complex knowledge structures. In collaborative learning, knowledge is constructed by learners through their experiential activities and with their interactions with teachers and peers. Usually constructivist classrooms are implemented using active teaching pedagogies to create an arena that promotes discussions and reflections by learners to develop in-depth understanding.

The CCL model is developed with the objective to utilize the beneficial aspects of structured collaborative learning and in the meantime improve their cognitive processes to enable them to construct knowledge and develop an intelligent convergence of their ideas with knowledge and skills. The proposed CCL model is derived from the Harasim’s Online Collaboration Model (OCM) that encourages students to work in teams to seek conceptual knowledge in order to solve real-world problems (Harasim, 2012). The conceptual map of the proposed model is shown in Figure 1.

The CCL model is a schema for educators to mimic real-world scenarios and situations encountered when working on projects, in class and bring the desired conceptual change in learners to seek and construct knowledge. This learning model incorporates four phases of idea and product development as given in Figure 1.

Figure 1. Convergent Collaborative Learning (CCL) Model

The first stage - Idea Generation (IG) - brainstorm and collect different ideas; The second stage - Idea Organization (IO) - compare, analyze and categorize different ideas; The third stage - Idea Convergence (IC) - synthesize the organized ideas and converge to generate solutions; The last stage - Final Design (FD) - integrate...
and complete the design; The 4-stage process in Figure 1 can be reiterated for further enhancement and more complex project design. This model provides the opportunity for the students to engage in deep learning.

This conceptual model has to be integrated with an appropriate implementation model to ensure that learners achieve desired learning outcomes. The implementation model is derived from the cooperative learning approach for implementing group projects by Felder and Brent (2001). In this approach, students embark on structured learning tasks that satisfy five criteria: positive interdependence, individual accountability, real-time interaction, inter-personal skills and self-assessment skills. To achieve this, an implementation model resembling a Jigsaw pattern as shown in Figure 2 is used. Two types of groups are formed – One is a home team and the other is an expert group. Home teams are formed with members who have diversified knowledge and specialities to work on the specific projects. Each member of the home team is responsible for a specific part of the project and require specialized knowledge and skills. Expert groups are formed with members from different home teams but assigned in the same specialized area. In this method, students benefit by taking ownership of one expertise area in the project, collaborating with expert groups and exhibiting professionalism in team work. Students are accountable for completion of their part in home team and also collaborate with team members to ultimately complete the project.

![Figure 2. Implementation model of CCL using Jigsaw structure](http://teachingadolescents.weebly.com/jigsaw.html)

Lecturers or facilitators play a crucial role in linking the conceptual and the implementation model. In the first IG stage of the CCL model, instructors provide resources and encourage the students to generate ideas in their assigned expertise area along with their expert group members. In the second IO stage, students return to their home teams and share the ideas generated during different expert group discussions. They compare, analyze and categorize the different ideas from various expert groups and discuss the pros and cons of each of the ideas generated. At third IC stage, students are involved in discussions with expert group members to identify viable solutions and the ways to overcome the issues identified during home team discussions. At this stage, students are stretched to develop the ability of customizing generic ideas to make it suitable for the home team project. In the last FD stage, students construct the final design or product by integrating the different expertise ideas of respective team members. Depending on the complexity of the project, the process can be reiterated and on every iteration the student may seek knowledge at a much deeper level to arrive at feasible solutions.

### Implementation and Data Collection

A pilot study of the proposed CCL model was carried out with 83 students of the Year 2, Biomedical Engineering course taking Healthcare Information Technology (HCaIT) module. The group projects in this module are formulated such that they mimic the real-life scenario in this module domain. The formation of project groups was the most crucial element of this model, thus careful and strategic selection of the group members is important in order to achieve the desired learning objectives.

Home teams were formed with a fixed number of four members per group. The students chose their home team members, but with lecturer’s supervision to ensure that the members of the team possessed diversified capabilities. Each group was assigned a different scenario of the real-life problem. The scenarios were chosen such that they were of same complexity and are similar in terms of the expert knowledge requirements. Once home teams are selected and expert groups are formed, their tasks will be assigned. Lecturers provide resources and initiate the start of the project work. They will also monitor the progress of both home teams and expert groups and will provide guidance and interventions where necessary.

Evaluation which is vital to validate this pilot study was carried out at two stages – first when the project is about 75% complete and second at the end of the project. All 83 students participated in this evaluation process and provided feedback about their learning experiences in the project. The first survey, ‘Group Dynamics: Group and Me’ was aimed to gauge the group dynamics during the project (Table 1). The questions for this survey were chosen with reference to the guidelines given by Swaray (2012) on the evaluation of effectiveness of the group projects. The seven questions on this survey focused on three areas: motivation (Q1 & Q2), team work (Q3, Q4 & Q5) and higher order thinking skills (Q6 & Q7).

The second survey (Table 2) was to evaluate the overall learning experience. The questionnaire for the second survey was developed using Ngee Ann Polytechnic’s Module Experience Survey (MES) guidelines to evaluate six specific areas: skills and knowledge, thinking, teaching and learning, feedback, materials and activities. The seventh question was to evaluate the overall experience. Each survey question is rated using 5 point Likert scale (SD–Strongly Disagree, D–Disagree, N–Neutral, A- Agree, and SA– Strongly Agree).
Table 1. Group dynamics: Group and Me (Student survey questions)

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Inspiring and motivating than the other group assignments I have experienced before.</td>
</tr>
<tr>
<td>Q2</td>
<td>More effectively encouraged me to work with my classmates. Enabled me to work closely with my classmates with whom I usually do not interact with so much</td>
</tr>
<tr>
<td>Q3</td>
<td>Enabled group members to observe and monitor each other’s understanding of the project</td>
</tr>
<tr>
<td>Q4</td>
<td>Experienced very little or no problems in the team due to group members laziness or lack of participation</td>
</tr>
<tr>
<td>Q5</td>
<td>We are able to complement each other’s strengths and weakness in completing the project.</td>
</tr>
<tr>
<td>Q6</td>
<td>Helped me to think out-of-box by generating ideas, critiquing each other ideas and identify the feasible solution to achieve the final goal.</td>
</tr>
<tr>
<td>Q7</td>
<td>I am able to synthesize and simulate the real-world application through this project which I will not be able to do so if I do the project alone.</td>
</tr>
</tbody>
</table>

Table 2. Overall learning experience for Group project (Student survey questions)

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 Skills and Knowledge</td>
<td>The group project helped me to develop useful skills and knowledge in this module.</td>
</tr>
<tr>
<td>Q2 Thinking</td>
<td>The discussions with expert groups and home groups helped to understand and execute the project better and achieve the desired learning outcome.</td>
</tr>
<tr>
<td>Q3 T&amp;L</td>
<td>The teaching and learning approach helped to stretch my thinking skills to complete and enhance the project.</td>
</tr>
<tr>
<td>Q4 Feedback</td>
<td>I received useful feedback for the activities and discussions.</td>
</tr>
<tr>
<td>Q5 Materials</td>
<td>The materials and resources provided are good and aided me to understand the content better.</td>
</tr>
<tr>
<td>Q6 Activities</td>
<td>The project activities helped to improve my collaboration and communication skills.</td>
</tr>
<tr>
<td>Q7 Overall</td>
<td>Overall, I enjoyed this approach of doing projects and it enhanced my learning experience.</td>
</tr>
</tbody>
</table>

Results and Discussion

The results of the survey “Group dynamics: Group and Me” are given in Figure 3. In general, the results of the survey substantiate the rationale of using the proposed CCL model for group projects, such as promoting deep learning, increasing student motivation and reducing free riding.

Results revealed that 91% (Q7) of students were able to synthesize and simulate the real-world applications using this learning approach. 81% (Q2) of students agreed that this method encouraged them to work effectively with their classmates and also enabled them to work in a more efficient manner with new teammates who were not part of their daily interactions. Furthermore, 86% (Q3) of the students indicated that they learned by observing and monitoring other team members’ work. 86% (Q5) of students also reported that they were able to identify each other’s strengths and weaknesses and this helped them to complement each other’s work to successfully complete the project. This indicates that students were able to do a self-evaluation as well as a peer evaluation of their contributions to the group project.

The CCL model has helped them to connect to the project and assisted in identifying plausible errors in their designs. This is an indication of the development of reflective and reasoning skills which the students might not acquire during traditional classroom teaching. These results assures that the CCL model catered opportunities for students to acquire and apply domain knowledge, and develop communication and collaboration skills by working in groups to solve real-world problems. The findings also ascertain that structured activities led to meaningful collaboration and nurtured students’ cognitive abilities.

The expert group discussions paved the way for learners to seek knowledge and bring desired conceptual change to build new knowledge and deepen existing knowledge. The work in the home team enabled learners to critically analyse and apply the knowledge to real-world applications. Due to the nature of structured processes in the design of CCL model, various issues
with group work such as free-riding and lack of domain competencies were minimized. Indirectly, these processes seem to have induced trust and commitment among team members which led to better team cohesion and group dynamics.

After the completion of delivery and assessments of the project, students were asked to do the next survey on the overall learning experience of this group project. Results of this survey, given in Figure 4 were very promising regarding the positive effects of the group project implemented using the CCL model. Consistent with the results of the first survey, more than 80% (Q7) of the students were optimistic about their learning experience obtained by doing this group project using the CCL model. 86% (Q1) of students have specified that the group project helped them to develop useful skills and knowledge in this module. Indirectly, the group project enabled students to learn in and out-of-class environment, enhance leadership skills and to work inclusively with all team members. The results obtained were consistent with the findings from prior research on group work, that group work encourages active learning and enhances communication and collaboration skills.

Figure 4. Results of the survey, Group Project: Overall learning experience.

85% (Q6) of students agreed that the activities enabled them to improve their collaboration and communication skills and 81% (Q3) of the students concurred that teaching and learning approaches stretched their thinking skills. They indicated that they might not able to get the same learning experience if traditional teaching and learning methods were used. The CCL model facilitated all students to achieve the desired domain knowledge, as well as the required 21st century skills such as collaboration and communication. It is important to note that only less than 5% of the students differed on the positive experiences and 15% remained neutral in their views about this learning model.

It is evident from the results that the strategies employed in the CCL model encouraged self-directed learning and nurtured independent reasoning as well. Specifically, the CCL model cultivated wide range of skills that can be applied to real-world work environments in the future. This would enable students to be more work ready upon graduation.

Conclusion

Results from this study confirms the CCL model as a viable teaching and learning approach for facilitating student group projects. This approach tends to develop the cognitive abilities of learners by scaffolding and converging different phases of knowledge construction. It also enables effective team work and aids to ensure that desired learning outcomes are achieved by all students undertaking group projects. Though activities are structured in this model, the implementation process aids to foster deep and critical thinking in students, while at the same time promoting the necessary soft skills such as decision-making, collaborating and communicating in the real-world. With further enhancement, this CCL model can be used for facilitating group projects in multitude of engineering courses.

References


INVESTIGATION OF EDUCATIONAL EFFICACY OF ACTIVE LEARNING: 
ESTIMATION FROM BIOLOGICAL VIEWPOINT

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Abstract:

We attempt to objectively visualize the effects of the educational efficacy of active learning (AL) by measuring students' physiological parameters during classes. We prepared four different types of 20-minute classes: (1) Information Technology and (2) Mathematics where three students in each class were engaged in (A) active learning or sat through (B) conventional lectures (CL). The students were split into two groups, where the first group was allocated to 1A and 2B classes, and the second group to 2A and 1B classes. For each class combination, the cerebral blood flow of one student was measured noninvasively with a NIRS (Near Infrared Spectroscopy) device, while the number of eye blinks and eye movements of two other students were tracked with a special type of glasses. Students were then asked to fill out a self-report questionnaire on their levels of satisfaction, concentration, and interest in the classes, as well as the extent of their self-thinking. Students engaged in AL reported higher scores for all items, especially for both concentration and satisfaction ($p<0.05$ respectively). The cerebral blood flow measurements (difference between oxygenated hemoglobin (Oxy-Hb) and deoxygenated hemoglobin (Deoxy-Hb)) revealed that brain activity increased during AL classes and decreased during CL, but this could be due to the heavy weight of the NIRS device on the students' heads. Data on eye blinks indicated that the level of concentration increased as the AL classes progressed. Overall, we observed a higher level of brain activity and concentration in students engaged in AL compared to those in CL. However, this is a pilot study with a small sample size, and individual variation may have affected the results. Further studies with larger sample sizes would be required to validate these results. In addition, it would be interesting to examine if there is any correlation between the observable changes in these data and the students' actual activities in the video recorded during classes, as well as the improvement in students' concentration and activation when ICT (information and communications technology) tools are used in classes.

Keywords: Active learning, cerebral blood flow, number of blinks, concentration.

Introduction

The National Institute of Technology (NIT) of Japan has stipulated the introduction of AL to ensure the quality of education, of which several initiatives called for each college to set up a new AL center equipped with ICT equipment to create the necessary environment, and for teachers to revise their lessons accordingly and attend workshops. The aim of incorporating AL is to get away from the mere imparting of information (considered as passive learning) and to provide a program where students can proactively participate in classrooms instead. This has resulted in a drastic departure from the former conventional classroom activities and the colleges had to come up with a new system to evaluate students and the classes. However, most of these evaluations are subjective, such as learning portfolios for students to assess their learning progress and reflection cards or questionnaires filled by students, as well as teachers’ feedback.

On the other hand, the commonly recognized objective indicators used to evaluate the educational efficacy are the level of academic achievement and the increase in students’ study time.

In this study, we will compare the biological data of students in AL classes against those in conventional lecture (CL) classes in an attempt to visualize the efficacy of AL using objective indicators of cerebral blood flow.
and eye blinks. We will also propose a new method based on our results to evaluate the educational efficacy.

**Experimental Methods**

2.1 Procedure

We conducted four different types of 20-minute classes as follows:

1A: Information technology class using AL and several quizzes.
1B: Information technology class in CL (see Figure 1).
2A: Mathematics class using AL where group work is required (see Figure 2).
2B: Mathematics class in CL.

Six students were split in two groups of three. The first group took 1A and 2B classes, while the second group took 1B and 2A classes. This arrangement was to ensure that each student would take one AL class and one CL class of different subject to prevent carryover effects. For each class combination, the cerebral blood flow of one student was measured while the number of eye blinks of the remaining two students were tracked.

2.1 Cerebral Blood Flow

The activity level in the prefrontal cortex was observed by measuring the difference between Oxy-Hb and Deoxy-Hb with a NIRS device using non-invasive optical topography (WOT-100, Hitachi High Technologies Ltd.) at a sampling frequency of 5 Hz. An increase in Oxy-Hb and decrease in Deoxy-Hb would indicate that the corresponding region of the prefrontal cortex is activated compared with the previous condition.

Conversely, a decrease in Oxy-Hb and increase in Deoxy-Hb would signify inactivity in the prefrontal cortex. We believe that the bigger the difference between the Oxy-Hb and Deoxy-Hb, the more the student’s brain is activated.

2.2 Eye Blinks

The number of eye blinks and eye movements were tracked with a special type of glasses (JINS MEME, n.d.). The glasses also capture data on the strength of eye blinks and head and movements, but we are only looking at the number of blinks for this study as we believe that people will blink lesser when they are concentrating on the task at hand.

2.3 The questionnaire

We conducted a 5-point Likert-scale questionnaire on the students (see Table 1). Students were asked to evaluate the items on five levels: 5 – Extremely well, 4 – Very well, 3 – Somewhat well, 2 – Slightly well, 1 – Not at all well.

<table>
<thead>
<tr>
<th>Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How interested were you in the class?</td>
</tr>
<tr>
<td>2. How much did you concentrate on the class?</td>
</tr>
<tr>
<td>3. How deeply did you think about the class?</td>
</tr>
<tr>
<td>4. How satisfied are you with the class?</td>
</tr>
<tr>
<td>5. Any comment about the class?</td>
</tr>
</tbody>
</table>

**Results and Discussion**

In this study, we investigated the biological indicators of students during classes and found that changes in the students’ cerebral blood flows mainly occurred around CH8 and CH14 (Moriya et al. 2017) of the right and left prefrontal cortices, respectively (see Figure 4). The chart on the left is the cerebral blood flow changes of a student in the AL class (1B) and the one on the right is that of the same student in the CL class (2A). The charts clearly showed a larger increase in Oxy-Hb and a larger decrease in Deoxy-Hb when the student was attending the AL class compared to the CL class.

Figure 3 shows the number of eye blinks by two students. The red line is the number of eye blinks in the AL class and the blue line is the number of eye blinks in the CL class. The number of eye blinks in the charts are the average number of eye blinks for every five minutes. The charts indicated that the number of eye blinks decreased as the AL classes progressed (red lines) but
increased in CL classes (blue lines) instead.

Figure 5 shows the average scores of the items in the questionnaire. Students consistently gave higher scores for AL classes than CL classes. The average scores for all items are shown in Table 3. A \( t \)-test revealed that the \( p \)-values between AL and CL are 0.06, 0.02, 0.17, and \( \leq 0.001 \) respectively for items 1 to 4 in the questionnaire, which seems to hint that students find it easier to concentrate and had a higher level of interest in the lesson during AL classes.

<table>
<thead>
<tr>
<th>Items</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>5.0</td>
<td>4.3</td>
<td>3.7</td>
<td>4.7</td>
<td>4.43</td>
</tr>
<tr>
<td>1B</td>
<td>3.7</td>
<td>3.7</td>
<td>4.0</td>
<td>3.7</td>
<td>3.78</td>
</tr>
<tr>
<td>2A</td>
<td>4.0</td>
<td>4.3</td>
<td>4.3</td>
<td>4.7</td>
<td>4.33</td>
</tr>
<tr>
<td>2B</td>
<td>3.5</td>
<td>2.3</td>
<td>2.5</td>
<td>3.0</td>
<td>2.83</td>
</tr>
<tr>
<td>Average</td>
<td>4.01</td>
<td>3.7</td>
<td>3.6</td>
<td>4.0</td>
<td>3.84</td>
</tr>
<tr>
<td>( p )-value</td>
<td>0.06</td>
<td>0.02</td>
<td>0.17</td>
<td>0.0006</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Unexpected change in cerebral blood flow of one student
Interestingly, while we had originally assumed that students would think more deeply about the lesson in AL classes, the self-report questionnaire seems to indicate otherwise (see questionnaire item 3, p-value = 0.17, Table 3). Granted that the difference is not statistically significant, we believe that the slightly lower score is because the information technology classes (1A and 1B) were conducted to merely impart information to the students whereas the mathematics classes required students to think deeply to understand new facts. Having said that, our results showed that students who attended the information technology classes that employed AL demonstrated a higher level of brain activity and concentration.

The mean score obtained from all students on the questionnaire for class 2B is the lowest. We suspected that the contents of the mathematics class were too difficult for them to understand, and the objective biological data and the subjective answers obtained from the questionnaires verified our suspicions.

