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TEACH BASIC OBJECT-ORIENTED PROGRAMMING TO NOVICE PROGRAMMERS THROUGH SCAFFOLDING IN AN INTERACTIVE ONLINE ENVIRONMENT

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Abstract

Frustration and eventually withdrawal can be one of the outcomes for novice programmers' struggling to grasp an early understanding of programming. High attrition rates for IT related diplomas in higher education institutions (IHLs) in Singapore recently may be due to learning how to program is too difficult. In the School of Informatics & IT, the first year programming subject, object-oriented programming, is offered to different diplomas of students. In this paper, the authors present how to improve the retention rates of students having difficulties in learning programming using novel learning technologies and how to take a tight control on the scaffolding process in the students, and allow them to navigate through many conceptual pitfalls in programming fundamentals. The paper also covers a discussion of applying an interactive online tool of teaching programming in detail and suggests several guidelines that can help the students facing difficulties to grasp a foundational level of programming skills.

Keywords: *fundamental programming, novice students, educational technology*

Introduction

While teaching fundamental programming to novice programmers has improved over the years through a variety of tools and alternatives techniques the level of scaffolding needed especially for students facing difficulties remains an area for consideration. This paper intends to explore the aspect of scaffolding in the context of learning basic object-oriented (OO) programming concepts.

Background

During the last many years there has been a large effort by the academic community to improve the retention of students learning fundamental programming. This has been in response to the many struggles students face in learning programming (Kaczmarczyk, Petrick, East and Herman, 2010). The effort has included the use of programming environments and tools, such as Alice and Scratch, and the adoption of new approaches, such as game-based learning and mobile learning. One of the tools that have become recently popular in teaching introductory programming courses to students is that of MIT's AppInventor (Gestwicki and Ahmad, 2011). Honig (2013) highlighted that students found AppInventor to be an effective tool for them in learning programming.

An approach that has gained traction in the recent years in light of the recent surge of online learning is the use of the flipped or inverted classroom. This was originally made popular through the Khan Academy (Khan Academy, 2014). Lockwood and Esselstein (2013) adopted this approach successfully as a pilot for teaching introductory programming courses.

Another area of rapid innovation has been in the delivery of subject content. While textbooks remain in force in many academic institutions, electronic books or ebooks have begun to gain a slow but firm foothold. Ebooks have been known to provide the potential to enhance active learning through the use of highly interactive content (McConnell, 1996). In addition, ebooks have shown the opportunity to increase student engagement (Wright, 2012).

While these environments and approaches have shown some success the area of scaffolding has not been adequately addressed. Scaffolding is defined as providing timely support for learners during their learning experience to achieve the necessary learning objectives (Wood, Bruner and Ross, 1976). Feden and Vogel (2006) indicate that scaffolding is an approach whereby the learner is assisted within their zone of proximal development. Further, McKenzie (2000) has stated that the goal of scaffolding is to help learners want to learn more.

This is more essential for students especially when facing difficulties learning introductory programming. Further, with today's increasing adoption of online and/or blended learning strategies more attention needs to be spent on the area of scaffolding. One example of scaffolding has been through the use of online feedback system to provide necessary support for students learning programming (Vihavainen, Vikberg, Luukkainen, and Partel, 2013).

Therefore, this paper intends to explore the use e-books in an interactive online environment as a means of providing the necessary scaffolding for novice learners learning introducing programming concepts.

Research Question

Some novice low-attaining students' different understandings of some central concepts in the introduction in fundamental programming and the object-oriented programming are critical from the students' perspective. The authors found that it is possible to establish general guidelines on how to organize the teaching and learning environment using the interactive online tool in such a way that students could get a better understanding of the concepts individually, and thus avoid common misconceptions by developing their own programming skills.

The interactive online environment used by the authors is MyProgrammingLab (2014) by Pearson (E-book by Liang, 2013). With MyProgrammingLab, students may gain first-hand programming experience in an interactive online environment. When students practice programming through the interactive online tool, MyProgrammingLab, it provides immediate personalized feedback. The error messages include both the feedback from the compiler and plain English interpretations of likely causes for the incorrect answer. Students' submissions are also automatically graded by the online tool, both saving our time, and offering students immediate learning opportunities.

Methodology

The methodology adopted for this study centered on a qualitative study. The rationale for choosing a qualitative approach was because our purpose was to study a small group of students who were facing difficulties in learning programming fundamentals and observe their behavior and responses to the scaffolding system provided.

The students were selected using simple random sampling by sampling a small group of students within a single class. The primary instruments used were observations and a semi-structured interview. Observations play a vital role in collecting natural data in a specific setting and are very conducive when studying a small sample. The research team felt this instrument would provide a good way to collect data as the participants used the interactive ebook with scaffolding to direct their learning of the subject content. The semi-structured inverview was chosen because it would allow the research team to probe the experiences of the student with the scaffolding as well as determine if any other factors such as background or prior learning may have influenced their learning of the subject content.

Data Gathering & Analysis

For novice low-attaining students, both informal interviews and the End-Of-Semester Survey were conducted. Given the tentative list of concepts derived from instructors, we began to investigate the question of whether these concepts are experienced by students as difficult ones. We started by addressing the challenging criterion, asking students for concepts they found difficult at first (i.e. places where they were initially facing problems when trying to write programs).

The aim of this deeper investigation was twofold. First, it enabled us to gather evidence as to whether specific concepts met the requirements for further usage to build the mental models. Second, it gave us data for an analysis of novice weak students' understanding of central concepts.

Finally the following concepts in programming learning were chosen to be used: *Selections, Definite and indefinite Loops, Nested Selection, Nested Loops, Array*. Then quiz questions of all the above mentioned topics were selected in the interactive online environment to help students build their programming skills' pools.

Results and Discussion

Through the interviews of all students at the end of using the interactive online environment, the authors identified three key positive perspectives. The first perspective is that the interactive online environment and the scaffolding provided the learners with ease of use. One of the students highlighted that "The MyLab is amazing when it comes to making school easier for me!!!" As such, the tool provided students the ability to not only learn quickly and but their process of learning the subject content that much easier. The second perspective was that the interactive online environment offered a level of engagement to the learners. One of the students highlighted that the tool was a "fun and interactive way to learn." This was in line with previous research that indicated that scaffolding helps learners maintain a high sense of motivation (Steels & Wellens, 2007). The third perspective was that the interactive online environment helped the learners identify where their common weaknesses were, thereby giving them some degree of control of their learning. In the words of one of the students, "it helped me to recognize my weaknesses." This perspective agreed with previous research that highlighted scaffolding helping learners potentially self-regulate their own learning (Shih, Chang, Cheng & Wang, 2005).