We would also like to highlight an interesting yet unexpected result that we observed in our study concerning one student’s cerebral blood flow in class 2A (see Figure 5). Both his Oxy-Hb and Deoxy-Hb levels started to decrease as the class commenced. He indicated in the questionnaire that the NIRS device was too heavy and annoying. He could not really open his eyes and even had stiff shoulders, and thus was unable to really concentrate on the class. We believe that the unexpected dips in both his Oxy-Hb and Deoxy-Hb levels were due to the heavy weight of the device.

Conclusions

In this study, we investigated students’ brain activation by measuring their biological responses. Due to a limited number of measurement devices, we could only perform measurements on six students only. However, our results demonstrated that the brains of students exhibited a higher level of activation in the AL classes than the CL classes. Moreover, the heavy NIRS device that students were asked to wear on their heads may have affected the results. On the other hand, students are under much lesser strain wearing the eyeglasses measuring eye blinks, so it was possible for us to measure their number of eye blinks throughout the entire 90-minute long classes.

Due to our small sample size, we decided to calculate the corrected effect sizes (Hedge’s $g$) and obtained 0.93, 0.62, 1.41, and 1.86 respectively for items 1 to 4 in the questionnaire. While these effect sizes are considerably large, there may be a large amount of bias due to the extremely small sample size. We will need to conduct further studies with bigger sample sizes to verify these results.

While we also analyzed the cerebral blood flow and the number of eye blinks, it would be interesting to examine if there is any correlation between the observable changes in these data and the students’ actual activities in the video recorded during classes, and to find out which class activity is more effective in activating the students’ brains. We believe that measuring the cerebral blood flow and eye blinks and correlating these data with observational data acquired from videotaping the students in classes would help us to select the ICT tools that would boost students’ level of concentration and brain activation, and thereby the educational efficacy.

This is a small pilot study but we intend to verify the efficacy of AL with bigger sample sizes in future studies and discover class activities that would be more efficient in enhancing the students’ level of concentration and brain activation. Our eventual goal is to propose a new way to evaluate AL’s educational efficacy using biological data as objective indicators.

Acknowledgements

This study was supported by the collaborative research grant of National Institute of Technology and Nagaoka University of Technology.

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INNOVATIVE LEARNING AND TEACHING IN JOB REDESIGN FOR WORKPLACE SAFETY AND PRODUCTIVITY: NURTURING PROFESSIONALS FOR SMART CITIES

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b Republic Polytechnic, School of Engineering, Assistant Director, Singapore

Abstract

Job design is an integral component in an organization. The way a job is designed affects a worker’s motivation and performance. A poorly designed job may inadvertently lead to issues with workplace safety and lost productivity. It is imperative that the organization develops an environment where workers feel motivated in their jobs and at the same time their work meets the goals of the organization. Well-designed jobs can have a positive effect on workers’ performance, motivation, satisfaction and safety on the job. Properly designed jobs and where necessary, redesign are crucial to effectively match the job to a worker’s strengths and abilities. This is of added importance especially in aging populations where increasingly elderly workers are reemployed to the workforce to keep the economy going.

A new methodology, the 4E Job Redesign Methodology, was developed and applied to the Human Factors Engineering (HFE) module via Project-Based Learning (PjBL) to provide a holistic and systematic framework for job analysis and improvement studies. Through a team project, students applied concepts of HFE and the 4E Job Redesign Methodology to redesign jobs for canteen cleaning assistant, laboratory assistant, librarian, goods receiving assistant, gym assistant and area cleaning assistant. Innovative and useful ideas were generated and made into prototypes for team discussions and evaluations.

Positive feedbacks from students who have taken this PjBL module will encourage more adoption of the Project-Based Learning approach.

**Keywords:** productivity, job redesign, workplace safety, motivation, aging workforce, project-based learning

Introduction

RP’s unique 4E methodology – Explore, Establish, Evaluate and Enhance shown in Figure 1, employs a systematic yet holistic approach to job redesign. The 4E methodology strives to understand and grow an enterprise’s bottom-line in a sustainable manner by providing measurable and quantifiable results.
learning packages will have equal weight corresponding to 4 assessment points for Continuous Assessment (CA). The knowledge and skills acquired in the learning packages will be applied to the team project. Students have been briefed at the beginning of the module on the required deliverables and expectations of the project.

A breakdown of the activities for the learning phases in each lesson is as shown in Table 1.

Table 1: Learning Phases in each lesson

<table>
<thead>
<tr>
<th>Learning phase</th>
<th>Key Attributes</th>
<th>Proposed Activities</th>
</tr>
</thead>
</table>
| 1 Theoretical Concepts and skills demonstration | • A series of mini-lectures and student activities will be used to introduce the learning objectives of the lesson and allow students to understand how the learning acquired will be useful for their project.  
• The lecturer will cover key concepts required to handle the week’s tasks with activities to understand the concepts. |
| 2 Practical applications and activities | • Students will conduct research, and consult lecture to clarify the content for their learning package tasks.  
• They will participate in hands-on activities to apply techniques and to practice their skills. |                                                                                  |
| 3 Project Discussion and Implementation | • Time will be allocated for students to provide an update on their project progress, highlighting difficulties that they face and knowledge gaps that should be addressed in order to complete the project.  
• Student and lecturer will provide feedback on learning and the effectiveness of their inquiry and project activities.  
• The teams will continue to work on their project by applying new techniques and knowledge they have acquired during the lesson. |                                                                                  |

Every CA grade is made up of a team-based component and an individual component. The Module Grade (MG) is calculated based on four CA grades and two Summative Assessment (SA) grades.

In week 13, students were assessed by a panel of lecturers. A poster based on 4E methodology and prototype such as physical model or simulation form part of the assessment criteria during presentation.

Results

A total of 120 students took the module in 2017. From week 1, the students form their own team of 4 or 5 and brainstormed on the job redesign project they wish to embark on. They were given 6 jobs to choose from:

a) Canteen cleaning assistant  
b) Laboratory assistant  
c) Librarian  
d) Goods receiving assistant  
e) Gym assistant  
f) Area cleaning assistant (e.g. classroom/toilet)

By the end of week 2, each project team is required to submit their chosen job and they can kick-start their project initiation and ideation using the first E - Explore. Figure 2 shows some of the project teams during project discussions and initial prototyping phase.

During the Explore phase, the project teams seek to understand the work environment and work flow processes of the chosen job. They also need to recognise basic human sensory anatomies employed to carry out the tasks and apply basic research methodology, for example, conduct survey and interview the worker to find out the job requirements.

The Explore phase will last 3 weeks and at the end, the students will have a basic understanding of the job being studied.

During the next phase, Establish, environmental parameters related to the chosen job, including physical distances/lengths, noise, lighting, temperature and humidity were measured. These formed the baseline environment which the worker is performing in. Measurement tools including light level meter, sound level meter and Wet Bulb Globe Thermometer were provided to the students. Figure 3 shows some of the tools provided to the students.

By the end of week 2, each project team is required to submit their chosen job and they can kick-start their project initiation and ideation using the first E - Explore. Figure 2 shows some of the project teams during project discussions and initial prototyping phase.

Figure 2 - Project Teams in Discussion and Ideation

The Establish phase will last 3 weeks during which the measured data were referenced to known standards to determine whether the baseline environment is suitable for the job. For example, light level results from one particular project team showed the laboratory assistant is working in an environment < 100 lux. This may be too low for comfortable and accurate work requiring performance of visual tasks of medium contrast or small size like reading off equipment or tool readings.

The next phase, Evaluate, is where the project teams analyse the worker’s anthropometry, work parameters and risk factors for injury and fatigue. Current work practice and work-rest schedule were also evaluated to sieve out infringements to recommended work duration. Finally the students inspect the workplace for likelihood
of human error and perform risk assessment for the workplace. Figure 4 shows the risk assessment conducted by a project team working on an area cleaning assistant job.

<table>
<thead>
<tr>
<th>Hazard Identification</th>
<th>No.</th>
<th>Activity</th>
<th>Hazard</th>
<th>Possible Adverse Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Too much soap dispensed</td>
<td>Work Environment – Slippery floor, Human Performance – People will trip and fall</td>
<td>Sprain, strain, slip, backache</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Janitor need to bend down often as the product is short</td>
<td>Ergonomics – User might have backache from repetitive bending motion</td>
<td>Backache</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Faulty product</td>
<td>Design Fault – Faulty soap dispenser</td>
<td>Product unable to work</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Material not durable</td>
<td>Design Fault – The stick might break</td>
<td>Injure the user</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Faulty product</td>
<td>Technical – Handle must be firmly attached</td>
<td>Users might hurt themselves</td>
</tr>
</tbody>
</table>

![Risk Control Table]

**Figure 4 – Risk Assessment for Area Cleaning Assistant**

In the final phase, Enhance, the project team make recommendations to improve the job by proposing improved hand tool design, improved work flow or enhanced physical workspace. They also rate the effectiveness of their recommended solution. Figure 5 shows the efforts of a team and the stages they went through in designing a 4-in-1 cleaning tool for janitors.

![Four-in-One Cleaning Tool Design](image)

**Figure 5 – Students project to design a novel 4-in-1 cleaning tool for janitors**

During week 13, the 24 project teams were then assessed by a panel comprising of the students’ project supervisor (40% weightage) and two independent assessors (30% weightage each) in a 30 minute presentation. The project teams were required to showcase their physical prototype and project poster, and defend their recommended solution using PowerPoint slides, team report and a Question and Answer session from the panel. Figure 6 shows some of the teams’ project presentation during week 13.
After the project presentation and prototype showcase, the student teams participated in a gallery-style walk to view and understand what other teams have done. This encourages peer learning from one another and gathering of feedbacks for future improvements. Figure 7 shows the gallery walks conducted after teams’ presentations.

At the end of the semester, students’ feedbacks were gathered to find out if PjBL has helped them to learn and apply HFE concepts and tools to real life scenarios, in particular job redesign. Figure 8 shows the graphical representations of the students’ feedbacks for PjBL in the module.

Samples of students’ feedbacks from their Reflection Journals are captured here:

“PjBL has allowed us to apply what we have learnt throughout the semester as we are tasked to select a project at the start of the semester. Lesson by lesson, we slowly apply what was taught to our selected project and through that we also understand the concepts better.”

“I appreciate that the Human Factors Engineering adopts PjBL because I believe that one will learn best by applying what one have learnt. Which PjBL gave us the opportunity to grow in that particular aspect. Not only applying what we have learnt, but also the time allocated to apply what we have learnt. Especially for my team, on the problem itself, we applied what we have learnt in Learning Phase 1 & 2 immediately and presented to our lecturer even though it was not required for certain problems. Reason for that is to keep...”
track of what we have learnt and not to miss out anything when week 13 comes... In summary, I am extremely satisfied with PjBL.”

“The PjBL in the module has helped me in understanding and applying the concepts by knowing which concepts to apply and how to apply them. This is because throughout the project, my teammates and I have identified and use the concepts into our prototype. For example, when putting the markings on the laptop stand, we calculated and decided that the font size of the markings should be 0.48cm so that the library officers can see the markings easily from their desk. Therefore, throughout this project, I can apply the concepts to the prototype. The PjBL in the module has helped me in understanding and applying the concepts by using the concepts of human factors in real-life. This is because in this project, my team choose to improve the working conditions of the library officers. Hence, we interviewed them to find out the problems that they are facing. From there, we decided to create a laptop stand for them and applying the concepts we have learnt into the prototype. Therefore, by doing this project, I can have a better understanding of the concepts taught.”

“When developing our project prototype, proposal and PowerPoint presentation, we applied HFE knowledge to help us generate the different requirements. We applied our weeks 1-3 knowledge to develop our prototype solution such as the poster to know what type of font size is needed to make reading easy. Our weeks 4-6 knowledge help us examine the physical environment such as heat, light and noise. Weeks 8-9 helps us to understand the work physiology and human error and violation within the Lab. Week 11 helps us to draft out questionnaire to make it reliable, valid and sufficiently sensitive. Week 12 helps us understand work safety. All these knowledge eventually was translated to generate the various requirement, thus making our project complete by identifying the different issues that we need to consider in order to perform job redesign. I personally feel that PjBL indeed is beneficial in our learning of HFE in a more practical and realistic manner.”

**Conclusion**

Project based learning (PjBL) was adopted for the teaching of Human Factors Engineering (HFE) module in Republic Polytechnic, Singapore. Using a real-life scenario of Job Redesign for common jobs around us, students taking the HFE module has ample opportunities to relate and apply HFE concepts and tools learnt to redesign their selected job to make them safer, more comfortable and more productive. Peer and collaborative learning among students was enhanced along the journey to conceptualise and materialise their prototype for job redesign. Positive feedbacks from students who have taken this PjBL module will encourage more adoption of this learning approach.

**References**


Abstract

Only theory lecture in the class makes students feel boring and sluggish in learning. Although the theory is very important. But doing activities together while learning will make better understand for the students. Therefore, not only theory that students learned, but also activities and assignments they did in Human Computer Interaction class. They have to design and test their interesting interaction types in assignments. Anyway, the results can show only the user interface of the interaction design. It might or might not match the user's need. Accordingly, this paper implemented the activity in Human Computer Interaction class by using User Experience design, in order to enhance interaction designed that support the user's need.

At the beginning, students learn HCI theory along with the basic UX process. They practice a few activities with every learning lecture for enhancing their understanding. After students learn persona, empathy map and user journey, those are basic of fundamental UX designs. They will set their user of the assigned topic. Their user is not only "who", but they have to imagine - "what" user wants, including scenario "when" user use their work at "where", and "how". Their new focus topic is how their work can solve user problems. Students will set problem by themselves and create their own work in order to support the user requirement and action. Results are Mockup prototype that every group will help to test and evaluate each other, including checked by the teacher. The goal is not a perfect finished result of the assignment, but it is how to improve for better results. The subject evaluation at the end of semester shown, students feel fun to learn by using UX to design their works. They can learn user viewpoint and better understand the user. Moreover, they know the advantage and disadvantage of their works and can give suggestions for the other group's work. This learning style is not only brainstorming in the group, but also enhance learning when evaluated and get ideas from the other group. Furthermore, students can apply UX design with any topics of their future works for better results.

Keywords: Active learning, problem based problem, project based learning, user experience, teamwork, brainstorming

Introduction

The interaction design term was invented by Bill Moggridge (Giuseppe & Giancarlo (2007)). It was adapted to user interface design that is understand user's need's and goals, designing tools with consider the limitation of the user's environment and technology. Human computer interaction is a subset of interaction design that HCI involves the study, planning and design of the interaction between user and computer (Wikipedia, 2018). The interaction design needs to meet the user's need, that is why user center design has entered a high role. User center design is a procedure to design software or system based on the user requirements. (Hugh and Karen, 1997) wrote a book that provides step by step guidance for user center design. In order to discover the system for the user, the simplest way is an interview with the user. Interview have to plan carefully for the effective action in proper time. And the user is needed for taking care to encourage cooperation until finishing the interview. After the system was built, the next process is testing. The testing is a procedure of finding and fixing usability problems (Steve, 2009). Finally, the figured problems were solved in the improved version of the system. These processes are looped to continuously improve the system. (Steve, 2014) wrote 'Don't make me think' book from his experienced of effective designing website that help to understand the principles of intuitive navigation and information design. Moreover, (Don, 2012) provide the fundamental principles of great and meaningful design that is applicable to any user. Anyway, user is different and is changed over time. It takes time and cost for the interview, built prototypes, testing and improving processes in each design. Therefore, user experience design has come to overwhelm this problem. In addition, the process of design Splint (Apirak, 2018) is an important role to speed up the process of system establishing and improving.
Material and pedagogy

Previous class of human computer interaction (HCI) in a few years ago, the closed Facebook group was used to contact or announce within this class. Students had submitted their works via Google Classroom, and comments were given back to the students. Normally, their assigned topics were testing, designing, or comparison between the interactive techniques. Students had at least one week to do the experiment. They discussed and chose their interested topic, started the process, tested by the other groups and concluded results. Even the evaluation of the assignment results were interesting, but it cannot show that the user like to use their interaction design or not. It is better to design to support user center, thereby the user experience (UX) design is combined with interaction design in the class.

One interesting assignment in HCI class is designing the application or website. The procedure and results of designing interaction and designing interaction by using UX are shown in the following topics A and B.

A. Interactive UI Designing

An assignment in the last year class was designed user interface (UI) of website or application. They were assigned to use proper interaction styles by rational and full functionality to design their interesting website or application.

After students formed their group, they brainstormed ideas about what website that they like to design. Then draw the draft of UI design, as shown in figure 1.

![Figure 1. Draft UI design.](image1)

Students had one week to modify their draft for Mockup UI website. It had just prototyped UI on each page. Students can use supported tools to generate this prototype, no need to do real programming to establish it. This prototype can be clicked to change to the next page, but it cannot process in reality. The reason to design just UI prototype in the assignment is if they have to make a real website or application, they will need more time and skill. And the purpose of this assignment is just want to discuss the proper of interaction designing. The example of a UI prototype website is shown in figure 2.

![Figure 2. UI prototype.](image2)

In the class, we were discussing about functionality and proper interaction type of each group's designing. Students judgement was from their previous experience. Most of the UI design seemed functional and beautiful design. But we did not discuss and did not know that design is proper for the user or not. Therefore, the next year HCI class was included basic UX to design the UI prototype.

B. Interactive UI by using UX Designing

At the beginning of the class, students were taught about their user. They learnt to set their focused user and wrote down their user characteristics, called Persona. Persona consisted of user's name, picture, quote, story and key goal, as shown in figure 3.

![Figure 3. Persona of UX design.](image3)
Persona details gave information about the focused user. How about user spent their daily life, what was Pain and Gain. And indicated the most important thing for the user, for example, time, money, convenience, luxury, etc. Then, each group designed their user's empathy, as shown in figure 4.

Figure 4. Empathy map.

Students were discussing what happened with their user for the situation that their application is needed. Empathy map were set the scenario that happens to the user, what user do, feel and commit. Then they figured the most significant problem to choose and solve in their application. Post-it that easy to re-arrange the situation was used. After that, the user journey was created. User journey gave details about the events - before, on service and after using an application in short details of touch point, user action and emotion, as shown in figure 5. Finally, the UI prototype of the application was created in the week after, as shown in figure 6.

Figure 5. User Journey.

The prototype design programs, eg. Marvel, Adobe XD, etc., was used. This program support to create the UI easily on a mobile phone, tablet or PC. The clicking area can be set to change to the next require page without needing any programming skill. After UI Mockup was created, the last step was testing. Students were volunteering for the other group testing, as shown in figure 7.

Figure 6. UI prototype.

Figure 7. Testing of interactive UI design.

In this year, 32 students were in HCI class. They were divided for 4 people in each group. When they started testing, two students sat stationary to brief the usability of their application and take note. The other two students walked around the class to test the other group application and gave suggestions for the improvement. From this setting, each group had comments and suggestions from the other 7 groups. And also they can see the weak point and learn how to improve their own application. Finally, they were figured out and concluded the things they do to improve their application efficiency, as shown in figure 8.
Results and Discussion

When students design the application or website, they are known well about what they did. Even they had created the most important options that needed, but still something lost. Because if students just design and create an application by only themselves, they were clearly understood how to use, where to press, and what they want. But when they learned UX design to set Persona, empathy map and user journey before create their application. These processes are very useful to understand better about their user. Moreover, the testing helped them to see that some people doubt with their designed and can figure out what they should improve for the better application.

Conclusions

Regarding to the previous HCI class, students chose their freestyle topic, within teacher assignment topic. They usually created a topic related to their group member interesting. But the details might not be required or appropriated by the user. However, UX design can help to overcome this problem in current class.

Students that learned UX process were understood their user better. And the testing helped them to figure out that what they should do to improve the design. The results needed is not a perfect design application. But it is what they can do to improve for the better application.

UX design can be used to enhance the learning efficiency of students in HCI class. Moreover, these processes are also useful with the other designing in the future.

References


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

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Abstract

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

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

Introduction

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

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

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

Motivating Students

Motivation is recognized as fundamental to learning, but there is much debate about how it works and, more significantly, how teaching professionals can harness such human energy in the pursuit of educationally desired learning goals. While there is much by way of models and theories of human motivation in the literature (e.g., Maslow, 1962; Herzberg, 1966; Deci and Ryan, 2002; Dweck, 2006), the famous management guru Peter Drucker made a damning assertion:
We know nothing about motivation. All we can do is write books about it.

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

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

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

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

Towards an Evidence-Based Teaching Approach

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

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

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

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

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

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

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

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

Another major focus of EBT owes much to Hattie’s definitive work in the book ‘Visible Learning’ (2009). He synthesized over 800 meta-analyses of the influences on learning and was particularly interested
not just in what factors impacted learning, but the extent of their impact - referred to as **Effect-Size**. Effect size is a way to measure the effectiveness of a particular intervention to ascertain a measure of both the **improvement** (gain) in learner achievement for a group of learners and the **variation** of learner performances expressed on a standardized scale. By taking into account both **improvement** and **variation** it provides information to which interventions are worth having.

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

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

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

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

<table>
<thead>
<tr>
<th>Influence</th>
<th>Mean effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal feedback for teachers (This is where teachers take action to get feedback on their teaching and act on it)</td>
<td>0.63</td>
</tr>
<tr>
<td>Whole class interactive teaching (including direct instruction)</td>
<td>0.81</td>
</tr>
<tr>
<td>A specific approach to active learning in class, which is highly teacher led, but very active for students; This involves summaries smaller and a range of active learning methods, including questioning</td>
<td></td>
</tr>
<tr>
<td>Feedback</td>
<td>0.73</td>
</tr>
<tr>
<td>Students getting feedback on their work from the teacher, peers, self or others</td>
<td></td>
</tr>
<tr>
<td>Teacher - Student Relationships (Building rapport and trust and positive expectations)</td>
<td>0.72</td>
</tr>
<tr>
<td>Metacognitive Strategies</td>
<td>0.69</td>
</tr>
<tr>
<td>Explicit teaching and use of metacognition strategies (e.g., conscious planning, monitoring and evaluating of thinking and learning)</td>
<td></td>
</tr>
<tr>
<td>Challenging goals for students (Goals that students can meet through effort on their part – specific as possible meaningful to the students involved)</td>
<td>0.66</td>
</tr>
<tr>
<td>Advance Organizers (Giving students a summary in advance and a purpose for the learning)</td>
<td>0.41</td>
</tr>
</tbody>
</table>

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

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

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

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

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

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

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

**Approach**

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

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

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

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

**Methodology**

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

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

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

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

Implementation

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

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

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

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

Table 2: Overview of the Flipped Learning Design

<table>
<thead>
<tr>
<th>Flipped Classroom Stages</th>
<th>Cognitive-Scientific principles</th>
<th>Key teaching methods used</th>
<th>EdTech tools used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Class</td>
<td>-Video lectures -Two-way feedback -Quiz</td>
<td>-Screen-O-matic -WhatsApp -Socrative</td>
<td></td>
</tr>
<tr>
<td>In-Class</td>
<td>-Mini lectures -Application activities -Peer instruction -Mid-point quiz -Learner support for weaker students</td>
<td>-Kahoot/ Socrative</td>
<td></td>
</tr>
<tr>
<td>Post-Class</td>
<td>-Exit poll -Two-way feedback -Question and Answer video</td>
<td>-Socrative -WhatsApp -Screen-O-matic</td>
<td></td>
</tr>
</tbody>
</table>

Findings

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

The analysis revealed a significant overall difference before and after its exposure (M = 6.47, SD = 29.90); t (181) = 2.92, p = <0.01; d = 0.28. Questionnaire 1 (M = 2.53, SD = 15.29); t (181) = 2.24, p = 0.03; d = 0.21, Questionnaire 2 (M = 2.13, SD = 9.37); t(181) = 3.07, p = < 0.01; d = 0.31 and Questionnaire 3 (M = 1.80, SD = 8.36); t(181) = 2.91, p < 0.01; d = 0.27 all saw a significant difference in scores. For Questionnaire 1, emotional and agentic engagement showed significant increases over the implementation period. For Questionnaire 2, which focused on 10 cognitive scientific principles of learning, five showed statistically significant increases over the implementation period. Further, more detailed, statistical analysis is presently
being conducted, but is not available at this time of writing.

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

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

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

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

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

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

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

“Makes the class very enjoyable”

Conclusion

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

Acknowledgements

Special thanks to Mr Dennis Sale who guided us in using the evidence-based approach to enhance our intrinsic motivation and flipped learning implementation.

References


Marzano, R. J. et al. (2007). Designing and teaching learning goals and objectives: classroom strategies that work. Colorado: Marzano Research Laboratory.


Appendix 1: Questionnaires

Questionnaire 1
Please respond to each of the following statements by indicating the degree to which you agree or disagree with the statement as it applies to your experience in this class.
Use the following scale:

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

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

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

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

<table>
<thead>
<tr>
<th>Not at all True</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Very True</th>
<th>5</th>
</tr>
</thead>
</table>

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Figure 1: Layout of the VAK learning package

Moreover, the multimedia design use Gagne’s nine instructional events as the design foundation to design the flow of the multimedia teaching materials. Firstly, the news cut video can attract student’s attention easily. It can teach students the real application of the software. If the teaching materials can hold their attention, the new knowledge can put into short-term memory & long-term memory in student’s information processing system easily. It is because attention is the first and important step in the human processing system (高源令, 2010). Secondly, the teaching materials should be recalled student’s prior knowledge. The new knowledge can construct based on their prior knowledge. This arrangement matches with the construction theory, which indicate the new knowledge can develop from zone of proximal development (陳世芬, 2010). Finally, online instant feedback can provide in the middle stage and final stage. One advantage of multimedia can provide instant and fast feedback to students when it compares with the traditional written feedback. If students can get the instant feedback, it can get a strong reinforcement, improve their level of understanding and achieve assessment for learning principles. The detail multimedia design used Gagne’s instructional event shows as below:
<table>
<thead>
<tr>
<th>Instructional event</th>
<th>Corresponding design</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gaining attention</td>
<td>News cut video introduced first.</td>
<td>To arouse student’s motivation in order to help the memory process</td>
</tr>
<tr>
<td>2. Informing learners of objectives</td>
<td>Simple wording and graphic to show Objectives</td>
<td>To let students the aim and the expectations in learning</td>
</tr>
<tr>
<td>3. Stimulating recall of prior learning</td>
<td>Use Moodle to check students prior knowledge</td>
<td>To help recalling prior learning</td>
</tr>
<tr>
<td>4. Presenting the content</td>
<td>Present the content systematically and different VAK learning styles can use.</td>
<td>To construct interrelationships of different concepts with multi-channel learning</td>
</tr>
<tr>
<td>5. Providing learning guidance</td>
<td>To give a examples to explain the array</td>
<td>To maintain learning motivation</td>
</tr>
<tr>
<td>6. Eliciting performance</td>
<td>To give a short quiz (MC) in Moodle to do the formative assessment</td>
<td>To check students’ level of understanding To provide online instant feedback</td>
</tr>
<tr>
<td>7. Providing feedback</td>
<td>To perform the summative assessment e.g. MC test and give an instant feedback</td>
<td>To check students’ level of understanding by instant feedback</td>
</tr>
<tr>
<td>8. Assess performance*</td>
<td>Provide scores of test results</td>
<td>To explain the difficult questions</td>
</tr>
<tr>
<td>9. Enhance retention and transfer*</td>
<td>To carry out a min-case study in laboratory in order to have an authentic assessment.</td>
<td>To carry out a min-case study in laboratory in order to have an authentic assessment.</td>
</tr>
</tbody>
</table>

*exercises will carry out in tutorial session and laboratory session  
Table 1: Gagne’s Nine Instructional Events Design

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

![Figure 2: VAK test questionnaire](image)

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

![Figure 3: Student’s learning styles pie chart](image)

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

![Figure 4: Sample of questions](image)
As Moodle platform can provide student instant feedback individually, students can enhance their knowledge by Moodle correct feedback. It can help to minimize the learning individual differences.

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

Design a LabVIEW program (block diagram) to generate a random integer number between 1 to 1000. Then the random integer number will be run until matches a number specified “Number-to-Match” in the front panel. The matched number is indicated in “Current Number” and the number of iterations is indicated in “# of iterations” in the front panel.

Evaluation and Results:

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

<table>
<thead>
<tr>
<th>Questions</th>
<th>Students (who know learning styles) get correct answer (%)</th>
<th>Students (who don’t know learning styles) get correct answer (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>84%</td>
<td>80%</td>
</tr>
<tr>
<td>Q2</td>
<td>96%</td>
<td>87%</td>
</tr>
<tr>
<td>Q3</td>
<td>56%</td>
<td>54%</td>
</tr>
<tr>
<td>Q4</td>
<td>76%</td>
<td>75%</td>
</tr>
<tr>
<td>Q5</td>
<td>61%</td>
<td>43.5%</td>
</tr>
<tr>
<td>Overall</td>
<td>75%</td>
<td>68%</td>
</tr>
</tbody>
</table>

Table 1: Performance in online formative assessment

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

<table>
<thead>
<tr>
<th>Students (who have online formative assessment)</th>
<th>Students (who have not online formative assessment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>31</td>
</tr>
<tr>
<td>(Test pass rate %)</td>
<td>90%</td>
</tr>
<tr>
<td>Mean</td>
<td>67.1</td>
</tr>
<tr>
<td>t-value</td>
<td>5.9</td>
</tr>
<tr>
<td>p-value</td>
<td>P&lt;0.05</td>
</tr>
</tbody>
</table>

Table 2: Performance in mid-term test

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

Conclusions

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

Acknowledgements

The author deeply grateful to the support received from, Dr Leung Yau Cheung, Frankie, Head of Department from Department of Engineering (Haking Wong) and Ir Cheung Siu Yuk, Senior Lecturer from Department of Engineering (Haking Wong).
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USE OF TECHNOLOGY ENHANCED TEACHING ROOMS TO SUPPORT FLIPPED TEACHING

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Abstract

In this paper we report on our experiences of flipping the classroom for three modules delivered to first and second year Mathematics students at the University of the West of England, Bristol. In particular we focus on how using collaborative teaching rooms have supported the flipped classroom. All of the modules described are now delivered in a Technology-Enhanced Active Learning (TEAL) space as opposed to a typical flat teaching room, as was the case previously. This space contains collaborative working pods comprising a plectrum-shaped table and a single large-screen integrated PC. Each pod can seat up to six students. The display on these PCs is flexible; options include reproducing the main podium display, displaying a different pod’s output or each pod having their own individual display. Flipped-style teaching or the flipped classroom has seen a surge in interest recently (Brame, 2013; Maciejewski, 2015). This style of teaching, pioneered by Mazur (1997), is a change to the traditional lecture model used in universities for hundreds of years. In the traditional model the lecturer is in charge of the class and largely dictates the material and pace at which this is delivered. Typically students are then required to work through more challenging material on their own before attending tutorials/problem classes for support. The idea behind the flipped classroom is that students’ initial exposure to material takes place in their own time, so students work through material independently at their own pace before the formal class. Class time may then be used for active learning, where students are able to deepen their understanding of the material, through for example problem-solving, peer instruction and discussion. Enabling students to work with each other is an effective methodology, encouraging students to be active learners by talking through concepts in their own words to each other. We have found that using a TEAL space encourages better small group discussion and peer instruction in class.

Keywords: Flipped-style teaching, active learning, TEAL classroom, collaborative teaching room

Introduction

We report on our experiences of flipping the classroom for three modules, namely a compulsory first year Calculus and Numerical Methods module (CNM), a compulsory second year Algebra, Combinatorics and Graphs module (ACG) and an optional second year Coding Theory and its Applications module (CTA). All these modules are taken by Mathematics students at the University of the West of England (UWE Bristol). Flipped-style teaching or the flipped classroom has seen a surge in interest recently (Brame, 2013; Maciejewski, 2015). This style of teaching, pioneered by Mazur (1997), is a change to the traditional lecture model used in universities for hundreds of years. In the traditional model the lecturer is in charge of the class and largely dictates the material and pace at which this is delivered. Typically students are then required to work through more challenging material on their own before attending tutorials/problem classes for support. The idea behind the flipped classroom is that students’ initial exposure to material takes place in their own time, so students work through material independently at their own pace before the formal class. Class time may then be used for active learning, where students are able to deepen their understanding of the material, through for example problem-solving, peer instruction and discussion. In this paper we focus on how using collaborative teaching rooms have supported the flipped classroom. All of the modules described above are now being delivered in a Technology-Enhanced Active Learning (TEAL) space (MIT iCampus, 2016) as opposed to a typical flat teaching room, as was the case previously. This space contains collaborative working pods which each seat up to six students and includes a PC. Students within each pod can work independently on their own or choose to project the pod’s output onto the whole class's screen if desired. A typical TEAL room used at UWE Bristol is shown in Figure 1 with a close up of one of the collaborative working pods shown in Figure 2. CNM and CTA used TEAL rooms for the first time in 2016/17. ACG was been flipped for the first time in the 2017/18 academic year.
The flipped approach has been used very successfully for the CTA and CNM modules for several years, measured in terms of student engagement, attainment and satisfaction (Henderson, 2017; Henderson, Hobbs & Last, 2017). However, we found that running the classes in a traditional flat teaching room was not conducive to group working. Enabling students to work with each other is an effective methodology, encouraging students to be active learners by talking through concepts in their own words to each other. Research has found that students who work in groups perform better academically, particularly in regard to reasoning and critical thinking skills (Lord, 2001). We have found that using a TEAL space encourages better small group discussion and peer instruction in class. In addition, the technology built into each pod facilitates students to use relevant software (e.g. Maple) during class.

Methodology

Calculus and Numerical Methods (CNM) is a 30 credit compulsory first year module taken by all mathematics students at UWE Bristol. It runs year-long and the second semester has been taught using a flipped approach since the 2014/15 academic year. For this module, a highly scaffolded approach was employed using technology to create pre-class materials (Hooper, Henderson and Gwynnlyw, 2014). A workbook containing gapped lecture notes was created as well as a handbook containing exercise sheets and extra reading material. Typically there were four screencasts to watch each week lasting on average 10 minutes each. A total of 35 screencasts were produced using Camtasia Studio software on a tablet PC. These were made available through SCORM packages on the University’s Virtual Learning Environment (VLE). Each week, prior to attending the class, students were expected to independently do the following:

- watch screencasts and fill in the relevant gaps in their workbooks;
- take a formative e-Assessment;
- try some basic questions from the exercise sheet;
- optionally do some extra reading and/or work through a Maple file.

The formative e-Assessments were run using Dewis (2012) and further details of how e-Assessment was used to support the delivery of this module can be found in Henderson (2017). During the two hour class, TurningPoint (TP) audience response questions and group activities were used to encourage active learning. Worked solutions as well as the filled in workbook were made available via the module’s VLE after the class.

Algebra, Combinatorics and Graphs (ACG) is a 30 credit compulsory second year module taken by all mathematics students at UWE Bristol. It runs year-long and the second semester has been taught using a flipped approach for the first time in the 2017/18 academic year. Prior to the start of the module students have been supplied with a booklet containing a complete set of lecture notes together with approximately three questions per weekly topic. In all a total of 60 screencasts were produced using Camtasia Studio software on a tablet PC. These included several which recapped some of the key topics covered in the prerequisite first year module. Each week students were emailed an announcement from the University’s VLE giving details of what topics were to be covered that week. Students were directed to read the relevant section of the lecture notes, watch particular screencasts (typically lasting a total of 1 hour, 15 minutes) and to try three pre-class questions which were designed to check surface learning of the material. Solutions to these questions were made available shortly before the start of the three hour class. Following a brief overview, students work through a set of more challenging in-class questions in groups and these are designed to encourage debate amongst the students and to develop deeper understanding of the topic. In addition some very challenging questions were made available but it was made clear by the lecturer that these went beyond what was required to satisfy the learning outcomes of the module. Full solutions to all of the in-class questions were made available after the class.

Coding Theory and its Applications (CTA) is a 15 credit optional module run in the first semester of students’ second year of the Mathematics award at UWE. It has been taught using the flipped approach very successfully since the 2013/14 academic year. For the last three academic years, students coming into the second year have had experience of the flipped approach through taking the CNM module in their first year. The CTA module is based on a set textbook (Biggs, 2008) and students are informed in advance of signing up for this module that they need access to it.
The style of the sessions each week varies, but the main philosophy is that mathematics is best learnt through doing rather than watching others. Students are expected to undertake directed reading each week in advance of the class; this is typically a chapter of Biggs (2008), and to attempt particular exercises from this book. Some videos, recorded via a data visualiser, covering particular algorithms/problems are available. During classes, which are scheduled for 3 hours, students work together on problems designed to check their understanding of the material. This takes the form of TP questions, further exercises from Biggs (2008) as well as supplementary problems. The style of the module is active rather than passive learning. Students are informed that it is expected that they will contribute to sessions, possibly by reporting on a particular topic they have researched, or by presenting their solutions to problems to the rest of the class. After each class, the TP questions (with solutions) as well as worked solutions to exercises are posted on the module’s VLE.

Results

Student feedback has been very positive to the flipped-style approach on all three modules. Students recognise that carrying out the pre-class work means that they get more out of the classes. We have found that module performance is strongly correlated to engagement and attendance (Henderson, 2017; Henderson, Hobbs & Last, 2017). In the first year of flipping CTA, feedback from the few students who failed to engage and did poorly in module indicated that they were unhappy about the lack of lectures and the requirement to engage during sessions. It is unlikely that we are able to please everyone all the time, but our goal is to change the culture so that our students recognise the benefits and move away from just being passive learners. We now emphasise the benefits of the flipped approach very clearly and set expectations at the start of each module and have received fewer comments along these lines as a result.

At the point of writing, two of the modules (CNM and CTA) have been fully delivered using the TEAL classroom for two years. ACG was flipped for the first time in 2017/18 and a TEAL room was used. Feedback from students on this aspect has been sought via the end of module evaluation (all modules) and via mid-term in-class questionnaires (CNM and ACG) as well as other aspects of the flipped-style approach. Feedback on the TEAL rooms has been positive with students remarking on how it facilitates the interaction with other students.