In addition, the study also highlighted two important other areas. The first was that students' grades showed some marked improvement after using the interactive online environment. This marked improvement was done through studying the students' grades at key summative assessment points in the subject. The second was that students voiced a great eagerness to use this interactive online environment again. The interview data revealed that students wanted similar systems for their subsequent programming subjects. One of the students said "I wish that there would be more courses with this kind of program."

Therefore the interactive online environment, similar to an e-learning environment, does provide some form of personalized learning for the learners (Davis, 2006). This is evident in how students were able to pace

their learning and focus on areas of weaknesses and make marked improvements.

Limitations

While the initial findings of the study are quite encouraging it is not without its limitations. First, the study focused on a small group of learners. A larger-scale study would be more helpful involving multiple classes of students. Second, the study focused on a particular subject. It would be useful to attempt to use the interactive online environment across multiple related subjects, such as year 1 and year 2 programming subjects. Therefore, the authors will further investigate the impact of the approach in Sep 2014 when the current semester finishes.

Conclusions

The passing and retention rates of novice low-attaining students who are having great difficulties in learning programming has been improved through the proposed novel teaching and learning approach. Taking a tight control on the mental model construction process in the low-attaining students and allowing them to navigate through many conceptual pitfalls in programming fundamentals are proved effective for helping them understand some critical programming concepts better. Applying the interactive online enviornment helps the students facing difficulties to grasp a foundational level of programming skills and gives instructors more room and flexibility in their teaching.

Beside the pedagogical, methodological and technical aids to help teach novice low-attaining students, succeeding with them is all about timing. If instructors are able to catch them and give them all that we can, we will be able to close the gap between what weaker students know and what we teach them. By the time these learners reach higher modules in their respective curriculum, however, they are already so demotivated to learn, they have little or no faith in their ability to succeed or in the teacher's ability to teach them.

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References

Davis, M.T. (2006). Using procedural scaffolding to support online learning experiences. *IEEE*.

Feden, P. & Vogel, R. (2006). Education. New York: McGraw-Hill.

Gestwicki P. & Ahmad, K. (2011). App inventor for Android with studio-based teaching. *Journal of Computer Science*, 27 (1), 55-63.

Honig, W.L. (2013). Teaching and assessing programming fundamentals for non-majors with visual programming. *In Proceedings of the 44th ACM Special Interest Group on Computer Science Education (SIGCSE '13)*. New York: ACM.

Kaczmarczyk, L.C., Petrick, E.R., East, J.P. & Herman, G.L. (2010). Identifying student misconceptions of programming. *In Proceedings of the 41st ACM technical symposium on Computer Science education*, 107-111.

Lockwood, K. & Esselstein, R. (2013). The inverted classroom and the CS curriculum. *In Proceedings of the 44th ACM Special Interest Group on Computer Science Education (SIGCSE '13)*. New York: ACM.

McConnell, J.J. (1996). Active learning and its use in computer science. *In Proceedings of the 1st conference on integrating technology into computer science education*.

McKenzie (2000). Scaffolding for Success. Beyond Technology, Questioning, Research and the Information Literate School Community. Retrieved from http://fno.org/dec99/scaffold.html.

Shih, K-P., Chang, C-Y., Chen, H-C., & Wang S-S. (2005). A self-regulated learning system with scaffolding support for self-regulated e/m-learning. *IEEE*.

Steels, L. & Wellens, P. (2007). Scaffolding language emergence using the autotelic principle. *In Proceedings of the 2007 IEEE Symposium on Artificial Life*.

The Khan Academy (2014). Retrieved June 19, 2014 from http://www.khanacademy.org/.

Vihavainen, A., Vikberg, T., Luukkainen M. & Partel, M. (2013). Scaffolding students' learning using Test My Code. *In Proceedings of the 44th ACM Special Interest Group on Computer Science Education (SIGCSE '13).* New York: ACM.

Wright, A. (2012). Tablets over Textbooks. Communications of the ACM, 55 (3).

Wood, D., Bruner, J.S., & Ross, G (1976). The role of tutoring in problem solving. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, 17(2), 89-100.

Pearson's MyProgrammingLab (2014). Retrieved from http://www.pearsonmylabandmastering.com/northamerica/myprogramminglab/

Y. Daniel Liang (2013). *Introduction to Java Programming, Comprehensive Version, 9/e*, ISBN-13: 9780132936521, Prentice Hall.

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AN EXPLORATIVE STUDY ON STUDENTS' PERCEPTIONS OF GAME MECHANICS BASED ON THEIR PROFILES

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Abstract

While not so long ago, games have always carried with them the negative connotations of addiction and violence, they are currently abuzz with promises of increased motivation and engagement through the "gamification" of non-game contexts. As the trend approaches the peak of the Gartner Hype Cycle, there is an explosion of implementations, embedded in an incomplete understanding of what draws people to games. There is a general inability to differentiate between traditional game mechanics and in-game feedback mechanisms. Gamification is seen as a single tool, rather than a toolbox containing multiple tools (game mechanics). Furthermore, the implementations do not take into consideration possible profiles that might exist in the target audience, which warrants special design considerations to suit these people.

In this study, I take a step back from the implementation and empirical evidence gathering, to look at students' perceptions and views towards individual game mechanics, in search of patterns within student' profiles. A questionnaire is devised to gather students' perceptions, and also to segregate them by their profiles, namely their gaming time, motivation levels, achievement levels, and their self-perceptions of their own popularity amongst their peers. The differences in their preferences between the two groups of students for each profile are then analysed for patterns.

The results of this study suggest that some patterns do exist. For example, higher-achieving students tend to like the Achievements game mechanic more, while lower-achieving students have a preference for the Levels game mechanic, and students with comparatively lower motivation levels tend to not like the Progression and Virality game mechanics. These results can be explained by motivation theories, in conjunction with students' experiences towards mainstream games in general. Based on these results, I recommend ways to implement the game mechanics so as to increase the motivation for students as much as possible. The results also suggest that students do not really like Achievements and Leaderboards, on the contrary to common knowledge, but rather, they are interested in a formative view of where they stand among their peers prior to the release of summative results.

Keywords: *gamification, game mechanics, motivation, digital natives*

Introduction

In the short span of four decades, the digital and video games industry has expanded from literally nothing, to a worth of over US$60 billion worldwide in 2013 (Nayak, 2013), and is on track to hit US$100 billion in 2017 (Brightman, 2014). Gamers of both genders and from a wide range of ages engage in digital games daily over multiple platforms, including Personal Computers (PCs), game consoles, and mobile devices (ESA, 2013). Games are being played for entertainment at home, in the arcades, at the bus-stops, and even while walking on the roads. Today, games transcend gender, age, geography, and have attained ubiquity.

Many people consider and acknowledge that games are fun and engaging, even addictive for some. Indeed, gamers have even died while playing games without stopping for sustenance (Rundle, 2012; Fahey, 2012), or even abandon their paternal instincts altogether (Campbell, 2014). The potential exists that this mind-boggling level of engagement and motivation could be harnessed and applied to other contexts, so as to make those other contexts as desirable as games.

Largely speaking, to merge games with these other contexts, you bring one into the other. The first way is to bring these contexts into games, by developing games from the ground-up using those contexts. These games, which are not developed for entertainment purposes, are termed as 'Serious Games'. Unfortunately, designing and developing games to the standards of commercial games is extremely expensive, and it might not be financially feasible with regards to the desired returns. The second, cheaper way, is to bring games into those other contexts, by bringing the game mechanics thought to draw gamers' attention and motivation into those contexts instead. This alternative method is known as 'Gamification'.

Gamification has been applied to multiple contexts, including business (Luckerson, 2012), advertising

(Chou, 2013), as well as education (Chou, 2013), with varying degrees of success. Education is one of those contexts in which motivation has been a long-standing problem. In addition, games have also been identified as one of the main entities that bring students away from learning, through addiction (Bean, n.d.). If gamification really does work, it could then be used to turn the students' attention back to learning, and increase students' motivation to learn.

Gamification is still a young concept, and although it has generated great interest, its application and research in education has been rather limited in terms of design and depth. It seems the general direction of the research and application of gamification does not differentiate between game mechanics and gameplay mechanics, nor does it differentiate between good games and bad games. Consider the statement by Kumar & Khurana (2012): 'it does not matter if you are a kid, teenager or an old age person; you will always love to play games'.

But we take for granted that all games are enjoyable and desirable, whereas the important questions should be 'what games are successful?', 'for whom?', and 'why?'.

Pelletier (2009) highlighted that one of the problems of game-based learning is that the games were implemented through an understanding of games that does not fully appreciate what goes on inside gamers when they engage in gameplay. The same phenomenon is happening to Gamification.

Another trend that can be seen in the current research landscape is that gamification tends to be seen as a whole and taken as one tool that can be used to improve motivation and engagement. In many researches with empirical data, the authors apply different game mechanics in attempts to explain whether gamification works. Rather, gamification should be seen as a toolbox, with many tools (the game mechanics). Some tools can be used to greater effect in certain situations, and in different combinations for increased effect, while some others might not be as effective in those same situations. Perhaps a better question to ask before we can determine if gamification works is whether a specific set of game mechanics that are applied in a certain context is suitable for that context, and well matched to the target audience.

It certainly makes more sense for us to try and implement a gamified learning activity that tries to improve the motivation of students with comparatively lower motivation levels or lower achievement levels among their peers. If so, how should we go about targeting them? Are there any causal patterns? Are there game mechanics that will help these students? Are there ones that will harm them instead?

I am interested to find out, through research, if there are any patterns and/or relationships that will relate to students with specific profiles, such as students with comparatively lower motivation levels, so that gamification can be tailored to specifically help these particular students in terms of motivation.

Materials and Methods or pedagogy

Although the basis of this study stems from the fundamental assumption in agreement with Constructivism that every student is unique, hence the need for targeted gamification, what I am hoping to find is the possible existence of patterns in their preferences for game mechanics. Therefore, after considering the suitability of different styles of research in education (Cohen et al., 2007), instead of looking at it from an ethnographic and naturalistic perspective, I opt to adopt a more generalist perspective, and conduct the study through the lens of exploration and description.

Without an implementation of gamification for the sample to experience beforehand, they will not be able to give us their feelings towards game mechanics; but if they do experience them through an imperfect implementation, their perceptions might be skewed. This gives us sort of a paradox for the sampling. However, this problem is solved if the sample is well-versed with the various game mechanics, without requiring prior experience in gamification. The course that I am teaching in deals with students who are primarily gamers and have ample gaming experiences, much of which deals with game mechanics. Therefore, these students will be able to give us their perceptions on game mechanics without going through gamification. Purposive cluster sampling can be used in this instance to target this particular group of students for a representation of Polytechnic students in general.

This study will look at students' perceptions on a set of game mechanics. The selection of the game mechanics is based on three factors. The first factor is the general popularity of the mechanics, both in popular games, and in current gamification studies. The second factor is to have good representation of a good representation of different types of game mechanics. The third factor is that the total number of game mechanics should not be too overwhelming, and should be distinctive enough, as they might be confusing to the students, which might lead to inaccuracies in the results of the study.

After cross-referencing the game mechanics listed on multiple gamification websites, such as *Bunchball*, *Gigya*, *BadgeVille*, *ClassDojo*, and *Gamification.org*, as well as considering the level of interest generated in academia, the game mechanics *Avatar/Equipment*, *Quests*, *Levels*, *Combos*, *Progression*, *Auction/Bidding*, *Achievements*, *Leaderboards/Status*, *Virality*, and *Community Collaboration* are considered for use in this study. In totality, there are five game mechanics that deal primarily with feedback mechanisms, three that deal primarily with competition, and two which deal with collaboration. It should be noted that some of the game mechanics are related to each other, and might be implemented together in many cases. For each mechanic, a short description is provided for basic understanding, but care is taken not to give too much detail about the implementation, as, firstly, the sample is well-versed with the game mechanics, and secondly, we

do not want the perceptions to be skewed by ideas of implementations.

As this study is explorative and descriptive in nature, a sufficiently large amount of data is desired. Hence, a questionnaire is selected as the main instrument for the survey. Questionnaires are relatively easy to deploy to large samples, and are sufficient in gathering valuable quantitative data for surfacing any trends or relationships that might exist between the profile of students and game mechanics (Cohen et al., 2007).

The questionnaire is divided into two main portions, 'Profiling' questions, and 'Perceptions and Views' questions.

The first portion attempts to obtain profiling information about the participants, and contains only closed questions. These questions will serve to profile the students based on the attributes I am interested in looking at. The four types of profiles looked at are *Gaming Time*, *Achievement*, *Motivation*, and *Popularity*. There is one question designed to categorize the students for each profile, totalling four questions. For each question, there are four options from which to choose, two of which will categorize students under the 'low' group for that profile, and the other two will categorize the students under the 'high' group.

For a quantitative study, ideally, the options should be quantifiable, such as the values given for the options for the *Gaming Time* profile and the *Achievement* profile. However, it is difficult to assign numerical values to the *Motivation*, and *Popularity* profiles, as they are relative to a social norm, which is subjective and sensitive to context. In addition, I am more interested in finding the relationships based on the students' own perceptions, relative to their own contexts. For illustration, let us use an example from the *Popularity* profile.