For CNM the same mid-term in-class questionnaire has been used on three separate cohorts (2015, 2017, 2018) and the results over these three years to some of the questions are displayed in Figures 3-5. Note that the 2015 classes were in a flat teaching room whilst 2017 and 2018 were in a TEAL room. It can be seen that responses have been quite consistent across the three year groups and that working in the TEAL room has not had a significant impact on student responses. However it is clear that the majority like the flipped-style delivery, would like to experience it in their second year modules and are happy with the amount of time available to go through the example sheet questions in class. As a result of earlier student feedback on CNM an additional weekly one hour extra support session was timetabled for students to utilise if they felt that they needed more help with a particular topic. This was not heavily used but was appreciated by the students that attended.

![Figure 3: CNM Student responses to the question: The time we had to go through the example sheet questions in class was.](image)

![Figure 4: CNM Student responses to the question: I liked the new style of teaching.](image)

![Figure 5: CNM Student responses to the question: I would like to experience this style of teaching for my level 2 modules.](image)
topic, that the in-class questions gave them a deeper understanding of the subject, that they benefited from working as part of a group and that they preferred this style of teaching. Typically mathematics students dislike working in groups so it was very encouraging to see students working together to solve problems and recognising the benefits of doing so. The TEAL room certainly facilitated this approach. In flipping ACG for the first time, the lecturer found a noticeable increase in the quality and depth of the questions asked to them in class.

Table 1: ACG Student responses to some of the questions used in an in-class questionnaire (April 2018).

<p>| Qn 1: I found doing the pre-class questions helped me understand the topic |</p>
<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

<p>| Qn 2: The in-class questions gave me a deeper understanding of the subject |</p>
<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<p>| Qn 3: I have benefitted from working on questions as part of a group |</p>
<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

<p>| Qn 4: For this topic, I prefer this style of teaching |</p>
<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

For all three modules we observed that students tended to sit at the same pod each week, so although group working was happening, it tended to be within the same students each week. All classes were held in a TEAL room which has a capacity of 56. This has worked better for the compulsory modules (ACG & CNM), which have higher student numbers than for CTA which is optional. For example, in the 2017/18 academic year only 20 students enrolled on this module resulting in students being quite dispersed in the room and just five of the possible eight pods were used. One way of resolving this issue would be to have a greater range of sizes of TEAL rooms available to use, which should be the case next year.

Students in CNM and ACG were specifically asked for their feedback (via the in-class questionnaire) on how they found the TEAL rooms. They unanimously preferred the TEAL room to a traditional flat teaching space. They liked working in small groups even though some did not like the flipped approach. The following is a selection of student feedback which typifies their comments:

- These rooms are so much better, more interactive, so I stay focussed for longer and can discuss with people better.
- The room we used was very useful as could work in groups using the computers for Maple.
- The room was good and it helps a lot for working in groups. It was good working with other people on questions.
- TEAL room was great – comfortable, good layout. Liked the idea of working in groups.
- Liked the group table, can discuss and share answers/methods more effectively. Less chance of getting lost/left behind.
- Room was great, however sometimes had issues with screen to computer and other way round. Otherwise really like it!

Conclusions

We have found that students recognise the benefits of being taught in TEAL rooms using a flipped approach. However TEAL rooms are also being used for classes for modules which are delivered in a more traditional way. Students have remarked that they like the layout, which also facilitates the lecturer moving around the room enabling them to more easily interact with students and view their written work. From a lecturer’s perspective, the TEAL rooms are proving to be very flexible teaching spaces. Two TEAL rooms, with capacity of 24 and 48, have been incorporated into the design for the new Mathematics and Statistics space that is planned to open at UWE Bristol in September 2018 (Henderson, 2018).

Although the collaborative rooms have software installed, enabling sharing of individual PC screens to the podium/other pods, facilities do not currently exist for students to be able to easily upload hand-written workings onto their pod PC. This is something that we aim to address in the future through the use of webcams and electronic writing pads which will enable the lecturer to easily share students hand-written work between pods.

References


STUDENT ENGAGEMENT IN DIGITAL MEDIA DOMAIN

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Abstract

This research paper seeks to examine how instructional strategies can influence students, from the digital media domain, to stay engaged in active learning that in turn improve their performance. Davis (1993, p15) mentioned that for effective teaching, the instructor’s need to interact with students in ways that enable them to acquire new information, skills, and expand on what they already know. Engaged students will enjoy the learning process and will be curious, interested and persist through challenging tasks and take pride and satisfaction in their learning.

Action research method was employed. Quantitative research tool like survey questionnaire was used to gather and collect statistical data from 150 second-year students from 3 diploma programs; Interaction Design, Digital Visual Effects and Motion Graphics & Broadcast Design. Qualitative studies were also carried out for 30 year 2 students, 10 from each of the 3 courses, to collect findings through focus group discussion.

The results show that student motivation is largely rooted in subjective experience identified in the following five themes: Friendship & Fun, Do-Learn-Interact, Explore & Experiment, Varied Problems, and Collaborative System. The findings suggest that a learner-centered approach optimizes students’ learning, helps the student connect to the course materials and enhances their learning experience to better engaged and involved them in the learning process better.

Through these active learning strategies, we can aim to produce better conceptual and problem solving creative individuals in School of Interactive & Digital Media (SIDM). Integrate out-of-class activities into passive tradition classroom bounded learning by designing instructional approaches that facilitate student learning and self-assessment. Encourage peer-to-peer and lecturer to student interaction to engage and enrich their learning abilities.

The Net Generation is interactive and social learners. Students want to experience work that is meaningful, solve real problems, learn from people within their communities, and subject experts. Engage in dialogue and know that their learning contributes to making a difference in the world. (Dunleavy, J., Milton, P. & Crawford, C., 2010). The findings of this paper suggest that a learner-centered approach optimize students’ ability to construct their own learning and knowledge acquisition thus it could be widely applied to students from a different discipline within SIDM.

Keywords: Student Engagement, Instructional Strategies, Digital Media Domain, Learner-Centered, Active Learning

Introduction

In this research study, we seek to examine how instructional learning strategies can influence student engagement in active learning that in turn improve their motivation and performance. Davis (1993) mentioned that for effective teaching, the instructor’s need to interact with students in ways that enable them to acquire new information, new skills, and expand on what they already know. If the students are truly engaged, they will enjoy the learning process and will be curious, interested and persist through challenging tasks and take pride and satisfaction in their assignments.

Agnes Chang Shook Cheong and Ian David Smith (1998) contended that Singapore students are capable of self-regulated learning and it is correlated positively with achievement. The hypotheses we are establishing are through various active learning instructional activities, students will be better engaged, and better learning occurred. The students will also take responsibility for their own learning, and their performance is likely to increase.
There is no best instructional activity; it will depend on the student, the context, and the discipline. The objective of this research is to rethink how our courses are delivered and assessed, investigate how we can improve our current education practices in our school, School of Interactive & Digital Media (SIDM). Like many design courses, our diploma programs do not have any form of examination; all assessments are via assignments, group projects, presentations and class exercises. So our students need to be constantly motivated and discipline to complete their work. The finding of this study will enable us to create a learning environment that is engaging and enjoyable for the students that will positively impact their learning. This will also make teaching enjoyable for the lecturers.

Methods

Action research method was adopted for this study. Quantitative research tool like survey questionnaires was conducted by the respective lecturer, to gather and collect statistical data from sample participants. Qualitative studies were also carried out for selective random students to collect findings through focus group discussion. This research aims to achieve practical and applicable solutions through our findings that can be implemented within SIDM.

This research sampled data from 150 second year students from 3 different diploma programs in SIDM, namely; Diploma in Interaction Design (IXD), Diploma in Motion Graphics & Broadcast Design (MGBD) and Diploma in Visual Effects (DVE). The active instructional learning activities were grouped into three main categories, in-class activities, out-of-class activities and interactive activities. In-class instructional activities include lecture slides, online video materials, individual and small group collaborative task-oriented exercises and minute paper. Outdoor learning consists of educational field trip like on-set production, visitations and observational excursions that encourage the student to experience the real-life problem. Lastly, the interactive learning looked into peer to peer and student to instructor interactions through activities like group discussion, presentation, formative assessment and active questioning. During in class or outdoor learning, a crucial technique of Socratic questioning was applied. Questions with the how, what and why was regularly asked to encourage students to interact with one and other and participate in conversation with the assurance of a safe environment for students to share their views and that there are no right or wrong answers. The various tests were conducted and designed by the lecturers that best fit each category for the diploma, and all three categories were carried out for each diploma.

Survey questionnaires were conducted after the completion of each activity to collect quantitative data on students’ responses to evaluate the effectiveness. All students from the 3 diploma programs anonymously respond to 2 questions. First question, based on a 3 point scale, whether instructional activities was a waste of their time (1 point), worth the effort (2 points) or very supportive of the activity (3 points). The second question, student will select the top 3 factors that influence their learning engagement.

Qualitative studies were also carried out at the end of the semester, to gather key concerns or ideas that the participating students can contribute. This allows us to gain more understanding and insight of the central phenomenon in engaging students purposefully. Participants include 10 students randomly selected from each diploma to participate in a focus group discussion with each representative lecturer from each course. A focus group will allow students to feel more at ease and willing to share realistic thoughts as the lecturer is going to play a minor figure during the focus group discussion. The questions are: 1. Can you share what are your experiences during in-class activities, out-of-class activities and interactive activities? 2. What activities help you make better connections to the course materials? Why? 3. Which instructional activities had made a positive impact to improve your engagement level during the learning process? Elaborate why. 4. Do you agree that student who is highly engage in his/her learning achieve better performance? 5. Any Suggestions on how engagement level can be increased to enhance learning experience to create positive impact on your learning. 6. Any other comments.

The Data collected was aligned with the unique characteristics of students from digital media design domain. Triangulation process was applied to enhance the validity and reliability of the findings.

Results

Data collected from the 150 second-year students are illustrated in Figure 1- In-Class Activities, Figure 2 – Out of Class Activities, Figure 3 – Interactive Activities and Figure 4- Factors that engaged your learning.

Figure 1: In-Class Activities

As shown in Figure 1 almost all students feel that lecture impact their learning positively. However, lecture should be designed to engage and interact with student in a fun and entertaining way to retain their attention span longer. Student suggests “Integrate things that are more current, or that would appeal to our generation,” “make slides interesting it helps to attract and keep my attention on the lecture for a longer period”, “include more visuals, videos that will be more interesting and exciting.” Student finds lecture important in learning and gaining new knowledge, making learning interesting help them to stay focus and engaged throughout the delivery.

Most students believe that individual and group class exercise positively impacted their learning. Student
comments reveal that individual exercise help to reinforce learning while group exercise help students to learn from one another. Other comments such as "makes everyone enjoy learning even if one doesn’t like the certain topic", "enable me to do it right away after learning, so that I will not forget what we are doing", "With a wider variety of activities to choose from it stimulates me to put more effort into expanding my horizon on learning", "able to learn from my mistakes” and "makes you understand everything on the spot and also if we have doubts we could also clarify" suggests that the students find the activities fun, helpful and enjoyable. The activities also allowed the students to learn effectively and clarify their thinking, it also challenges the students and makes them feel competent.

Student perceptions of in-class exercise also support the finding of Mearns et al. (2007) that if the teacher is perceived to be approachable, well prepared and sensitive to student needs, students are committed to working harder, get more out of the session and are more willing to express their own opinion. Komarraju and Karau (2008) mentioned if students perceived an in-class activity was valuable, then thinking and desire for improvement increased.

It is noteworthy that half of the students believe watching online video tutorial during class is a waste of time. Student’s comments that the video is available at all times and this activity could be done during their free time. They prefer to use class time to learn from the lecturers or to have discussions.

Students find out-of-class activities (Figure 2) such as educational trip, field study, and assignments to have a positive impact on their learning. Comments such as "seeing how thing works in the industry is engaging and fun than just being in the lab", "helps me to learn new things and discover new stuff which can help me in my assignments", "this opens up our eyes and we’ll know how the things that we learn could be applied to real world situations" and "learn new things and explore new learning way" suggested that students stay engaged if there is relevancy, educational trip or field study provides an opportunity for students to see how their learning can be applied to real-life situations as compared to just classroom bounded activities.

During the focus group questionnaire, students also state that they appreciate out-of-class activities because they can (1) learn from the professionals in the relevant industry; (2) Have more opportunities for discussions with each other and other people; (3) build relationship with the lecturers.

Evaluational trip and field study also resulted in an authentic intellectual engagement, it allows lecturers to explore and learn alongside the students to build learning experiences and knowledge together and develop meaningful relationships and respect. Taylor, L. & Parsons, J. (2011) stated students want stronger relationships with teachers, with each other, and with their communities and want their teachers to know how they learn.

Students also highlighted that they want their assignment to be relevant to the industry, authentic and meaningful. The assignment needs to be thoughtfully designed so that students will feel that it is worthy of their time. This allows the students to stay motivated and engaged. As Claxton (2007) also further suggests (1) relevancy: the topic connects with students’ interests and concerns; (2) reality: solving problems or making progress genuinely matters to someone.

A noticeable high number of students find activities such as e-learning and journaling waste of time. Students reveal that these activities lack social interaction and unlike individual assignment, they are not challenged to tackle a real-world problem. This reflects the characteristic of Net Generation learners who value social interaction. They find that learning from people within their communities, subject experts enhance their knowledge and feel more authentic.

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Figure 3: Interactive Activities

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Figure 3 revealed that students feel connected to and interested in learning if the lesson entertains them, challenges them or helps them to learn what can be done better. More than half of the students like the learning to be interactive, that is fun and engaging. Lecturers should be encouraged to use a variety of online platforms such as Padlet, Kahoot, and Slack to engage the students. Comments such as "doing something active will keep me awake," "I feel like I can learn faster by playing games rather than doing boring stuff" and "Using slack on the phone allow for more honest private feedbacks and opinions. And students will be able to say what they want" suggested that students appreciated such learning activities.

Small group discussion allows collaborative learning to take place. Students responded that they enjoyed learning through discussion with friends; they find friends often are able to explain the content. Small group discussion creates opportunities to clarify and reinforce learning with each other. Many students also responded
that discussing in a small group is less intimidating as compared to working alone. It was also noticed that small group discussion often increases the willingness to participate in whole-class discussion. Increased class participation encourages discussion that helps students analyse an argument, reflect and reinforce their learning. Windham (2005) mentioned that today’s students ask for the opportunity to explore and to find solutions and answer themselves. Critique and feedback sessions and one-to-one consultation allow the student and lecturer to discuss ideas together, this encourages more interaction and exploration as compared to just lecturer telling students what the answers and outcomes should be. Students also mentioned that in such activity, they feel less fear to ask the lecturer when they are in doubt. While for others, such activity enables discussion and gain advice and knowledge from the lecturer.

This finding supports Zepke and Leach (2010) discussion that there is a need to create educational experiences for students that are enriching, challenging and extend their academic abilities. The varieties of the activities helped the students to stay focused and engaged as the activities involved them.

Figure 4: Factors that engaged your learning

Lastly students were asked to choose their top 3 factors and provide reasons to why these keep them engaged during In-Class Activities, Out-of-Class Activities and Interactive Activities. The top 5 responses were categories as follow, Friendship & Fun; Do-Learn-Interact; Explore & Experiment; Varied Problems; and Collaborative Systems.

Friendship & Fun category reflects the highest intensity of need to satisfy their relational and emotional state of mind with comments such as, “with friends it makes stressful times easier”, “a friend will encourage you so you will not give up”, “more friends will learn more things”. With friends there are fun factors in class with responses such as, “friends are not only fun to be with, they help clear your doubt when you are lost”, “talk with friends about fun stuff keeps us awake”, “it is fun to have friend around to share what we learn and help each other”.

A substantial group of students selected Do-Learn-Interact. These students prefer practical hands-on with real-time feedback on what they have done. Some of their responses were, “while practicing a craft it provides a better experience compared to lectures”, “it makes one understand immediately and when in doubt one can ask”, “doing and learning is entertaining” and “when I learn something new, I need to practice it once to remember it.”

Explore & Experiment categorizes a group of students who urge to try the unknown to better equip themselves for the future. Their responses were as such, “to explore and find out more knowledge about work and life”, “exploration brings new answers”, “it makes me think differently with new information”, “new explorations bring about learning in a new way” and “exploration gives a free reign for the mind to focus on new ideas”. All the above statements were evidently showing students minds are engaged in learning through experimentation and explorations.

Varied Problems and Collaborative Systems are the minorities where these students prefer learning through a variety of problems through team effort in a logical and systematic fashion and deem efficient. Their responses were that, “collaboration help each other do things faster”, “collaboration exposes me to the varied style of works”, “seeing stuff from a different perspective through collaboration can be fulfilling”, “a variety of activities stimulates me to put more effort into expanding my horizon of knowledge” and “I enjoy putting different things together and finding common ground between the various group to achieve a goal”. In the ever-changing digital media domain, it is important to develop conceptual and problem solving creative individuals.

Discussion

The conceptual model above summarizes our key concept in fostering student engagement. Student motivation is largely rooted in subjective experience identified in the 5 themes that increased their willingness to engage in In-Class Activities, Out-of-Class Activities and Interactive Activities.

Students responded on why they perceive these 5 themes aids learning positively. Majority of the students enjoy fun activities, and engaging content that entertains them and friendships are important aspects of a student's experience in school. According to Senior and Howard
(2014), existing friendships between students on a course and in the wider student community were a resource in which the students developed their understanding of theoretical concepts through discussion, explanation, and application to “real life” contexts. Peer and peer interaction, therefore, may have increased their engagement and opportunities to gain different perspective that facilitate a more fun and better learning experience.

Many students enjoy the learning by doing approach used in In-class exercises as knowledge is retained longer and it facilitates easy understanding of knowledge components with applications. While student may not enjoy out-of-class assignments, they understand that engaging in such challenges allow them to learn through problem-solving, engaging in critical thinking and most importantly make meaningful connections to the content learned in various way in and out of class. Interaction with lecturers and peers such as critique and feedback sessions help them acquire new information, new skills and expand on what they already know most importantly guide them towards the achievement of the intended learning outcomes. This is especially crucial for design courses as the nature of all design problems and processes are unique and different, student finds meaningful discussion between peers and lecturers, feedback and consultation with lecturers as highly beneficial and stimulating in their learning. These Interactive activities promote analysis, synthesis, and evaluation of class content between lecture and students.

Many student welcome out-of-classes activities as they see this as an opportunity for authentic learning through quality interaction with community and industries. In the process, students learn to explore, investigate, connect information and draw conclusion. It encourages the student to explore and experiment, drive their curiosity to challenge themselves to seek for answer. This self-directed learning allows students to learn beyond the classroom, developed self-learning and problem-solving skills that equipped them with life-long competency necessary for the real world.

A minority of the students appreciate opportunities to tackle varied problem through collaborative work. Student believed this broaden their exposure, stimulate their creativity and participation in collaborative problem solving with students from different academic discipline and/or different cultural background give them new perspectives.