Suppose a student feels that within his group of friends, he is rather unpopular. However, as compared to another group of students from another course, from the point of view of a third person, he is actually pretty popular. Now, when we later find out that this student does not like a game mechanic due to his unpopularity, do we benchmark it against his internal understanding of the world, or others' external understanding of the world? From a Constructivist point of view, a person's views, values, and tendencies depends on his own understanding of the world, hence, it is his own view of himself that really matters in what he will feel towards game mechanics. Therefore, in this case, taking the measurement using the students' own world as the benchmark will give a more accurate representation of the results.

The second portion attempts to obtain the students' perceptions and views towards the game mechanics as well as gamification in general, and contains both closed and open questions. The closed questions seek to find out the 'what' of their perceptions and views in a quantitative sense, and the open questions seek to find out the 'why' behind the 'what' in a qualitative sense.

The questions can be divided into three types; questions that seek to gain insights on gamification in general, questions that seek to gain insights on game mechanics, and questions that seek to gain insights on visibility.

In particular, there are two questions on game mechanics. The first question asks students to rate each game mechanic on a numerical scale, so as to find out how they feel towards each game mechanic. The second question asks students to rank the ten game mechanics in order of interest. The problem with the first question is that it will be unable to differentiate between 2 or more game mechanics with the same score, while the problem with the second question is that it will be unable to detect the level of interest towards the game mechanics (for example, even though a student might have ranked all ten game mechanics in order, he/she might hate all of them, while another student might love all of them). Having the two questions together solves the deficiencies of both.

For this study, mean scores will be used to assign values to game mechanics, based on ratings, rankings, and preferences for visibility. The mean score calculation is based on the 'Likert Mean Score' calculation by Galtung (1967), which assigns a value to each option, multiplies that value with the frequency at which that option is selected by participants, and then finally dividing that sum by the total number of participants. According to Galtung, the mean scores provide statistical evidences of degree of skew between items in the questionnaire, and is a reliable form of measurement for attitude. In this study, the calculated scores will serve as a basis of comparison of students' perceptions and preferences towards the game mechanics.

In order to look for patterns in each of the five predetermined profiles, participants' data will be segregated into two groups based on their choices for that profile, and then mean scores will be computed for each group for every game mechanic. The mean scores will then be compared between the two groups, and game mechanics with more significant gaps in the mean scores will be discussed further.

For each profile, three types of mean scores are calculated.

The first type is calculated based on the ratings question. The score has a value range of 1 to 5. This gives an indication of how much students like a particular game mechanic in an absolute sense. A higher score means more students rate the game mechanic highly on average.

The second type is calculated based on the ranking question. The score has a value range of 1 to 10. This gives an indication of how high students rank the game mechanic in relation to the other nine. A higher score means more students favour the game mechanic over the others if they are forced to choose between them.

The third type is calculated based on both questions. As discussed earlier, the purpose of having both the ratings question and the ranking question is to eliminate each other's weaknesses. This third calculation type takes the rating score and multiplies it with the ranking score to have the final score for that game mechanic

before computing the mean score using the final scores. A game mechanic with a rating of 1 (lowest) and ranking of 1 (lowest) will hence have a final score of 1, as compared to a game mechanic with a rating of 1 (lowest) and a ranking of 2 (second lowest) will hence have a final score of 2, which exposes the difference and illustrates the relationship between the results of both questions. On the other hand, the best achievable score is calculated on a game mechanic which has a rating of 5 (highest) and a ranking of 10 (highest) which gives a final score of 50. In general, the third type gives results that are largely similar to that of the first two, but at the same time it is better able to differentiate between the game mechanics, and surfaces differences that were less detectable in the first two types. In this study, I will mainly be using the first and third calculation types to discuss the results.

Results and Discussion

Results show that patterns do exist within the Achievement and Motivation profiles. I will look at these two in detail. Figure 1 shows the gaps in students' preferences based on their Achievement levels:

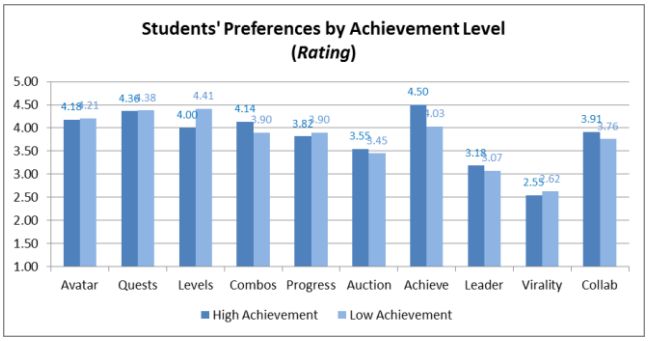

Figure 1: Students' Preferences by Achievement Level (Rating)

Results show two game mechanics of interest. The first one is Levels, which seems to be much preferred by students with lower achievement levels. The second one is Achievements, which shows a distinct increase in interest among students of higher achievement levels, although it is still well-liked by students with lower achievement levels. If we look at both game mechanics through the lens of the Cognitive Evaluation Theory (CET), a subset of the Self-Determination Theory (SDT), both of them, which are feedback mechanisms, should fulfil students' psychological need for competence (Deci, 1975) to the same degree. However, the differences in attitudes towards both mechanics can be explained if we consider the differences between the two game mechanics in the gaming sense.

In games, levels are gradual. A player's character starts from level 1, and the player will complete tasks and quests to gain experience points, which will increase the character's level to 2. Further acquisition of experience points will increase the levels further. All players will gradually become of higher levels as long as they put in the effort. Levels are designed as a feedback mechanism to growth and experience with the game, and scales with effort and hard work.

Achievements, on the other hand, are designed to be relatively more difficult to attain, usually through the completion of more difficult, extensive tasks. In contrast to levels, achievements are meant to mark accomplishments rather than growth, although this stigma of the Achievements game mechanic seems to have been diluted over the years (Lane, 2011), and games have started to include achievements that denote growth and progression. In the case of more competitive gamers, it is usually the achievements that are difficult to attain (e.g. gold achievements) that they hold in high acclaim. These achievements usually require a lot of effort, such as the 'Virtually Impossible' achievement in Metal Gear Solid 2, which requires players to 'complete all VR and Alternative missions', or a high level of skill, such as 'Complete Stealth', which requires players to 'clear the game without entering alert mode'. These achievements are designed as a feedback mechanism to skill and ability, and scales with aptitude.

When this concept is applied to the gamification of education, levels will mean doing the usual work to gain points and level up, while achievements will mean completing the harder, more challenging tasks. The lower-achieving students will like to try these challenges, but it is the high-achieving students who thrive on these challenges.

If we look at achievements through the lens of Maslow's Hierarchy of Needs theory, they might satisfy slightly different needs for each group of students. For the low-achieving students, achievements may help to fulfil their need for self-esteem. By completing tasks and earning achievements, these students would have proven that they too are able to complete some of the tasks set for them. For the high-achieving students, the achievements might actually be satisfying their need for esteem that is closer to that of self-actualization, as they challenge themselves to explore the limits of their full potential. One of the high-achieving students mentioned that he 'likes to challenge myself and solving a hard challenge will give me a boost in my self-esteem and greater confidence in tackling more difficult challenges'.

In comparison, levels would be a more suitable mechanic to satisfy the need for self-esteem in low-achieving students, since they might view achievements as more difficult for them to attain, while in contrast, they can attain high levels more easily simply by completing a larger quantity of tasks. In games, repeatedly completing the same type of tasks for the sole purpose of accumulating points and/or commodities is known as 'grinding'. Games usually offer different paths for players to attain the same commodities in games, but some players prefer to 'grind' for the commodities as, although they are repetitive, they are easier. This might be the same mind-set that exists behind low-achieving students.

Based on these observations, then, perhaps a good gamification design will need to keep both game mechanics present, and in balance.

The Levels game mechanic will need to be implemented to cater to low-achieving students, to provide the basic levels of motivation for them to engage in school work, and to satisfy their need for self-esteem. Since it is expected that these students will engage in grinding to earn experience points to level themselves up, a large number of tasks should be available for them to engage in, and with wide variety, so as to cater to breadth in their learning. The large variety of tasks available for selective completion by students would also give the students a sense of choice, and hence perceived autonomy, which in turn drives intrinsic motivation (Deci & Ryan, 2000). In order to increase depth in learning, the Levels implementation will need to make sure that as the levels reach a certain stage, grinding in lower level tasks will no longer seem viable, hence encouraging the students to engage in tasks of higher difficulty. Most games with the Levels game mechanic already implement this type of system. It is extremely important that when this happens, the students will not perceive the next level of tasks as too difficult, and stop doing it altogether (Csikszentmihalyi, 2008).

At the same time, Achievements will need to be implemented to cater to high-achieving students, to satisfy their need for self-esteem and self-actualization. In these cases, it is recommended to set achievements that will really challenge these students to go beyond what they would normally do in class, so as to stretch their limits, rather than giving them achievements that are tagged to simple tasks, such as 'Completed task 1'. This is important, because tagging achievements to tasks that are too simple might give high-achieving students a feeling of manipulation, which might diminish their sense of autonomy, which in turn lowers intrinsic motivation (Deci et al., 1999). With respect to low-achieving students, one might consider implementing a few achievements that deal not with the quality of work, but with the quantity of work, for them to 'grind'. While high-achieving students may not deem these tasks worthy of their time, the mutual-exclusivity of the achievements attained might bring a good amount of self-esteem to both sides. We have to keep in mind, though, that these achievements require a lot of work, and will not become the goals of students with lower motivation levels.

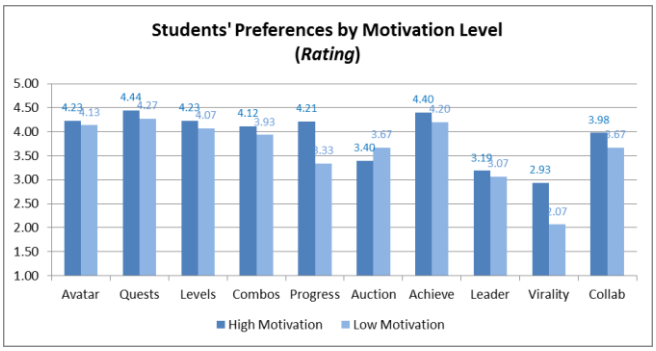

Figure 2: Students' Preferences by Motivation Level (Rating)

Results (Figure 2) show that the low-motivation group seems to have lower interest levels for virtually every single game mechanic, except for Auctions. It also shows two game mechanics with large gaps in interest between the two groups. The first is Progression, which seems to be comparatively disliked by students with lower motivation levels. The second is Virality, which shows a distinct drop in interest among students of lower motivation levels, to the point of negativity.

It is easy to see why lowly-motivated students would not like Progression, as they simply do not want to expend effort to unlock new study materials. If possible, these students would like everything to be given to them without them having to do any work at all. The Progression game mechanic forces the students to do work in order to gain access.

It is also easy to see why lowly-motivated students would not like the Virality game mechanic as well; Virality can be seen as the social version of Progression, which means that it is even more of a hassle than getting themselves to do work. Furthermore, Virality does not only work in the direction from them to their friends, but from their friends towards them as well. For example, a lowly-motivated student might not want to do a task, but when their friends add them to the team through the Virality game mechanic, they might be forced to work with their friends on the tasks because of the value they see in their friendship. Although the students may feel controlled and have a sense of loss of autonomy, they will probably see their friends as the reason to this loss of autonomy rather than the Virality game mechanic. The need for love and belonging will encourage these students to see past the loss of autonomy, and encourage them to work harder instead.

If we look at the ratings of students in the Achievement profile, we see that there is not much difference in the two groups in that profile. This means that we have lowly-motivated students in both high-achieving students and low-achieving students for both game mechanics. There are lazy students on both sides.

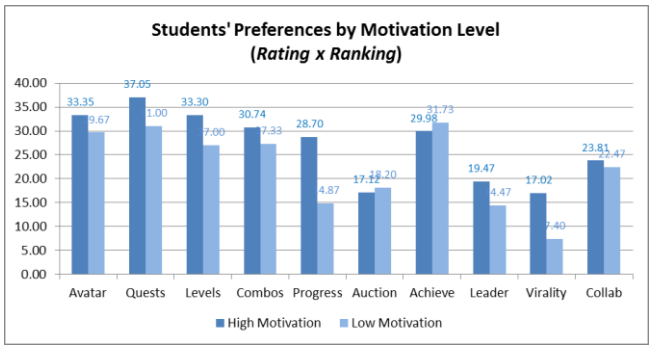

Figure 3: Students' Preferences by Motivation Level (Rating x Ranking)

Results of the third type of chart (Figure 3) largely resonate with the findings of the first type of chart, and simply show the differences in the interest levels more clearly. The only three mechanics with roughly the

same interest levels between the two groups of students in this profile are Auction, Achievement, and Collaboration.

Based on these observations, then, perhaps a good gamification design will be to not steer away from the Progression and Virality game mechanics, but rather, to embrace and emphasize them.

The level of dislike for the two game mechanics by lowly-motivated students strongly hints that these are the two game mechanics that will effectively get them to do work. It is interesting how the students have a gap in interest for the Virality game mechanic, but not so much for the Collaboration game mechanic. That suggests that the students do not mind working with their friends, but don't like to be forced to do so, and probably will not do so by themselves if given a choice. The Viral game mechanic can be implemented to skilfully get highly-motivated students to force lowly-motivated students to engage in collaborative tasks, and put them to work through their need for love and belongingness.