Conclusions

The result of this research suggests that a learner-centered approach optimize students’ learning. Make their learning more impactful and enjoyable. Incorporating Friendship & Fun, Do-Learn-Interact, Explore & Experiment, Varied Problems and Collaborative System into in-class activities, out of class activities and interactive activities help student connect to the course materials and enhance their learning experience to better engaged and involved them in the learning process. Engaging students in various active learning instructional activities, students will be better engaged, and better learning occurred. The students will also take responsibility for their own learning, and their performance is likely to increase.

Through these active learning strategies, we can aim to produce better conceptual and problem solving creative individual in SIDM. Positively impact students’ perception of learning by adopting student-centered pedagogy to enhance their educational experiences. Student learning increased when student is encouraged to take responsibility for their learning and reflect on their learning. Integrate out-of-class activities into passive tradition classroom bounded learning by designing instructional approaches that facilitate student learning and self-assessment of their understanding outside of class as a significant amount of learning happens beyond the classroom. Encourage peer to peer and lecturer to student interaction to engage, enrich and extend their learning abilities.

The Net Generation is interactive and social learners. Students want to experience work that is meaningful, solve real problems, learn from people within their communities, and subject experts. Engage in dialogue and know that their learning contributes to making a difference in the world. (Dunleavy, J., Milton, P. & Crawford, C., 2010). The findings of this paper suggest that a learner-centered approach optimize students’ ability to construct their own learning and knowledge acquisition thus it could be widely applied to students from a different discipline within SIDM.

Acknowledgments

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References


GROUPWORK ABOUT RESPONSE TO FICTIONAL SECURITY INCIDENT IN INFORMATION SECURITY EDUCATION

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Abstract

The information security become an important factor on ICT (Information and Communication Technology) to use and keep computer system. But the number of engineers having the skills of information security is shortage and the nurture of human resource is desired on the industrial societies in the world. There is same situation in Japan and NIT (National Institute of Technology, Japan) goes ahead with the plan for nurturing human resource in the education. The K-SEC (Kosen Security Educational Community) project start to grow the skills of information security. This paper shows the design and practice of information security education with active learning method in K-SEC project. A skill for information security response is one of the most important skills in modern society. And we also think the moral for information security is one of important factors in the education on information science and students think about moral on information science in this groupwork. Groupwork in this paper is design for students to play four kinds of posts, which are division manager, department manager, employee and a part time worker, in a company and think how to prevent incidents as each post. In the group works we set a information security incident caused by a part time worker’s careless operation. And students think each post should prepare for prevent the incident. The group work is consisting of 3 steps, first step is consideration of points of cause of the incident on each post, second step is making proposals of auctions to prevent the incident and third step is the presentation of proposals of actions in each post. In each step, student think about themes using whiteboard and tags and contents in the group work is inputted to e-learning system to share the contents with other groups. In the presentation, suggestions of most of students are appropriate proposals in the real company and our groupwork achieved success to train the skills and morals on information security.

Keywords: information security education, grope work, LMS, K-SEC, moral on information

Introduction

The developments of ICT (Information and Communication Technology) is in progress and the information security become an important factor to keep ICT systems. But the number of engineers having the skills of information security is insufficient and the nurture of human resource is desired on the industrial societies in the world. There is same situation in Japan and NIT (National Institute of Technology, Japan) starts an education project for nurturing human resource. The project is called the K-SEC (Kosen Security Educational Community) (figure 1). K-SEC was organized in 2015. The number of the campus of NIT joining K-SEC is increasing (Kochi Kosen (2018)). Our campuses also join the K-SEC and develop the contents for information security educations. The skills which should be grown in the education of information security is not only ability on ICT but also the proportional senses on using and/or designing the ICT systems. For example, some rules designed for protecting important information is not usability for users. The system with less usability is not able to be excellent system. Because of these backgrounds, we need to design and make the educational contents for growing ICT skills and proportional senses by groupwork.

Materials and Methods or pedagogy

The educational contents for information security developed by the K-SEC consists of three levels. The contents for 1st level are for all students in NIT to learn common knowledge of ICT and information security, and the content for 2nd level is for the student in each department to learn the factors of the information security on their fields of study. The content for 3rd level is for student learning information science to learn and get the skill for the information security to become a capable engineer and/or scientist like as a white hacker. The teaching style on the contents developed in the K-SEC is classroom learning style, self-learning style, active-learning style and practical training style. In this paper, we use the contents about the moral on the information security for the self-learning and carry out grope work to learn proportional senses on ICT system and information security.

The grope work is planned as flip teaching and is carried out in the event for nurturing human resource in Kosen on 30th August, 2017. In the event, students selected from all Japanese Kosen assembled in NIT, Ishikawa Campus. The contents of the event are this grope work and hackathon to create questions for CTF(Capture The Flag). This paper explains about the grope work.

We think engineer related to the information security should have sense about morals and balance between availability and limitation on the rule of corporation. We design a groupwork to make rules of corporation which has information security incident. In groupwork, students make rules for each post. The grope work consists of two stages. One is previous learning using internet and the other is face-to-face class. The course for the previous learning is set up on the Blackboard, which is the one of the LMSs which we can used. The contents of the course are about morals on using information and we input basic knowledges into students. These contents are developed by K-SEC and available at all campus of NIT. Then the students who already learn basic knowledges gathered at Ishikawa Campus and start face to face class. The theme of class is grope work to make the rule of corporation against incident on information security. Students are separated to 7gropes and the number of students at each grope are 5 students.

Each grope discusses about the rules on corporation on information security. The themes on grope work are PC, smart phone, SNS, cloud service and e-mail. The processes of grope work are following:

1. Ice Break
2. Explain about incident on information security at the corporation.
3. Digging up the problems on the rules at each post.
4. Sharing the problems with other gropes using ICT
5. Making new rules against the problem
6. Sharing new rules with other gropes using ICT

At first, we explain the story about the information security incidents in the corporation. In the story, a part-timer leaks an information about a behavior of information system in a division in the corporation as problem to the SNS and a director of the headquarters, who find the information on SNS, forces to stop the system, but the behavior is by design.

In the process of digging up the problem, students discuss the problem on each post in the corporation. The posts in the discussions are the director of the headquarters, he director of the division, the regular employee of the division and a part-timer of the division. Students discuss about the incident and find the problems at each post. After the discussion, they summarize the problems and input the contents about problems into LMS. Then we disclosure the contents to all students and share the problems discussed in each group.

In the process of making new rules, Students consider problems they found and propose the rule against the problems for each post in the corporation. After the consideration, they organize the rule at each post and input the rule into LMS. Then we summarize the rule that students consider and present the rule in real corporation and

Self-evaluations were carried out before and after the event. These results of evaluations were used for estimation of effects of event.
Results and Discussion

The event is held on 30th and 31st August 2017, at NIT, Ishikawa campus. 35 students come to the campus. A half number of students belong to Ishikawa campus and another half is come from other campus or Kosen.

Figure 2 shows the slide for this groupwork and title of groupwork is “the discussion about rules for the information security by students in KOSEN”. We explain the story about information security incidents using this slide. 5 students work in one table and discuss about information security incidents using white board at each group (Figure 3). Results of discussion by students are inputted to LMS (Microsoft Forms) as shown in Figure 4.

Figure 5 shows results of problems dug up at each post and inputted to LMS by students. In this process, it is can be said that students analyze the story and find proper problems at each post in the corporation. Figure 6 shows results of rules made and inputted to LMS by students. Students analyze problems properly and make rules to prevent incidents while keeping usability. These results are very close to model answers which we assumed and it is identified that students have senses to treat information properly.

Self-evaluations and peer-evaluation was carried out during the event. In evaluation, best score is 5 and worst score is 1. The points for evaluation are teamwork, independently, logical mind, problem solving ability, moral and communication skill. In the radar chart, scores after the event on all points of evaluation in self-evaluations is larger than that before the event. This result means that student can be grow problem solving ability and other skills and can feel the growth of skills.

Conclusions

The grope work is planned as flip teaching and is carried out in the event for nurturing human resource on information security in Kosen. In the grope work, students analyze the security incident in a corporation and find the problem at each post. After that they make new rule against problem in information security with availability. Additionally it is confirmed by self-evaluations that the other skill of student grow.

References

ROBOT CONTEST FOR THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

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Abstract

This is a report on N.I.T. Maizuru, a participant of a robot contest organized by N.I.T. Fukushima College. The creative robot contest is based on problem-based learning (PBL) education and was held at the decommissioning Fukushima Daiichi Nuclear Power Station. It aims to encourage student interest in decommissioning and to simultaneously discover problem-solving abilities. For the team who passed the document screening, a summer school was conducted as a preliminary learning of the nuclear power plant. In the summer school, the contestants actually observed the situation of the decommissioning work at the Fukushima daiichi (=first) nuclear power plant (core damaged) and daini (=second) station where the core damage was avoided. Tours in the building and storage containers are also carried out.

The competition was held in two fields, the mock-up stairs and the step fields, assumed inside the reactor building. The two fields have the following common environment. ① There is no lighting and it is dark. ② Since the robot is remotely operated, it is impossible to look directly. ③ Radio waves will not reach because there is a thick wall of concrete. ④ Because of the influence of strong radiation, there is time limit to the operation of the camera / semiconductor device.

The N.I.T. Maizuru team proposed an idea to use multiple balloons divided into a parent node and child node for these difficulties. The balloon is divided into a parent node that transports the tip of the fiberscope, a child node that carries the optical fiber and the electric cable. By changing the direction, only the direction of the parent node changed so that the change of direction for all nodes was completed.

In the questionnaire after the contest, many students answered "I want to learn or study more about the Fukushima first decommissioning." As a result, this PBL is considered to have succeeded.

Keywords: problem based learning, robot contest, nuclear power plant, Fukushima Daiichi, step field, mock-up stairs

Introduction

In the Great East Japan Earthquake in March 2011, serious damage was caused due to the effects of the earthquake and tsunami. At TEPCO's Fukushima Daiichi Nuclear Power Plant, which was in operation in Fukushima Prefecture, the emergency stop was steadily implemented, but the earthquake the supply of electricity from the grid and the emergency power generator were both cut off. It became a crisis situation as the total power supply was lost and the equipment was flooded and therefore stopped functioning. A nuclear reactor, that failed to remove the heat of the collapse, became a catastrophe that destroyed the building and pressure vessel after an explosion was caused by the generation of gas and release of radioactive materials to the surroundings. Currently, the decontamination of radioactive materials, and the demolition of nuclear power plants that caused accidents, are rapidly being advanced.

The dismantling of the nuclear power plant that caused the accident is a long project which is thought to continue for the next 40 years or so. Many human resources are necessary, and many new technologies are required for the development. In particular, it is not the technology of past research and development of nuclear power that is required, but the engineers trained by the Kosen colleges who need the strong technologies oriented to this field. Under such circumstances, N.I.T Fukushima College in Fukushima Prefecture, which suffered damage in this accident, was the center of the creation and hosting of Robocon, a robot contest aimed at nurturing human resources for decommissioning furnaces. The first tournament was held in FY 2016 and 15 teams from 13 Kosens participated.

Outline of the competition

The competition was held in two fields for the 1st and 2nd games. One field was a mock-up staircase and the other was a step field. In either field, the task is accomplished if the robot gives the name of the object in front of it and clears the field on the way to the monitor. Figure 1 shows a picture of the mockup staircase. Figure 2 shows a picture of the step field. Other rules include the environment in which the task is carried out is considered according to the actual situation, the robot cannot be
viewed directly, and differences exist in competition time depending on the shielding performance.

The team who joined Maizuru consists of one faculty of the mechanical engineering department and three fifth-grade students. The robot proposed by the Maizuru National College Team is a flying robot. In this year's decommissioning robot contest, a number of teams proposed a flying robot, but all used multi-copters. In addition to the difficulty of limiting the usage time of electronic devices under radiation environments, the robots were required to move in rubble. The N.I.T. Maizuru team proposed an idea to use multiple balloons, divided into parent node and child node, to overcome this difficulty. The parent node balloons transported the tip of the fiberscope, and the child node carried the optical fiber and the electric cable. By changing the direction, only the direction of the parent node changed so that the change of direction for all nodes was completed. To utilize self-controllability, the balloon can keep the same altitude in any situation using an anchor cable. As the on/off control of the propulsion motor was sufficient, electronic devices were not installed. In addition, the imaging device was mounted onto the robot using optical fiber. The robot was able to avoid the influence of the radiation by moving to outside the radioactive area.

Results and Discussion

After finishing the competition, we administered a questionnaire to find out the change in awareness before and after joining the waste furnace creation of Robocon. Three students, who participated from NIT, Maizuru, completed the questionnaire, all of whom were impressed with the decommissioning of the nuclear power plant reactor, resulting in the objective of this contest being achieved. Figures 4 to 6 show the questionnaire results.
Conclusions

The educational effect of the waste furnace creation of Robocon began with the purpose of increasing the interest from students of the nuclear power plant waste furnace, and led to verification of the responsible human resources for the waste furnace. The robots produced by the students proved to be of high quality, considering the limited time and budget provided and students’ manufacturing skills. Among them, some colleges of technology have proposed innovative ideas and have proven a high level of problem solving power.

Based on the results of the questionnaire, it can be said that all the students who participated from Maizuru college gained a strong interest after the contest on the decommissioning furnace and related technology, and the purpose of the contest was achieved.
EVALUATION ON THE STUDY PERFORMANCE OF THE MODULE “CREATIVE PROJECTS” USING QUANTITATIVE SURVEY APPROACH

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Abstract

We are now living in a highly developed world, which is sustained by a variety of engineering systems and technologies. One of the indispensable pillars to support these systems is fossil fuel. However, fossil fuel is not a sustainable resource and will be running out in the future. On the other hand, alternative energy sources such as a photovoltaic cell, wind turbine, and hydrogen fuel cell are gaining more attention nowadays because of their inexhaustible and pollution free properties. As a competent engineer in the future, each of the Diploma of Foundation Studies (DFS) engineering students have been trained in how to solve problems with a creative mind in the module “Creative Projects”. Initially, students learned about the process of problem-solving and creative thinking in lectures. They then conducted three experiments on renewable energy sources and investigated their energy performance. Finally, students proposed and presented their own creative projects on the use of renewable energy for household applications. They worked in groups and applied what they had learned in lectures to identify and solve related engineering problems.

In order to evaluate the study performance of students, a quantitative survey was conducted for the DFS students. There were 151 students participating in the questionnaire survey. Nearly 90% of the questionnaires were successfully collected. The result of the study has been analyzed using a descriptive approach. It has revealed that over 80% of the respondents agreed that they had learned how to apply problem-solving techniques in creative minds. In addition, more than 75% of the students agreed that they were capable of identifying and solving engineering problems in their projects. Meanwhile, around 75% of the respondents agreed that they were able to plan and monitor their projects within the timeframe. Finally, 75% of them agreed that this module provided them a creative learning environment. This quantitative survey has successfully evaluated the study performance from the students’ points of view. The result has shown a positive outcome for DFS students in terms of problem-solving skills development and creative minds incubation.

Keywords: creative projects, study performance, engineering students, module evaluation, problem-based learning

Introduction

Engineering is a creative application of science and mathematics and used to solve our daily problems, enhancing our living standards and shaping our modern world (C. J. Atman, R. S. Adams et al., (2007)). Most of the technologies found today have experienced a long design and development process where involves complex engineering knowledge and application of science (N. R. Council, (2011)). A successful engineering design not only relies on the adequate knowledge in science and mathematics and high-order problem-solving capabilities but also depends on the individual’s creativity and the teamwork among engineers. There were plenty of studies (R. A. Streveler, T. A. Litzinger, R. L. Miller &P. S. Steif, (2008)) have revealed that students who were more capable to understand conceptual principles, the more they could identify problems, recognize errors and generate a successful solution. Apart from the conceptual understanding, experimental approaches can provide a different learning experience to the students. A. Eroglu, (2010) and A. J. Wheeler & A. R. Ganji, (1996) have pointed out that students could gain a solid foundation through the application of the engineering theories during the experiment. S. J. W. a. S. To, (2015) also mentioned that conducting engineering experiments could enhance students’ logical thinking and their abilities of planning, execution, data acquisition, data analysis, drawing conclusion and reporting. Experimental learning approaches also promote the team building among engineering students since everyone can contribute their own suggestion and find for an optimized solution.

The existing technology education regards the engineering design activities as the major instructional approach where the conceptual science knowledge and practical engineering knowledge merge together, forming virtual ideas to touchable objects. One of the trending topics in the education sector of Hong Kong is the STEM education (an abbreviation of Science Technology Engineering Mathematics). Students ranging from junior level to tertiary level are engaged with the STEM activities. However, some researchers like M. Hynes, M. Portsmore et al., (2011) found that there was a common misconception regarding the “engineering” sector when implementing the STEM activities. Teachers or students commonly believed that the engineering design process was mainly related to building “things”, without involving other engineering design processes such as defining problems, conducting
research on the problem, testing and evaluating the prototype and redesigning the prototype, until the optimized product. M. Hynes, M. Portsmore et al., (2011) also mentioned that engineering education is not only related to building something but more importantly associated with the defining problem, repeating testing, data analysis and optimizing products. During the above engineering design processes, students not only exploit their knowledge of science and mathematics but also exploring other higher level technological concepts for a better solution. This design process can strengthen the cognition of science and mathematics of students and provides an innovative environment for the technology education development.

The module “Creative Projects” was one of the major subjects for DFS engineering students to study. DFS engineering programme was designed to prepare the HKDSE graduates for employment and further studies by equipping them with professional engineering knowledge and skills. The module integrated both conceptual and experimental content. For the conceptual part, students learned the thinking tools including research method, mind-mapping and six-thinking hats etc. After that, the module entered the experimental part. Students were worked in groups and conducted three experiment which related to the renewable energy. The experiment covered three types of renewable energy such as photovoltaic cell, wind turbine and hydrogen cell as shown in Figure 1. Before the experiment started, students studied the nature and characteristics of the renewable energy, teachers then introduced the engineering instruments such as luxmeter, anemometer and tachometer to students for the coming data acquisition. After that, students received the experimental kits and prepared for the experiment. During the experiment, students were asked to collect data through a variety of parameter setting. Students had to overcome different obstacles, either from environmental and instrumental, in order to minimize the errors taken. After the experiment, students discussed their findings in groups and analyzed their data using the scientific and mathematics methods. Finally, students were asked to design a household application using renewable energy. Each student drafted and presented their own design to the teachers for evaluation.

Methodology

This study employed the qualitative approach for data collection. A total number of 170 DFS students were invited to conduct a questionnaire about their study performance regarding on the module “Creative Projects”. Nearly 90% of the questionnaires were successfully collected. The result of the study was analyzed by descriptive methods and presented by graphical method.