In addition, the third type of chart for the achievement profile suggests that the Virality game mechanic is actually comparatively more favoured among the low-achieving students. Therefore, a good implementation of the Virality game mechanic will also help the low-achieving students. On the other hand, although the high-achieving students really hate Virality, if it is used to get them to help out in Collaboration rather than to impede their own progress and work, then they might not be so negatively affected by it. In the worst case scenario, it is still not that bad, as they are by default, high-achieving in the first place.

If we are going to attempt to get highly-motivated students to start engaging the lowly-motivated students, it has to be a Virality mechanic with a Collaboration component linked to something that the students have a high interest in. Judging by the chart, it seems the students like to engage in Quests. A suitable implementation of these three game mechanics together would be Party Quests. Party quests require players to form parties of multiple players, and collaborate to complete a quest together. Many MMORPGs implement party quests to great results. For example, party quests are one of the main attractions in 'Maple Story'. To further enhance the students' desire to engage in party quests, we can link it with rewards to the next best two game mechanics, Avatar and Levels. For example, we can design the party quests to drop rare equipment with which to decorate their avatars, and deal out large amounts of experience points for completing party quests.

Conclusions

The study was designed to pick up patterns that might exist within students based on their profiles. Although the gaps might not be very significant in some instances, out of the four profiles selected and studied, it was found that patterns indeed exist within two of the profiles: achievement, and motivation.

The results have shown that patterns do exist within students with different profiles, and through the analysis, I have found that what students really want, is not to know who the best is and who the worst is, but rather, what their progress is relative to everyone else. Even if the only thing that gamification is able to achieve is to provide this feedback that they want, I think it will already give increased motivation by default.

A natural next step would be to try out a gamification implementation based on my recommendations, and collect empirical data on its effect on students' motivation towards their studies. If the empirical data is promising, then I would hope that more research of similar nature as this study is conducted, so as to find more information which would guide us in our implementations of gamification. An example would be to find out more about other samples, and another would be to find out more about other game and/or gameplay mechanics. It is also worthwhile to explore if patterns exist for other profiles of students, for example, their comfort levels with using technology for learning.

Further, we must not forget that the fundamental aim of gamification was to improve learning, and the increased motivation is but a means and not an end. Whether, and how, the increased motivation will lead to improved learning, is another big question in itself. Is gamification intended to just to get students to study early and not wait till the last minute? Is gamification intended to increase the breadth of learning? Or is it intended to increase students' depth in understanding? In game-based learning, students are said to achieve deep learning through active cognizing (Doolittle, 1999). More research has to be done to tie this increased motivation in engagement and learning to see how gamification can achieve the desired outcomes in learning. More specifically, we need to know how to tie the game mechanics or even gameplay mechanics to learning activities, so that students will get the most out of them.

References

Bean, S. (n.d.). *"Does My Child Have a Video Game Addiction?" How to Set Limits Around Video Game Use. Empowering Parents.* Retrieved from: http://www.empoweringparents.com/how-to-set-limits-around-video-game-use.php#

Brightman, J. (2014). *Mobile gaming to push industry above $100 billion by 2017. Games Industry International.* Retrieved from http://www.gamesindustry.biz/articles/2014-01-14-mobile-gaming-to-push-industry-above-USD100-billion-by-2017

Campbell, C. (2014). *Gamer Dad Arrested After Toddler Dies of Neglect. Time.* Retrieved from http://time.com/63033/south-korea-gaming-toddler-death/

Chou, Y. (2013). *Top 10 Education Gamification Examples that will Change our Future. Yu-Kai Chou & Gamification.* Retrieved from http://www.yukaichou.com/gamification-examples/top-10-education-gamification-examples/#.U1ISifmSzHU

Chou, Y. (2013). *Top 10 Marketing Gamification Cases You Won't Forget. Yu-Kai Chou & Gamification.* Retrieved from http://www.yukaichou.com/gamification-examples/top-10-marketing-gamification-cases-remember/#.U1IP8_mSzHU

Cohen, L., Manion, L. & Morrison, K. (2007). *Research methods in education*. London New York: Routledge

Csikszentmihalyi, M. (2008). F*low: The psychology of optimal experience*. New York: HarperCollins.

Deci, E.L. (1975). *Intrinsic motivation*. New York: Plenum Publishing Co. Japanese Edition, Tokyo: Seishin Shobo, 1980

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). The undermining effect is a reality after all: Extrinsic rewards, task interest, and self-determination. *Psychological Bulletin*, 125. (pp. 692-700)

Deci, E. L., & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11. (pp. 227-268)

Doolittle, P. (1999). Constructivist pedagogy. Retrieved from: http://web.archive.org/web/20080311211131/http://edpsychserver.ed.vt.edu/workshops/tohe1999/pedagogy.html

Entertainment Software Association. (2013). *Essential Faces about the Computer and Video Game Industry. Entertainment Software Association.* Retrieved from http://www.theesa.com/facts/pdfs/esa_ef_2013.pdf

Fahey, M. (2012). *Gamer Dies in Taipei Internet Cafe, Nine Hours Later Someone Notices. Kotaku.* Retrieved from http://kotaku.com/5881944/gamer-dies-in-taipei-internet-cafe-nine-hours-later-someone-notices

Galtung, J. (1967). *Theory and methods of social research*. New York: Columbia University Press

Lane, R. (2011). *Why Are You Addicted To Achievements? Imagine Games Network.* Retrieved from: http://www.ign.com/articles/2011/10/10/why-are-you-addicted-to-achievements

Luckerson, V. (2012). *Ideas for Business: Let the Gamification Begin. Time.* Available from http://business.time.com/2012/11/14/let-the-gamification-begin/

Kumar, B. & Khurana, P. (2012). Gamification in Education: Learn Computer Programming with Fun. *International Journal of Computers and Distributed Systems*, 2(1)

Nayak, M. (2013). *FACTBOX - A look at the $66 billion video-games industry. Reuters.* Retrieved from http://in.reuters.com/article/2013/06/10/gameshow-e-idINDEE9590DW20130610

Pelletier, C. (2009). Games and learning: What's the connection? *International Journal of Learning & Media*, 1(1)

Rundle, M. (2012). *Taiwanese Gamer Dies After 40-Hour Diablo 3 Session. The Huffington Post.* Retrieved from http://www.huffingtonpost.co.uk/2012/07/18/taiwanese-gamer-dies-diablo-iii_n_1682600.html

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A NEWLY DESIGNED EXPERIENTIAL LEARNING MODEL BASED ON STUDENTS MAJOR PROJECT AND INTERNSHIP CASE STUDIES

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Abstract

This paper describes a new designed experiential learning model by linking up year three students' major project and internship reports with year two and year one teaching case studies. After students complete their major project and internship at first semester of year three, the selected excellent project reports will be examined and revised as teaching case studies. These case studies, after carefully reviewing and revision by lecturers, will be used as part of the teaching materials for year one and year two subjects. In addition, simulation software is used to build vivid three dimensional models for these case studies to provide students with interactive and direct observable effects. With such newly designed model, the latest state-of-art industrial knowledge can be brought into teaching syllabus as case studies in a much timely manner, and students are better prepared to capture the fast changing and latest industrial requirements. Through the experiments of this newly designed model, the initial results showed that it could help students to close the potential gaps between the teaching syllabus and rapid industry development and emerging industrial requirements.

Keywords: *Major Project, Case Studies, Experiential Learning, Industrial Requirements*

Introduction and Background of Experiential Learning

It has been always a challenge for polytechnic educators to teach and equip the students with the latest industrial knowledge and state-of-the-art skills sets. Traditionally the teaching materials and contents are lagging behind of the industrial development due to the delays caused by the processes of conceptualizing, summarizing, transferring, reviewing, approving and finally incorporating before the industrial knowledge and know-hows could be merged into standard teaching syllabus.

In addition, students have difficulties to understand the concepts and theories written on text books due to lacking of industrial experiences and knowledge. The students at this stage normally have little or nil industrial experiences just after completing their study of secondary school. They are unfamiliar to most of the industrial environment because of not having exposure or even observation opportunities of the real world industrial settings.

As one of the foremost thinkers on the subject of experience and education, John Dewey (1938) pointed out that to understand the world learners need to interact with it and experience is the foundation of education.

David Kolb's (1984) experiential learning cycle is the most often cited literature and is shown in Figure 1. Kolb explained that learning is the process whereby knowledge is created through the transformation of experience. The learners are encouraged to apply the knowledge through role plays, problem solving, case studies, evidence-based learning or work experience. Experience and information are not able be converted to knowledge until they are manipulated and changed by individuals through active experimentation, practice, trial and errors, and seeing the results as in Kolb's cycle.

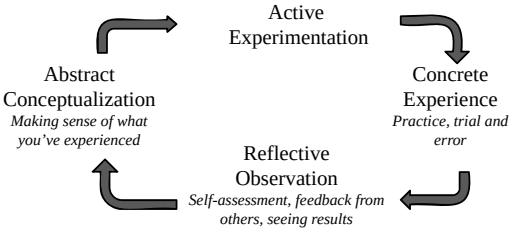

Figure 1. Experiential learning cycle developed from Kolb

Similarly, Boud *et al* (1993) stated that experience is the central consideration of all learning and it cannot be bypassed. Learning can only occur if the experience of the learner is engaged, at least at some level. Downing and Herrington (2013) described the applied learning design principles and examined their effectiveness on enabling students to integrate theory with practice and develop the skills required in their workplace.

Experiential learning has its limitation also. One of the challenges is the indoor learning environments in schools, colleges, universities and training centres. Some data showed that students spend approximately 20,000 hours in classrooms by the time they graduate

(Fraser, 2001). Indoor learning environments are typically referring to "lecture theatres", "classrooms" and "textbooks".

However, contemporary technologies are changing the indoor environments with a profound impact, including e-learning technology, virtual discussion groups, distance education etc. Thus, we believe the experiential learning is increasingly reached out into the broader learning environment of the future "learning space".

Current Situation and Problem Statement

The total length study for BZE (Business Process and Systems Engineering) diploma of Temasek Polytechnic (TP) is three years, and the first two years are full time study at school. Table 1 provides a list of core subjects BZE students need to study during the two years study at school. Year one subjects provide students with fundamental knowledge and skills in business, economics, mathematics, process and systems, quantitative methods, market intelligence and computer programming. Year two subjects are more relevant to process improvement and systems engineering areas with applications in marketing, project management, process optimization, decision analysis, manufacturing and logistics etc. During the first two years, students spend most time to study in class rooms, lecture theatres, computer labs. Occasionally they may have chance to attend industrial visits organized by school with general observation purpose.

Table 1. A list of the core subjects BZE students need to study during year one and year two

Subject code	Subject	Level	Credit Units
EBZ1001	Business Fundamentals	1	5
EBZ1002	Principles of Economics	1	4
ESC1002	Engineering Physics	1	4
EMA1001	Engineering Mathematics 1	1	5
EMA1002	Engineering Mathematics 2	1	4
EPZ1001	Introduction to Processes and Systems	1	4
ESE1006	Computer Programming For Problem Solving	1	4
ESZ1001	Systems Concepts and Tools	1	4
ESZ1002	Quantitative Methods	1	4
EBZ2002	Marketing Intelligence	2	4
EBZ2003	Engineering Economy	2	4
EBZ2005	Marketing Concepts and Strategies	2	4
EBM2004	Project Management	2	4
EQM2001	Process Management and Innovation	2	4
ESZ2001	Decision Analysis	2	4
ESZ2002	Process Optimisation and Improvement	2	4
ESZ2003	Management Systems and Assessment	2	5
ESZ3002	Systems Modelling & Simulation	2	4
EMF3002	Manufacturing Logistics and Simulation	2	4

Students will only start their industrial attachment to companies, so called major project and internship, in their first semester of year three. The major project and internship, as name indicated, is a mixing of internship and final year project. Before the project starts, companies need to work with school lecturers together to define a proper project for students. During about four month's period of time in companies, students need to achieve the objectives they have defined, and of course, if more can be done beyond the expectations.

The purpose of major project and internship is for students to have a better understanding of industrial practices and also apply what they learnt in school to solve real world industrial problems.

However, due to fast moving industrial development and therefore constantly evolving industry requirements, there exist gaps between what students learnt during their first two years study at school and the actual knowledge and skill sets requirements for their major projects and internship.

Many students felt that what they learnt at school are somewhat theoretical and not practical enough when they are trying to apply into their projects in companies, and very often they found that new skill sets are required to get the jobs done which they never learnt at school.

Quite often, companies' supervisors need to spend extra time and efforts in guiding and training the students for new skill sets required but never learnt at school. Such a mismatch leads to unexpected struggling to both students and company supervisors.

In order to overcome such issues, new experiential learning model is imperative to address this problem systematically. This paper describes a newly designed experiential learning model by (1) shortening the replenishment cycle of teaching syllabus; (2) using Simulation for active experiential learning. The details of the model and these two benefits will be described in following two sections.

New Designed Experiential Learning Model – Shortening the Replenishment Cycle of Teaching Syllabus

Currently the year one and year two subjects' teaching syllabus are reviewed every two years or even longer. The teaching team and course management will review the subject review report together with subject teaching team. The inputs of subject review report come from three main sources: (a) On-going classroom student feedback; (b) Student focus group; (c) Teaching team meeting. The concerned areas are subject design, subject delivery, assessment, and students' performance.