The questionnaire has included four questions regarding the study effectiveness from the students’ perspective. Students were asked to circle the appropriate level of Likert scale in the questionnaire. The first question asked if the students have learned the problem-solving techniques in creative minds. The second question was related if the students have learned how to identify and solve problems using engineering science knowledge. The third question was about whether the students have learned how to plan and monitor an engineering project and completed it within a given period of time. The last question was related if the module has provided a creative learning environment for the students.
Results and discussion

A total of 151 questionnaires were collected and analysed as shown in Table 1. The detailed figures for the four questions are shown in Figure 4. It has revealed that over 80% of the respondents agreed that they had learned how to apply the problem-solving techniques in creative way. More than three quarters of students agreed that they were able to identify and solve engineering problems in their project, planned and executed the engineering projects within the time frame. Finally, there was about 75% students believed that the module has provided them a creative learning environment. The result entails the module has enhanced the students’ problem solving skills and their creative thinking.

Table 1 Descriptive statistics for study performance for the module of “Creative Projects”, where Score 1 to 4 refer to different Likert scale from strongly disagree, disagree, agree and strongly agree, respectively.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have learnt how to apply problem solving techniques in creative minds.</td>
<td>2</td>
<td>4</td>
<td>3.05</td>
<td>0.44</td>
</tr>
<tr>
<td>I have learnt how to identify and solve engineering problems in Structural Mechanical Science and Electrical Science.</td>
<td>1</td>
<td>4</td>
<td>2.99</td>
<td>0.52</td>
</tr>
<tr>
<td>I have learnt how to plan and monitor the to-do list(s) in the project development within given time frame.</td>
<td>1</td>
<td>4</td>
<td>3.06</td>
<td>0.49</td>
</tr>
<tr>
<td>This module has provided me a creative learning environment.</td>
<td>2</td>
<td>4</td>
<td>3.09</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Figure 4 Questionnaire findings presented by graphic method: Capability to apply problem solving skills (Top left hand corner); Capability to identify and solve engineering problems by using Engineering Science (Top right hand corner); Capability to plan and monitor engineering project within given time frame (Bottom left hand corner) and Creative learning environment (Bottom right hand corner)
Apart from the statistical findings, there were other intangible learning outcomes in this module. For instance, students have gained the hands-on experience when they prepared the renewable energy learning kit. They have also collected the data using different engineering instruments while minimizing the measurement errors during experiment. Moreover, students have learned how to present their own household application design using descriptive and sketching technique during presentation. As shown in Figure 5, one of the designs work was about a backpack which was embedded with a solar panel, and the stored power could be used for USB charging. Another design shown in Figure 6 was a foldable louver which was designed for battery charging. Students were capable to present their ideas creatively with basic engineering senses and knowledge.

Figure 5 A backpack embedded with solar panel was designed for USB charging.

Figure 6 A foldable louver using the flexible solar panel was designed for battery charging.

Conclusion

This study has reported the study performance of the module “Creative Projects” using quantitative approach. A total number of 151 students were participated to the study and gave their opinions on the learning outcome in this module. Over 75% of the students agreed that they have gained knowledge from problem-solving skills, engineering science application and project management skills in this module. In addition, there were other intangible outcomes like the experience in hands-on practise, handling instrument, data processing, engineering sketches, reporting and team-working. Students have gained valuable engineering knowledge and experience from this module.

Acknowledgement

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References


Abstract

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

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

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

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

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

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

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

Introduction

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

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

Background

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

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

In the beginning, there are some illustrations of how the resources abstracted from the digital world, then teaching and learning stuff would be discussed. Next is that how the Ed-tech tools are useful for the assistance of the student’s self-study. Finally, there are some shares concerning the successes of the results and
feedback from my students and are better than what I expected before.

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

**Fun Based Learning (FBL) Setup**

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

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

Besides, some quizzes were uploaded and embedded on Moodle for the students’ self-study outside class. Students could discuss their queries in a specified mobile application (App) named “VTC@HK IM” with me at any time. The quizzes could be scheduled to issue outside the class (i.e. computer room, library or home).

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

Setup with Youtube

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

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

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

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

Setup with Moodle

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

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

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

Setup with Google Map

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

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

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

Setup with Mentimeter

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

Setup with Quizlet

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

Upon completion of the above activities of fbl, a questionnaire issued for the collection of feedback. The results of the questionnaire survey summarise as follows:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

![Figure 1](image1)

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

![Figure 2](image2)
Discussion

From the above survey, the following analyses are:-

The student did have the experience with online learning in the other modules in VPET.
The students confirmed that the fbl activities were helpful for their study outside class and preparation for the examination.
The students responded that making connections with peers, within the learning context, beyond the classroom. It sounds that these are the critical elements on the development of digital environments.
The students responded that they enjoyed their self-study involved the scenario of inquiry, and working. It sounds that there is room to make up the online pedagogy similar to the Quizlet device.
The students prefer to learn in the environment with online communication.
The students prefer to use the mobile phone as an essential tool for communication and learning.
The results of the examination indicate that the fbl could help to improve and engage the students’ to pay attention in the session of study with more interest.

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

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

Conclusion and Recommendation

Given the above, I believe that the mobile phones do multi-function wide these days. It replaces the recorder, drawing boards, typing machine, camera, and television. John, Traxler & Agnes Kukulska-Hulme (2016) have studied the impact of mobile phones. The change is not just only on the student and also the public behaviour. It proves that the adjustment of pedagogy to have been the connection with all kinds and levels of education as well as in VPET.
The smart learning environment studied by Liu, Wosinski and Huang (2017), there are some essential elements categorised, such as the learning resources, creative tools, teaching community, and learning community. In facts, the students could have learnt from their experience either directly or indirectly, either by the group or by themselves. The creation of such environments is going to be a new mechanism to track in VPET.

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

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

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

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

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

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

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

Acknowledgement

I wish to acknowledge the time permissible by our Head of Department, Ir LO Wing Hong and Program leaders, Mr POON Yiu Hoi, Anthony and Dr HUI Ken for my study last. My special thanks extend to the colleagues of the Centre for Learning Teaching of VTC for sharing the skills of Ed-tech tools for me to establish the fbl activities.

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

Reference:


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NURTURING FUTURE CYBERSECURITY PROFESSIONALS: AN EXPERIENTIAL LEARNING PEDAGOGY

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

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

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

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

Keywords: Experiential learning, cybersecurity, Kolb’s learning model

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

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

Table 1: Traits desired in a Cyber Security Professional.

<table>
<thead>
<tr>
<th>T-shaped skills</th>
<th>Striving for accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solving skills</td>
<td>Integrity and responsibility</td>
</tr>
<tr>
<td>Critical thinking</td>
<td>Perseverance</td>
</tr>
<tr>
<td>Lateral thinking</td>
<td>Continuous learning</td>
</tr>
<tr>
<td>Analytical thinking</td>
<td>Communication skills</td>
</tr>
<tr>
<td>Self-directed learning</td>
<td>Community service</td>
</tr>
</tbody>
</table>
The list of traits gave the teaching team with a “direction” as to the type of learning experience and approaches that they will require in order to develop these traits in their students. The review of literature shows that Experiential Learning was most suitable for this course as the learning process will provide the opportunities for the development of “traits” of the profession.

Experiential Learning as ISF’s signature pedagogy

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

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

Experiential Learning at the Module Level

Ethical Hacking (EH) is a core module taken by the students of the Diploma in ISF during their first semester in Year 3. This module offers foundational ethical hacking and penetration testing knowledge and skills. Students learn the techniques and tools malicious hackers use, but in a lawful and legitimate manner, with a goal to assess the potential impact and risk of an actual cyberattack, and to deploy necessary countermeasures.

In addition to the content knowledge that students acquire during the experience learning process, students are also able to develop professional traits that are essential for the cybersecurity professionals in the EH module. Table 2 summarizes the implementation of experiential learning stages in the EH module, along with the professional traits honed by the students at each stage.

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

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

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

Implementation

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

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

Stages 1 & 2: Concrete Experiences & Reflective Observations.

In the EH module, students gain concrete experiences and carry out reflective observations through hands-on lab exercises. Students are provided lab worksheets to learn and practice the basic hacking tools and skills using industry recognized pen-testing tools such as Kali Linux and Metasploit. During the reflective observation process, students think through how their own experience has impacted their understanding of “Hacking”. These observations made during the hands-on lab exercises also allow students understand the modus operandi of hackers, which will enable them to better protect networks, systems, and applications.
Stage 3: Abstract Conceptualizations.
Students experience this stage of “abstract conceptualizations” through an open-assignment on real-world cyberattacks. This process gives students the opportunity to draw on their understanding from their hands-on experience and reflective observations done previously as a reference in their research and further study into the topic.
This open-assignment is a self-directed learning exercise whereby every student gets a chance to choose a latest system hack to research on, construct a demo and a worksheet to teach others in a step by step manner. Students need to present their findings and perform a live demo in front of their peers. They are also given a chance to better their grade by creating a demo video.

Stage 4: Active Experimentations.
In this stage, students are given access to a testbed that simulates an IT infrastructure for a small and medium enterprise. Students apply skills acquired in previous stages and carry out active experimentations via a pen-testing assignment on this testbed. This is a group assignment consisting of two to three students per team. Students brief the tutors on their findings and action plan.
Although students are provided with a brief about the project and have support from their tutors, the teams are very much left on their own to develop the proposal by themselves. This is the opportunity for students to showcase the knowledge and skills that they have acquired over the course of the module, and to demonstrate the traits that they have developed as a result of their experiential learning journey.

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

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

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

“The self-directed learning in open assignment has made profound impact on my learning as it has nurtured me to become more self-directed in my learning.

Although we started of not knowing anything about ethical hacking, this assignment has allowed us to understand the various vulnerabilities that exist and the numerous ways in which we could exploit these vulnerabilities...”

Experiential Learning at the Course Level
The curriculum for Diploma in ISF requires each student to complete 21 core, 3 disciplinary elective modules and an internship. In addition, students are also required to complete 8 interdisciplinary modules. Figure 2 depicts the core and elective modules, and their dominant association with one of the four stages of experiential learning.
It can be seen in Figure 2 that the year 1.1 (year 1 semester 1) modules emphasize more on providing concrete experiences to the students. Year 1.2 modules are best at creating opportunities for students to carryout reflective observations. Year 2.1 modules support students to derive abstract conceptualizations. Finally, year 2.2 to 3.2 modules allow students to carryout active experimentations.
Table 3 shows how the experiential learning process is anchored in the different modules within a course and the teaching and learning (T&L) approaches used in these modules to hone the traits of a cybersecurity professionals.

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

<table>
<thead>
<tr>
<th>EL Stages</th>
<th>Modules</th>
<th>Supporting T&amp;L Approaches Implemented in the Modules</th>
<th>Professional Traits Honed by the Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE</td>
<td>Cryptography</td>
<td>Hands-on exercises</td>
<td>Problem solving</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Simulation tools</td>
<td>Analytical thinking</td>
</tr>
<tr>
<td>RO</td>
<td>Vulnerabilities 101</td>
<td>Invited expert talks</td>
<td>Lateral thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Real-world case study</td>
<td>Communication skills</td>
</tr>
<tr>
<td>AC</td>
<td>Information Security</td>
<td>Open assignment</td>
<td>Self-directed learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Critical thinking</td>
</tr>
<tr>
<td>AE</td>
<td>Digital Forensics</td>
<td>Use of Industry recognized tools</td>
<td>Integrity &amp; responsibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Striving for accuracy</td>
</tr>
<tr>
<td></td>
<td>Governance &amp; Data Protection</td>
<td></td>
<td>T-shaped skills</td>
</tr>
<tr>
<td>Internship</td>
<td>6-months Internship</td>
<td></td>
<td>Continuous learning</td>
</tr>
</tbody>
</table>
One such sequence of modules supporting each stage of the experiential learning at the course level is presented below.

**Stage 1: Concrete Experiences.**

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

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

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

**Stage 2: Reflective Observations.**

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

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

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

Figure 2: Experiential Learning at the Course Level

Figure 3: Concrete Experiences: CTG Module
This study tour cum masterclass enabled students to observe and reflect on the academic, enterprise, culture, environment and economic aspect of US. The students visited reputable universities and prominent information security and technology companies.

**Stage 3: Abstract Conceptualization.**

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

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

**Stage 4: Active Experimentation.**

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

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

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

**Effectiveness of Experiential Learning at the Course Level**

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

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

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

**Figure 4: Active Experimentation - Cyber Security Operations Centre**

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

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

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

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

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

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NEW CURRICULUM INCORPORATING CLUSTER-BASED, PROJECT-DRIVEN APPROACH TO TEACHING COMPUTER SCIENCE FUNDAMENTAL SKILLS

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Abstract

Teaching computer science fundamentals effectively has been a challenge over the past twenty years. Many independent approaches have been tried with differing levels of success. In addition, with the increasing pace of change of technology in light of emerging areas, it is imperative for students to be able to learn core computing skills that, not only help them master their domain, but become a strong foundation from which to launch into a career of lifelong learning. In response to this, at the Temasek Polytechnic School of Informatics & IT, the first year curriculum was re-envisioned. The curriculum was reviewed and revamped based on the following three pillars: (a) developing cluster-based competencies, (b) integrating a project-driven focus and (c) incorporating greater industry engagement. This paper highlights the design and delivery of the revised curriculum that was adopted for over 500 students in 2017. It describes the structure of the curriculum in terms of the three pillars. Specifically, this paper will focus on the delivery of the software cluster of subjects to the first year students during their first semester. In this cluster, the students learned two subjects related to (1) mobile application development and (2) the design of the user experience and interface. Students were then tasked with integrating what they learned from the two subjects and developing their own mobile application. The paper concludes by sharing about how the students performed with this new curriculum compared to the previous curriculum that comprised of multiple disparate subjects. The paper also examines how this new curriculum enhanced student interest and motivation in programming. Finally, this paper discusses the key learning points that the teaching team garnered from this mode of teaching.

Keywords: cluster-based competencies, integrated project, industry engagement, mobile application development, user experience, user interface, student interest, student motivation

Introduction

As part of Singapore’s Smart Nation vision, the government, companies and educators advocate that learning core computing skills can help students to gain an edge when they enter the workforce because computers and information technology have permeated almost every discipline and profession (Lauw, 2018; Tham, 2017). These skills will enable students to build a strong foundation so that they can contribute more effectively to their domain and start them on a path towards a career of lifelong learning.

In Singapore, coding fever is growing with kindergarten kids being introduced to coding, schools offering computing as GCE O-level and A-level subjects, and an increasing number of enrichment centres even offering coding boot camps (Lauw, 2018). For example, in 2017, Singapore launched a Digital Maker Programme that aimed to distribute 100,000 micro:bits to school-going children and adults over two years to encourage them to learn basic coding, while since September 2014, a coding curriculum became mandatory in all British primary and secondary schools (Tham, 2017).

However, numerous studies have highlighted that teaching computing and programming can be very challenging (Ahmed et al., 2018; Kannan et al., 2018; Mow, 2015), as it poses a different set of challenges and techniques compared to learning other traditional subjects such as learning reading, writing or physics (Brown and Wilson, 2018). In response to this, the first-year curriculum at the Temasek Polytechnic School of Informatics & IT (IIT) was re-envisioned to enhance student interest and motivation in programming. The revamped curriculum focused on three key pillars – developing cluster-based competencies, integrating a project-driven focus, and incorporating greater industry engagement.

This paper will present a review of prior literature on teaching computer science fundamentals, describe the new curriculum offered by IIT, elaborate on the impact of the new curriculum on student interest, motivation and skills in programming, and discuss the key learning points of the teaching team after adopting this new mode of teaching.
Teaching Computer Science Fundamentals

One of the core challenges is how teachers can help students to better understand and apply programming skills and knowledge so as to increase their motivation to continue to learn and eventually embrace a computing related career. Motivation here is defined as a “student’s willingness, need, desire and compulsion to participate and be successful in the learning process” (Mow, 2015). In particular, this paper focuses on how IIT enhanced students’ intrinsic motivation by growing their interest in programming, and how they structured their subjects and assignments to provide students with a greater sense of achievement to further motivate them (Mow, 2015).

Teachers need to adopt learning methods that enhance the engagement of students to increase their interest in the subjects (Kannan et al., 2018). This is particularly important because a number of the first year students possess little or no background in computing or programming (Kannan et al., 2018), so they may find it challenging to learn these computing skills. So they require greater resources and support to scaffold their learning so they achieve success and bolster their confidence, self-efficacy and ultimately their motivation to learn programming (Mow, 2015). This is necessary because competence in programming is not an innate ability but rather a skill that can be acquired and improved with practice (Brown and Wilson, 2018).

There is also a need to go beyond simply understanding the syntax of a programming language, to developing multiple skillsets and knowledge (Ahmed et al., 2018) to help learners become more effective problem-solvers (Lauw, 2018). As Steve Jobs once said, “Coding teaches you how to think” (Tham, 2017). Furthermore, this includes skill sets and knowledge related to managing the data and databases used by the application, and enhancing the user experience and interaction design (UXID) of the application.

Classroom teaching and lectures are, however, only beneficial for teaching programming if the students already have a certain level of comprehension and logical thinking and can fill in the gap between the lessons and actual practice on their own (Ahmed et al., 2018). First year students though, typically have little or no such background knowledge in programming and thus have difficulty in writing codes or detecting syntactical or logical programming errors (Ahmed et al., 2018) so they need more hands-on practice to help them apply what they are being taught. Moreover, through traditional classroom style teaching or lectures, students are merely passive recipients of knowledge so they often perceive programming lessons as dry, boring and tedious (Ahmed et al., 2018).

Instead, students often prefer more hands-on activities to help them to learn through doing (Mow, 2015). This is in line with studies that advocate that higher levels of student engagement in the learning process can facilitate deeper learning (Mow, 2015). For example, in a study by Ahmed et al. (2018), 65% of their survey respondents listed lab sessions as their most favorite resource for learning programming compared to just 18% who preferred using books. In particular for first year students, instead of merely asking them to complete a series of tasks on their own, teachers should engage in live coding to create the solutions in front of their students so that they can better respond to “what if” queries from their students as they code along with their teachers and understand how their teachers diagnose and correct their mistakes (Brown and Wilson, 2018).

However, it is challenging to find the right balance of hands-on practice activities for them. If they are given multiple small lab tasks, they may find it easier to complete each task but may struggle to understand how these tasks are related or how they can solve more complex problem. Alternatively, if they are given a big project, they can better appreciate how the different components of the application, such as the functions, database and UXID, are inter-related but without adequate scaffolding, they can easily be overwhelmed by the project and thus de-motivated from continuing to learn programming. Teachers therefore need to provide students with a sufficiently complex sample application which has been broken down into multiple sections, each with its own step-by-step guides on how to achieve that particular sub-goal (Brown and Wilson, 2018).

Finally, teachers should provide students with authentic tasks that they will find more engaging compared to abstract coding examples that students may have difficulty appreciating or linking to the real-world problems that they need to solve (Brown and Wilson, 2018). For example, instead of merely asking students to program an application to find the maximum number from a list of numbers, it could be more meaningful if they were asked to find the highest student grade from a list of grades for a class. It would be even more meaningful if teachers could relate the course content to the industry and real-world problems through the use of real examples and cases (Kannan et al., 2018).

Description of the New First-Year Programming Curriculum

In the past, first-year IIT students learned each core computer science skillset separately. For example, programming, databases and UXID were taught as disparate subjects. This provided students with the opportunity to learn each skill in greater depth without the additional complexity of trying to integrate the skills. This was particularly useful in helping students who were new to computing to understand the basics of programming. However, the students subsequently faced challenges in learning more advanced computing subjects later in the course as they had not fully understood how these different skillsets need to be implemented in tandem, such as to develop complete mobile and web applications.

In the new curriculum, students learned the related subjects collectively as a cluster. They were taught how each component was related to the others and how they should manage each component as part on a single comprehensive application development process. The students were then given one project task – to develop a mobile application in semester one and a web application in semester two – and they had to integrate all these skills
to develop a complete application. To help the students to better understand and develop this single big project, they were given multiple hands-on tasks during lessons to scaffold their learning. Each task focused on a different programming skillset or piece of knowledge.

Students were thus forced to apply what they learned each week to complete each task in class under the guidance of their teachers. Furthermore, all the tasks were related to one another so that in effect, they students were building a simplified version of the actual application during their lessons. In this way, the teachers could help the students to understand how these different components of an application were inter-related, and concurrently build their skillsets and knowledge step-by-step until they were ready to develop their final project.

To increase student interest and help them to better understand the real impact of the application of their computing skills, their final project was based on a real context that the students regularly experienced. In semester one, they developed a music streaming mobile application and in semester two, they developed an F&B related web application.

**Impact of the New Curriculum**

Students were asked to complete a survey at the end of each semester so that the teaching team could gather feedback on their experiences with the new curriculum subjects. Generally, the feedback from the surveys were positive.

During the first semester, students were first introduced to Java programming and UXID, and were tasked with developing a mobile application (see Figure 1). About 500 students took these subjects and 322 of them responded to the survey.

![Figure 1: Screenshots of Mobile Applications Developed by First-Year Students in Semester 1](image)

About 94% of respondents feedback that their learning experience helped to raise their interest in coding, with about 95.7% finding it interesting that they learned computing by developing an actual mobile application. This was evident during lessons as teachers found the students to be more willing and pro-active in engaging in self-directed learning to search for online resources, such as forums and videos, so that they could learn how to implement other functions into their applications, beyond the scope of what was taught in the subjects.

This behaviour was particularly encouraging to see in students who were new to programming, who in past would typically have been apprehensive about learning coding. As one student, with no prior programming experience, shared, “I found it enjoyable, perhaps because I have not experienced using other programming languages yet. It feels great whenever I am able to come up with and implement my ideas successfully into my app.”

In fact, 75.2% of respondents expressed that they felt at least somewhat confident in their ability to develop other mobile applications in the future, with 80.1% stating that they were at least somewhat interested in developing other mobile applications and releasing them on a mobile app store such as Google Play.

The students were also generally more confident in their programming abilities when they saw that they were able to develop a fully operational application that was in some cases comparable to the applications that they found on the iTunes and Google Play stores and had drawn inspiration from. During the semester break, this motivated a number of students to pro-actively engage in further self-learning to deepen their programming skills and improve their applications in preparation for the next semester, which was a good sign that they were being intrinsically motivated to start their journey of being lifelong learners.

During the second semester, the students were introduced to more advanced programming concepts and multiple new programming languages, including HTML, JavaScript, CSS and MySQL, as well as how to work with databases, and develop both client-side and server-side codes as part of a web application (see Figure 2).

About 500 students took these subjects and 114 of them responded to the survey.
As a person who is always using the website, I did not use it outside of school. Likewise, as another student shared, useful as I can use the skills that I have learned and apply them to work, as compared to just completing multiple disjointed lab activities or a lab test.

Another learning point was that by clustering several related subjects together, it enabled students to better appreciate the holistic picture of how an application worked. They could thus better understand what each component did and how they were inter-related. For example, they could develop a more comprehensive function by designing a more user friendly screen for users to create new user accounts, writing the necessary functions to not only capture the user data but also verify whether the data was valid, and storing the data in a database so that subsequently, they could access this data for login verification.

Several teaching staff were initially sceptical about whether first year students were capable of picking up the necessary skills and knowledge to develop a mobile or web application, which in the past was only attempted by second year students. However, the teaching team learned that the students were not only motivated to do well but also able to produce higher quality applications when they were given projects that were more relevant to them, experienced the development of a complete application that incorporated multiple inter-related components, and received comprehensive scaffolding to support their learning and application development.

However, since many of the students were new to programming, they initially found the task of developing their own mobile and web applications to be rather daunting. They required much more scaffolding to help them to understand and apply the various computing principles and codes. As this was a first attempt at giving the students such challenging projects, the teaching team provided the students with additional ad-hoc scaffold throughout the semester based on the feedback from students and teachers’ observations of students’ performance in class. For example, the team identified and provided access to online learning packages, such as on Lynda.com, and developed mini-coding-tasks and e-learning activities to help students reinforce what they had learned. All of these additional scaffolds will be evaluated and incorporated into the learning materials for future runs of the subjects.

Conclusion

If this approach successfully enhances students’ skills, interests and motivation in computing, it is potentially easier for teachers to teach them further programming subjects in subsequent semesters (Kannan et al., 2018).

Acknowledgements

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IMPROVEMENT OF STUDENT'S PATENT ACQUISITION COMPETENCY
AND INTELLECTUAL PROPERTY RIGHTS EDUCATION

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Abstract

Many Southeast Asian nations advocate strengthening patent protection as part of economic policy today. The educational institutions of each country follow this policy of strengthening patent protection, and students are taught in engineering education to acquire abilities necessary for product development.

However, many universities are confused in the enforcement of intellectual property rights education. What kind of intellectual property rights curriculum should we establish? How should we find teachers? In the first place, how should we teach intellectual property rights as a subject?

In higher education in Japan, intellectual property education is divided into two aspects: "the understanding of the intellectual property system" and "ability to invent." The former is carried out by specialists in law, such as a patent attorney or a jurist who knows the intellectual property system well; while the latter is given by professors having experience of product development. The knowledge of law teachers about product development is imperfect, and they have been thought to provide problematic instruction in product development. However, many students invent many new products with the guidance of the law teacher every year at the specific National Institutes of Technology (NIT), and several students acquire patent rights.

In this article, I will discuss various educational methods based on the cases of National Institute of Technology, Miyakonojo College, to show how to make students' ideas into patent rights. It is thought that a theory of alternative dispute resolution in civil affairs disputes can contribute to improving the situation in patent acquisition for such a student. Mainly, this will be discussed as I refer to a principle of legal theory—Felstiner's "naming–blaming–claiming" model—in relation to a civil affairs dispute about the competency required of a student for the patent and the acquisition.

Keywords: Intellectual Property Rights, Idea, Innovation, Patent, Competency, Legal Science

Introduction

In Asian countries including Japan, intellectual property education is taking an essential role in engineering education now.

In Japan, the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) updated the course of study in elementary and junior high schools in 1998 and in high schools in 1999. Both of them were upgraded under the education program named as "manufacturing education: MonozukuriKyoiku." Each educational institution has worked on each subject in the education about intellectual property rights in school education positively by the revision of these guidelines.

The Japanese government has been trying to realize a nation based on the creativity of science and technology. This policy views ethics as human resources supporting Japanese technology in the revision of the course of study of the higher education system, and it becomes essential to bring up creation-related rich, high-quality human resources—so to speak, a senior engineer having knowledge of intellectual property rights.

As a matter of course, the Japanese government revised a similar curriculum in higher education. Each university planned to carry out interdisciplinary engineering education that was to become the foundation for manufacturing and reorganized large-scale departments to produce engineers in the compound-specialty domain. Furthermore, the incorporation of the national universities, which the Japanese government carried out in 2004, helped to set up an organization and a budget so that each university freely and voluntarily became part of it. Each university applies high standards of merit and adopts an aggressive approach leading to the activation of the field of study and improvement in the education of science and technology.

Intellectual Property Policy in Japan

The Japanese government proposed the "Nation Declaration Policy by Intellectual Property" in 2002. Prime Minister Junichiro Koizumi made a policy speech on the strategic use of intellectual property at the Diet on February 4, 2002. He announced that Japan was to become an "intellectual property country," endeavoring to make intellectual property a key driving force behind national prosperity.
The first point to be discussed was the Japanese IP policy. The term “intellectual property right” (IPR) is defined in the IPR Basic Act, in Article 2-2 as follows:

"intellectual property right" as used in this Act shall mean a patent right, a utility model right, a plant breeder’s right, a design right, a copyright, a trademark right, a right that is stipulated by laws and regulations on other intellectual property or right pertaining to an interest that is protected by acts.

The guidelines of the Strategic Formulation on the Intellectual Property of July 2002 led to the enactment of the IPR Basic Act in December that year. Since 2003, the IPR Strategic Program has been published. The issues regarding IPR education at National Institute of Technology (NIT) colleges and in higher education were first mentioned in this publication (Table 1). How has IPR education been introduced to NIT colleges?

Table 1. Strategic Policies of “IPR Country” in Japan

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>Patent Office published “the Standard Textbook for Studying Industrial Property Rights” and started the “School Assistant Program for IPR Education.”</td>
</tr>
<tr>
<td>2001</td>
<td>METI established &quot;IPR Curriculum.&quot;</td>
</tr>
<tr>
<td>2002</td>
<td>PM Koizumi’s speech: &quot;Intellectual Property Country&quot; (February); Intellectual Property Strategy Formulation Guideline (July); Intellectual Property Basic Act (November)</td>
</tr>
<tr>
<td>2003</td>
<td>Intellectual Property Strategic Program 2003 announcement</td>
</tr>
<tr>
<td>2011</td>
<td>MEXT added IPR education to industrial, commercial, and agricultural high schools</td>
</tr>
</tbody>
</table>

Outline of IPR Education in Japan

IPR education, the Japanese scholars, as well as students had to say enough educational content and are also provided (INPIT 2010). As highlighted in Yoshii (2012) in particular, systematization of intellectual property teaching through college tuition is insufficient from the subjective standpoint of supervising teachers, but an expanded curriculum has not been sufficiently built up. Compared with the educational institutions in Taiwan and Singapore that actively use the curriculum and problem-solving techniques, at present, we have not been keeping pace with them in this domain. To ensure promotion of internationalization of colleges in the future, the time has come for us to modify the curriculum, to set the global standard for intellectual property education and to understand the current state of intellectual property in the ASEAN countries.

Most NIT students cannot fully understand the IPR legal system due to its complexity. Consequently, IPR has been taught as a special subject and only a few NIT colleges have offered it.

It is currently difficult to conduct the IPR Strategic Program due to overlaps and discontinuities in the roles of various offices in the Japanese government. It is commonly thought that the Ministry of Economy, Trade and Industry (METI) handles administrative duties and policymaking. METI controls its sub-organizations and administers the Japanese patent policy formulated by them. For example, the Patent Office, one of METI’s sub-organizations, is an administrative office for patents, design registration, and trademarks. The National Center for Industrial Property Information and Training (INPIT), another METI sub-organization, was formed to run the J-Plat Pat, Intellectual Property Rights Digital Library.

In 1998, aware of the importance of IP education, the Patent Office published the “Standard Textbook for Studying IPR” and began to support school programs for IPR education. Based on this textbook, the Patent Office and IPDL produced the “Standard Curriculum for IPR” and launched the “School Assistant Program for IPR Education.”

Although METI and its sub-organizations have contributed greatly to the dissemination of IPR knowledge, it has not been able to provide enough opportunities to students to study IPR at school. Because the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has ultimate authority over educational divisions, METI could not spread IPR education among schools. Until 2002, the Japanese education system did not feature IPR in its curricula, and MEXT had no plans to train secondary education teachers in the subject. Only a few teachers have been aware of the importance of IPR, and they have taught this subject without licenses. In fact, there are only nine lines that mention IPR among the 230 pages of the most-used Japanese social science textbook for secondary-education students.

Since IP’s role in higher education is at an early stage, there are several issues concerning the start of new education in this field. Osaka Kyoko University launched a program called the Education System for Teachers to Teach IPR in 2005. The Patent Office and Yamaguchi University also conducted a study titled “Research Project on IP Education at the University” in 2006.

Professors can teach students high-technology skills and awareness through their own initiative. However, there are not enough lectures on “creating new ideas,” such as developing mind maps, quality control circles, etc.

MEXT established the 5th Science and Technology Basic Plan, approved in a cabinet meeting on January 22, 2016. This plan stipulated the following:

ii) Upbringing, achievement promotion of a variety of human resources through technology innovation.

Besides, technical support for the Program Manager to implement a plan, manage research, and ensure progress on the project on,
a research administrator (URA: University Research Administrator) to control of the whole research activities with a superintendent-in-charge, a research facility, various human resources such as technology transfer, human resources, and university management resources are necessary to promote creation of high intellect and social implementation in a university and a public research organization. Also, human resources specializing in management of human resources, technology, and intellectual property to take on the corporate strategy of new business development and changes in the business model are demanded to promote the standard implementation of the intellectual resources quickly and effectively in companies. While such human resources make use of the specialty that each person has, it is essential to create the environment that can show ability in the right person for the right place. However, the qualitative-quantitative mismatch of human resources between a university and the industry may occur, and the human resources are getting such jobs are short; and also, there are problems such as each person’s ability to cope with a rapid social change occurs.

In this plan, MEXT predicts the drying up of human resources with the ability for intellectual property operation. For this reason, personnel training in IPR that can provide global leadership is urgent for Japan. However, it can hardly be said that intellectual property education is being imparted in an environment where it is regarded as necessary in the Japanese higher education system. In many educational institutions, lectures for the IPR class are often taken by teachers lacking expertise in the subject.

**IPR Education at NITs**

How has IPR education been conducted in higher education in Japan, especially in NITs? According to NIT’s syllabus, only 8 of the 61 schools (13%) teach IPR subjects. However, the number of NIT colleges joining the School Assistant Program for IPR Education is 15. About half of those schools have no lecture titled IP, rather teaching IPR in lectures with different names or through club activities. Surveying the actual situation from a different standpoint, lectures in NIT colleges are separated into two types: product-based teaching (PBT) and classroom-based teaching (CBT). While PBT consists of product development, CBT involves instruction in the IPR legal system and the patent application process. In NIT colleges, many of the IPR lectures given are PBT (Table 2).

Most NIT colleges have taught IPR using the “Standard Textbook for Studying Industrial Property Rights” with the “IPR Curriculum.” By using this textbook, most students can understand the concepts of IPR within just twenty-five hourly lessons. Additionally, this textbook is provided free-of-charge by INPIT, so students taking PBT lectures can use free textbooks.

An exceptional example of IPR education among the standard technical NIT colleges is the NIT, Miyakonojo College. At this college, a professor delivers intellectual property rights education about practices, which is rare in Japan. In addition to explaining the legal system, the professor trains his students in “the thought process that leads to the invention,” using mind mapping and the KJ method.

**Table 2. Details of IP education lectures in NIT colleges**

<table>
<thead>
<tr>
<th>Year</th>
<th>Product-based teaching</th>
<th>Classroom-based teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>2007</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>2008</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>2009</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>2010</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>


Education through both PBT and CBT provides opportunities for students to understand IPR. Nowadays, there are many IPR education lectures at NIT colleges. In 2007, INPIT studied when the teachers had begun to study IPR. The results are shown in Table 3. It must be noted that many of the teachers at NIT colleges have no experience of, or license in, IPR education.

**Table 3. Stage at which teachers studied IPR in Japan**

<table>
<thead>
<tr>
<th></th>
<th>High School</th>
<th>NIT</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>At school</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>10%</td>
</tr>
<tr>
<td>Employment in enterprise</td>
<td>15</td>
<td>9</td>
<td>24</td>
<td>20%</td>
</tr>
<tr>
<td>Employment in NIT</td>
<td>31</td>
<td>6</td>
<td>37</td>
<td>32%</td>
</tr>
<tr>
<td>On this Program</td>
<td>32</td>
<td>2</td>
<td>34</td>
<td>30%</td>
</tr>
<tr>
<td>Aftertime</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td>8%</td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>21</td>
<td>115</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: INPIT (2007:23)

There is a further point that needs to be clarified. The IPR curriculum established by INPIT lacks some elements: while it provides an effective means for students to understand IPR legal systems within a short time, it offers no guidance on “creating new ideas.”

**A Case of NIT, Miyakonojo College**

NIT, Miyakonojo College (NITM) is one of a few Japanese higher education institutions having a curriculum in IPR from 1985. They have an IPR class for senior students, attended by approximately 60 students every year.

Teacher guidance policies are apparent, and they are thoroughly helped through the patent law system and how to put out ideas. As an example of the former, they were prepared for the national examination on intellectual property management skills; and as an example of the latter, they were thoroughly trained in the
mind map creation method and the KJ method. Besides, all students are obliged to exhibit in the patent contest organized by the Patent Office.

Remarkably, this class has been conducted by faculty majoring in law. Up to now, three teachers have helped students acquire ten patents in the patent contest. To put it briefly, senior students in NITM need knowledge of IPR rather than manufacturing skills.

The patents obtained by students are by no means sophisticated, and only a few have been commercialized. However, the Japan Patent Office grants licenses to students after recognizing originality. Our students are smart enough that they will be able to acquire patents with minimal effort. The intellectual property faculty of NITM believes that what is necessary for students with basic knowledge of engineering is not further knowledge of engineering but knowledge of intellectual property and the practical aspects of acquiring patents.

Teaching guidance by such law teachers is low in teachers' evaluation from specialized departments. But as N. Luhmann (2012) states, the information initiative lies not on the originator but on the recipient. It is the patent office, not the teacher, who evaluates the students' inventions, and eventually granted patents, recognizing the novelty and creativity of their invention. Although the inventions acquired by students may be peculiar to them, experiencing the process of obtaining licenses helps them to grow as next-generation inventors, to create innovative inventions, and to change the world. Even for Thomas Edison, inventor among inventors, the first invention was "a device that automatically transmits telegrams to get rid of work."

Naming-Blaming-claiming

Such IPR education in NITM can be conceptualized based on a conflict model by Felstiner and others. Discussion by Felstiner and his colleagues focuses on the stage where conflict development does not result in litigation, and discusses factors that cannot be appealed in court. According to that theory, they state the importance of exploring why the legal system does not function effectively in the real world as follows (Felstiner 1980):

But disputes are not things: they are social constructs. Their shapes reflect whatever definition the observer gives to the concept. Moreover, a significant portion of any dispute exists only in the minds of the disputants. These ideas, though certainly not novel, are important because they draw attention to a neglected topic in the sociology of law—the emergence and transformation of disputes—the way in which experiences become grievances, grievances become disputes, and disputes take various shapes, follow particular dispute processing paths, and lead to new forms of understanding. Studying the emergence and transformation of disputes means studying a social process as it occurs. It means studying the conditions under which injuries are perceived
or go unnoticed and how people respond to the experience of injustice and conflict.

Furthermore, Felstiner analyzes the process until these conflicts reach the court as being into three stages.

Chart 1. Naming–blaming–claiming model

<table>
<thead>
<tr>
<th>naming</th>
<th>blaming</th>
<th>claiming</th>
</tr>
</thead>
<tbody>
<tr>
<td>A state where people can perceive infringing acts.</td>
<td>A state where the victim can be conscious of who the victim is suffering for.</td>
<td>A state where people can inform the specified counterparty of the fact of infringement and seek relief against it.</td>
</tr>
</tbody>
</table>

Their assertions that showed that no conflict reached these stages and did not develop into a trial are supported by legal sociologists all over the world. This model is also useful in patent rights, and it is also helpful to show why students’ inventions do not achieve patent acquisition.

Through the concept of Felstiner et al., it becomes clear that there are many ideas buried in the world that are never realized as inventions. What we can actually see is only the idea filed with the Patent Office; and many ideas have disappeared namelessly in this way.

Students have sufficient capability regarding inventions, but they are burying ideas for patent acquisition. It is unfortunate that the small numbers of patent applications by students is seen as a problem of students' ability. If the teacher believes in the student’s potential and if the idea does not lead to patent acquisition, it is thought necessary to discuss the factors according to the stages developed by Felstiner et al.

Chart 2. IPR naming–blaming–claiming model

<table>
<thead>
<tr>
<th>IPR naming</th>
<th>IPR blaming</th>
<th>IPR claiming</th>
</tr>
</thead>
<tbody>
<tr>
<td>A state where you can realize that the idea is worthy of the invention.</td>
<td>A state that can claim to be a patent on what we invented.</td>
<td>A state that claims to be an invention and is able to file a patent application.</td>
</tr>
</tbody>
</table>

Analyzing the reason why students do not file a patent in this way, as a process in three stages, and providing instruction accordingly leads to nurturing engineers who voluntarily create inventions. The case of NITM is that in the student's patent application it is not engineering literacy but IPR competency that has a significant effect. A faculty advising on IPR should instruct the students, paying attention to the question, "why do students file a patent for that idea?"

Conclusions

In Japan, IPR in higher education is currently focused on providing students engineering knowledge through engineering faculty members. Unfortunately, this was not the result of adequate consideration, and was born out of a struggle due to budget reduction from MEXT and the lack of teachers. As shown in this paper, effective IPR education is no longer to give students knowledge of engineering but to enable competencies to develop ideas and to make presentations in contests and the like.

It is only a small attempt of one Japanese school that forms the grounds from this conclusion. As a matter of course, by an environmental difference and a national difference, the conclusion is more likely to change. Perhaps the reader might take this as an opportunity to test the same in each school.

Acknowledgements

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REPORT ON DESIGNING AND BUILDING MANUAL-CONTROLLED ROBOTS
AND SHARING OF THE LECTURE CONTENTS

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Abstract

This paper reports a practical course performed in “Comprehensive Practice” for the third grade mechanical engineering students at National Institute of Technology (NIT, KOSEN), Suzuka College. In the practical course, each team of five to six students in a class builds their small manual-controlled robot over one year. The robots made of aluminium consist of four motors and different kinds of gears. A total of 40 small cardboard boxes are placed at Area-A. The robots compete on how many boxes they can transport from Area-A to Area-B. After discussing their ideas, designing roughly and then in detail with 3D-CAD: SolidWorks, students machine parts and assemble robots with provided materials following the prescribed rules. They cannot move on to the next step unless their ideas and designs are confirmed. The competition is held at the end of the academic year. The results of the competition as well as idea award, design award and technique award are reflected in the grade evaluation. As lectures progress, each team becomes more united and tackle their problems together. We conducted questionnaires for students twice to measure the effectiveness of this course. In the questionnaires, the students evaluated the difficulty of the task on a five point scale. While 3 out of 44 students marked 1 or 5 in the questionnaire and 20 students marked 3 (appropriate). The lecture contents, including the competition rules, a list of provided materials, an example drawing of a gearbox, a lecture schedule, a questionnaire form, a weekly report form, a format of the final report, a grading standard, ballot papers for each award, and a video of the competitions, are released on LMS (Learning Management System, Moodle) to students. In 2015 the lecture contents were released on LMS (Blackboard) which is available to staffs and students in KOSEN. NIT, Kitakyushu College started a practical course under the same rules based on the lecture contents. The paper presents the details of the practical course which has been carried for more than 10 years. The results of questionnaires for students, the lecture contents released on LMS and the results of the competition with Kitakyushu College are also reported.

Keywords: Creative engineering, designing and building robots, teamwork, questionnaires, shearing lecture contents, LMS, joint competition

Introduction

National Institute of Technology (NIT, KOSEN) in Japan is a higher education institute established to cultivate engineers through lecture and practice. In recent years, the number of PBL (Problem/Project Based Learning) and Active learning to encourage the creativity of students is increasing (Kanematsu et. al., 2013; Shibasato et. al., 2012; Yajima, Okumura, Sugaya, Takeichi, & Sato, 2016). Active learning is compatible with a robot education (Niimi, 2016).

A practical course: UNSOYASAN has been carried in “Comprehensive Practice” for the third grade mechanical engineering students at NIT, Suzuka College, since April 2006. The lecture contents are released on LMS (Learning Management System, Moodle) to students. In 2015 the lecture contents were released on LMS (Blackboard) which is available to staffs and students in KOSEN. NIT, Kitakyushu College started a practical course under the same rules based on the lecture contents. The paper presents the details of the practical course which has been carried for more than 10 years. The results of questionnaires for students, the lecture contents released on LMS and the results of the competition with Kitakyushu College are also reported.

Competition rules

In the practical work, each team of five to six students in a class of about 40 students builds their robot. Students are allowed to use a 7.2 V battery for radio control cars and two D batteries for powering their robots. The maximum size and weight of robots is 400 mm × 400 mm and 4 kgf, respectively. There is no height limit.

Figure 1 shows the layout of the game field. The game field is rectangular plane of 2 m × 3 m with borders of 60 mm in height on each side. A robot is placed in the start zone. After starting a game, the robot moves to Area-A where maximum 40 small cardboard
boxes are piled and carries as many boxes as possible within 3 minutes to Area-B which consists of two areas: Area-B1 and Area-B2. There is a barrier of 60 mm in height installed between the field and Area-B2. Thus, teams can score points either by crossing over the 60 mm barrier or by pushing the cardboard boxes to Area-B1 though it takes time. There is a step of 10 mm × 10 mm square rod between Area-B1 and Area-B2. The robot has to cross over the step in order to move from Area-B1 to Area-B2. The score points for Area-B2 is greater than those for Area-B1. Teams obtain a score of 1 point for a box in Area-B1 and 2 points in Area-B2. Thus, the maximum score will be 80 points. The size of the cardboard box is about 103 mm × 94 mm × 38 mm, the weight is 30.6 gf. The way of piling boxes in the Area-A is unrestrained. Teams can use a heavy cardboard box besides the mentioned boxes. The heavy box sizes the same, but weighs 650 gf. Teams obtain a score of 10 points, when the robot carried the heavy box to Area-B1 and 20 points to Area-B2.

Competitions are conducted twice for each team. Teams are ranked in order of their obtained scores. The results of the competitions are reflected in grades. Besides the results of the competitions, idea award, design award and technique award in each team chosen by students are reflected in grades. Students are allowed to buy other materials except too expensive ones.

Provided materials

Students can use two kinds of motors: 7.2V DC motor (RS-540SH manufactured by Mabuchi motor co., 200 gf · cm, 14,000 rpm) and 3V geared motor (worm gear box manufactured by Tamiya inc.). A total of 4 motors are given. Spur gears made of polyacetal (module 1, 16 teeth), Worm gears and worm wheels (reduction ratio 40:1), Miter gears (number of teeth 30, made from polyacetal), Caster wheels (reduction ratio 40:1), Miter gears (number of teeth 30, made from polyacetal), Casters (Wheel diameter φ 25), Bearings (BC6-12ZZ, inner diameter φ 6, outer diameter φ 12, thickness t = 3 mm). Aluminium circular pipes (outer diameter φ 16 and φ 12, aluminium round bars (φ 10 and φ 8), aluminium rectangular rods (cross sectional shape 35 mm × 5 mm), aluminium square pipes (10 mm × 10 mm, t = 1 and 20 mm × 20 mm, t = 1.5), Chamber materials (20 mm × 20 mm, t = 1.5), boards (t = 1), PVC round bars (φ 50, φ 80) are also provided. Screws M3, M4 are available. Students are allowed to buy other materials except too expensive ones.

Lecture contents

Table 1 shows the practical course schedule. Each lecture takes 180 minutes and 28 lectures are held in a year. In the first two weeks of the course, an orientation and a home electronics disassembly practice are conducted. In the orientation, the rules, descriptions of provided materials and the schedule are explained and various robots built in the previous years are also introduced to students by competition videos. In addition to the robots which record high scores and realized stable motion, those score low but have uniqueness, those were unable to achieve their motions as expected, those broke apart during the game, are shown to students through the videos. At the beginning of the course, we warn students that physical phenomena easily betray their expectations. We let them know that they need various ingenuity to realize even a simple idea like lifting a box over to a height of 60 mm with a belt conveyor. Figure 2 shows a class scene of the home electronics disassembly practice. The home

Table 1 Lecture plan

<table>
<thead>
<tr>
<th>No. of lecture</th>
<th>Lecture contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Explanation of the competition, Home electronics disassembly practice in team</td>
</tr>
<tr>
<td>2</td>
<td>Idea and concept development for designing a robot</td>
</tr>
<tr>
<td>3</td>
<td>Idea competition in the team</td>
</tr>
<tr>
<td>4</td>
<td>Practical training</td>
</tr>
<tr>
<td>5</td>
<td>3D CAD</td>
</tr>
<tr>
<td>6</td>
<td>Drawing check</td>
</tr>
<tr>
<td>7</td>
<td>Part drawings of the team robot</td>
</tr>
<tr>
<td>8</td>
<td>Machining of parts</td>
</tr>
<tr>
<td>9</td>
<td>Driving function check</td>
</tr>
<tr>
<td>10</td>
<td>Machining of parts</td>
</tr>
<tr>
<td>11</td>
<td>Assembling and adjusting the team robot</td>
</tr>
<tr>
<td>12</td>
<td>Competition</td>
</tr>
<tr>
<td>13</td>
<td>Report writing</td>
</tr>
</tbody>
</table>
electronics disassembly practice aims at generating students’ interests in the structure and operation principles of various products, developing understanding that a device which even seems simple also consists of many parts and acquiring skills to use tools correctly as well as encouraging good teamwork in group members by carrying out a task together. The home electronics used in the disassembly practice are provided free of charge from our staffs and they are completely disassembled and then recycled or disposed. Reassembling them is not a matter of concern in the disassembly practice. We believe it is important to disassemble them completely. Practical training in operating NC milling machines and five-axis machining centres is conducted in four weeks. The competition is held at the 27th week. The final week of the academic year is scheduled for report writing. Through 20 lectures excluding a total of 8 lectures, students complete their robots from scratch. In the third lecture, each student not as a team submits their idea sheets. In the following week, each student presents their ideas using the submitted idea sheets to their group members to develop a new concept (Idea competition). Each team completes an idea sheet including the members’ ideas and then works on designing a robot. Three lectures are assigned for designing assembly drawings. The team who passed the drawing check is allowed to move on to part drawings. Three lectures are also assigned for the part drawings. The team who passed the drawing check is allowed to machining parts using machine tools including lathe, milling machine, drilling machine.

Figure 3 shows work scenes in the Creation Center. Ten lectures are assigned to works on machining parts, assembling and adjusting robots. The schedule after designing assembly drawings is just a guideline. The drawing checks for assembly and part drawings and the driving function check in the 20th lecture are setted as milestones which also make students recognize the delay of the schedule. Although the competition is scheduled on the 27th lecture, the schedule tends to be delayed and in fact the competition is usually held in the final 28th lecture.

Examples of robots

Samples of robots made by students are shown in Figure 4. Robot-A in Figure 4 (a) is the type of robot which carries boxes piled flatly in a wall shape at one time. Maintaining the whole boxes together requires high manipulating skills. Students practiced adequately for the competition. Robot-B in Figure 4 (b) is the separated type of robot. The robot puts a slope on the barrier of 60 mm at the boundary between the game field and Area-B2 before carrying boxes and then pushes boxes to Area-B2 through the slope. This type of robot scored high. Robot-C in Figure 4 (c) is the common type of robot which stores and carries boxes piled in tower shape. Robot-D in Figure 4 (d) is the type of robot which stores box towers in the same manner of Robot-A and Robot-C. Robot-D has the separated part which supports the box towers behind to prevent from felling. Robot-E in Figure 4 (e) and Robot-F in Figure 4 (f) are characterised by their tires. Robot-E has tires

![Figure 2 Home electronics disassembly practice](image)

![Figure 3 Machining work](image)

![Figure 4 Various types of robot](image)
with slits to cross over the small step with a height of 10 mm and a width of 10 mm between Area-B1 and Area-B2. Robot-F has tires with large slits to step over the barrier of a height of 60 mm between the game field and Area-B2. The important point to cross over the step or the barrier is that the phases of the left and right tires must coincide.

Lecture questionnaire and Discussion

Lecture questionnaires are conducted in the 14th lecture in October and the 28th lecture in February. Two kinds of anonymous questionnaires as listed in Table 2 and Table 3 are performed. In the self-evaluation questionnaire, students evaluate their own attitude towards the practical course by themselves. In the teammate questionnaire, they choose those who are contributing to designing and building their robot in the team. The self-evaluation questionnaire has ten questions. In the questionnaire, students evaluate on a five point scale. The mark 1 means “no”, the mark 3 means “to some extent” and mark 5 means “yes”. Note that it is desirable to evaluate as “to some extent (=3)” in Question 9 which asks the difficulty of the practical course, because when students feel the practical course is too easy (=1) or too hard (=5), they do not actively participate in the practical course. The results of the self-evaluation questionnaire for 3 years from 2015 to 2017 are shown in Table 4. Oct. and Feb. are the class average values, \( \sigma \) is the standard deviation, Average, Min and Max are the average, the minimum value, and the maximum value of each question for three years, respectively. Feb. – Oct. is the increase / decrease value of the average value of the first and the second self-evaluation questionnaire of the same year. Questions 1 to 3 ask students if they actively participate in the practical course. The results of Questions 1 to 3 indicate that students participated most actively in the practical course of the machining parts but less actively in the designing. There is not much difference between the results of Oct. and Feb. This is because only those who are good at 3D CAD tend to be involved in the designing, while in the case of machining parts which require manpower, everyone can equally contribute to work. The results in 2016 and in 2017 for Questions 4 to 5 which explore students’ level of understanding in their robot structures show no significant increase in the average values of Oct. and Feb. Unlike those in 2015, since 2016 we have given tasks for all students to learn 3D CAD skills from the early stage. Thus, even if some students in the team design their robot, all students can contribute to draw parts. This results in discussion the robot structure in the team. The understanding of the robot structure in 2015 has significantly improved to the same level as in 2016 and 2017, through the machining process of robots. The similar trend of a difference by year can be seen also in Questions 6 which asks students their willingness and Questions 7 which asks them the importance of the practical course. The results of questionnaire show that it is important to prevent the development of robots.
learning motivation which has once risen at the stage of giving ideas from decreasing at the stage of designing and drawing. The answers for Questions 9 which asks the difficulty of the practical course marked close to 3 as expected.

Grades are evaluated on a scale of 100 points. The breakdown is as follows. The evaluation of the reports submitted after each lecture is 60%, the evaluation of the final report is 25%, the evaluation of the robot is 5%, and the evaluation according to the contribution of each student is 15%. Question 10 asks students the fairness for the grade evaluation mentioned above. The reports submitted after each lecture are handwritten. The final report has to be typed and electronically submitted. Note that the final report deadline is scheduled after the Questionnaire in February. Students’ evaluations improved up to 4.0 at the end of the academic year in 2015 and in 2016, however it decreased to 3.7 in 2017. No clear reason could be found.

The results of teammate evaluation indicate that some students can machine parts actively even though they are weak at generating ideas and designing. Some scored high marks for Question 4, who are good at scheduling and encouraging their teammate to keep a high level of motivation. Students can choose two people at maximum from their team in the teammate evaluation questionnaire. Naturally, they can choose themselves. Two students who won the most votes in the two questionnaires in October and in February, obtain additional points. It is difficult for teachers to accurately measure the degree of active participation of each student in practical course. In the course, the degree of active participation is evaluated from the reports submitted after each lecture and the final report as well as the results from the teammate evaluation questionnaire. Evaluating by teammates can lead to students’ motivation for the practical course.

Lecture contents

The lecture contents (electronic files) have been released on LMS (Blackboard) to National Institute of Technology (KOSEN) since 2016 as shown in Figure 5. The lecture contents include a) lecture syllabus, b) handouts for students, c) an example drawing, d) an idea sheet, e) Self-evaluation questionnaire and teammate evaluation questionnaire, f) ballot papers for each award, g) the template of the final report (MS-Word), h) videos of the previous competitions, i) the template of the report for the home electronics disassembly practice.

Kitakyushu College has also held the practical subject of “mechanical engineering experiment 1” (second semester, 4th grade students) under the same rules using the shared lecture contents since 2016. The similar practical course is planned to be held in 2018 as well. Although the course period is half of our “Comprehensive Practice”, the number of lectures is the same because the lectures are held twice per week in Kitakyushu College. The practical course in Kitakyushu College targets the fourth grade students, while ours targets the third grade students.

The robots of our college were invited to the competition held on 23rd February 2018. Two robots shown in Figs.4 (a) and (b) which won the first and second place and four students (2 students for each robot) were participated in the competition. The top four out of seven teams of Kitakyushu College qualify for the final tournament. Four teams compete in the final tournament by two teams each. The two teams of Kitakyushu College who won and the two teams of Suzuka College compete in the semi-finals. The robot who won in the competition at the Suzuka College won the first place here as well. Few robots operated perfectly without breaking down during the game because the lecture of Kitakyushu College is the second year of implementation. In contrast, the robots of Suzuka College had held the competition earlier than the competition at Kitakyushu College and manipulators were familiar with the robot operation. This is one of the reasons for the victory of Suzuka College. The fact that students in KOSEN who are geographically apart had an opportunity of exchanging technical ideas through the same competition is a great achievement.

Conclusions

This paper reports the practical course which has been performed in “Comprehensive Practice” in Department of mechanical engineering, National Institute of Technology (NIT, KOSEN), Suzuka College since 2016. The third grade students were divided into eight teams in the practical course. Each team generated ideas, presented the ideas, designed and built a robot, adjusted it and held the competition. We conducted our own questionnaires. The analyzed results of questionnaires for three years were discussed. The paper also presented the lecture contents which have been computerized and released to all KOSEN colleges through LMS. NIT, Kitakyushu College held practical course under the same rules based on the lecture contents. Students in Suzuka College participated in the competition held in Kitakyushu College and exchanged technical ideas.

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