Thus, any changes to the teaching syllabus are based more on internal staff reviews and students feedbacks. Another trigger of the changes comes from the releasing of new edition of textbooks. It is not a common practice to take into consideration the feedback from industries into subject review report. The adoption of direct input and feedbacks from industrial requirements into teaching syllabus was not regularly taken place.

Figure 2 illustrates the proposed experiential learning model in terms of shortening the replenishment cycle of teaching syllabus by adopting latest major project and internship requirements from industries. It can be seen that the major projects and internship

reports are reviewed annually, and excellent reports are selected and recommended to be developed into case studies for year one and year two subjects teaching purpose. Therefore, the case studies of year one and year two subjects are possibly refreshed on yearly basis with latest case studies written based on the major project and internship reports.

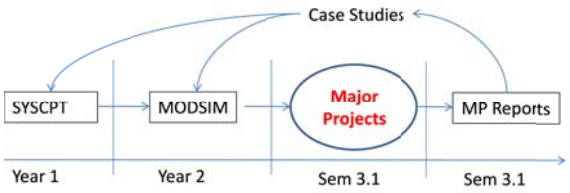

Figure 2. Proposed experiential learning model to bridge the potential gaps

Under the proposed model, after the students have completed their major project in year 3.1, the major project and internship reports are reviewed, examined and refined in year 3.2. Excellent major project and internship reports are selected, revised and tailored carefully into case studies by the same students group with help and assistance from lecturers. These case studies will be recommended to be used for Year 1 and Year 2 subjects teaching to enrich the syllabus with latest industrial development and requirements.

With such an approach, it forms the same year feedback loop of transferring latest industrial knowledge and know-how from industrial applications and requirements to teaching case studies, so that the students in Year 1 and Year 2 stages could access the latest industrial requirements and the opportunities to learn the state-of-the-art skill sets reflected in the case studies.

In addition, because the case studies are based on major project and internship requirements, the context of the case studies are very relevant and with local context. Students felt more interesting to read the case studies on companies they are very familiar with, rather than strange and unfamiliar companies' names from other countries provided from the international text books.

With such newly designed model, the latest state-of-art industrial knowledge can be brought into the teaching syllabus as case studies in a much timely manner, and the students are better prepared to capture the latest trend of industrial requirements.

The model was found very practical and equip the students with the state-of-art skill sets closer to industrial requirements before they embark on major projects and internship at year three. The model is also contributing to the closer collaboration with companies, because the students are trained in advance and prepared well with the required knowledge and skill sets before they are attached to the companies who are expecting the well prepared students with much shortened learning curve. It will make the time spent at companies more effective and the major project and internship more productive. The continuity of the collaboration with companies are further enhanced because the interruption of training the new batch of students are minimized.

New Designed Experiential Learning Model – Using Simulation for Active Experiential Learning

A simulation model can be an excellent learning tool for education, especially for business process and systems engineering domain. For students who are lacking of experience of real business process world, simulations provide an observable effect on the business processes and showing the dynamic changes over time. It is an excellent learning tool to encourage deeper learning, and simulations can be used in lectures and tutorials or for self-study by students, and allow active experimentation with ideas.

Traditionally, it is difficult for students to make their own simulations even with special purpose software, because heavily programming skills are involved. In the past, it is time-consuming to build a simulation model and need extensive testing to ensure the model is correctly built. Traditionally the simulation can be rather slow with slow speed computers and especially over internet.

Since the year 2000, the simulation marketplace has dramatically changed with the new key attribute that modern simulators strive to achieve is known as ease of use (Beaverstock *et al*, 2011). Such dramatic change is the result of the combination of a new level of simulation software and more powerful, less expensive computer hardware.

There are many factors when evaluating the simulation software. Visualization is an important factor for active experiential learning purpose, especially a good three dimensional representation of real world environment. Figure 3 below shows a 3D simulation model for an outpatient eye clinic built by a group of students during their major project and internship period. The simulation model provides students a direct visualization effect for a much better understanding when teaching healthcare operational processes at school with only classroom settings.

Figure 3. Three dimensional visualization and simulation for active experiential learning

Other than visualization, simulation software could provide more interactive and advanced manipulation of the models. Some technical specifications of selecting of simulation software are listed as below:

- Graphical model construction (icon or drag-and-drop)
- Parameters setting up
- Model building using programming
- Input Distribution Fitting
- Output Analysis Support
- Optimization
- Animation
- Export animation(e.g., MPEG version that can run independent of simulation for presentation)
- 3D Animation
- User Friendly
- Learning Curve

For active experiential learning purpose, higher weightages should be given to factors like User Friendliness, 3D Animation, Export Animation and so on. Based on survey results from domain experts, three kinds of simulation software available at school are examined and compared. Figure 4 shows the results from the survey summary indicating that Flexsim is elected as better simulation software especially in terms of user friendliness and 3D animation features.

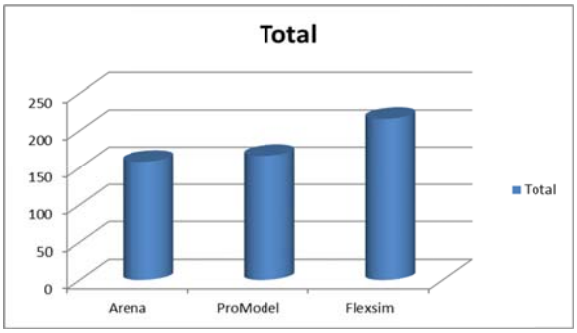

Figure 4. Simulation software comparison study with higher weightage on user friendliness and 3D effects

Experiment of the Proposed Model for Systems Modelling and Simulation Subject

One particular subject taught at Year 2 is Systems Modelling and Simulation, which mainly covers simulation tools for simulation analysis. The subject covers basic modelling skills of queuing model, inventory model and transportation models. The software used for the subject provides example models but mainly for learning the basic skills of modelling rather than problem solving skills.

The subject adopted Flexsim software in 2012, and the subject syllabus was reviewed and examined with the request to look for a proper case study for the subject teaching. In order to provide students a real life scenario, the subject was considered to use a case study based on a major project collaborated with National Library Board of Singapore.

Case Study of Public Libraries of Singapore

The public libraries of Singapore allow patrons to return their borrowed books to any of the 24 libraries, not just the library they borrowed from. Each library has built-in "book drop" chutes which made it easier for users to return books. Behind a book drop chute, an operations room exists where books are sorted. As the book slides onto the book drop, it is recognized by a radio frequency reader that updates the user's account by canceling the loan. The books are then sorted by library staff and put away books belonging to other libraries. For the books to be shelved locally, a computer displays the shelf code encoded in the RFID chip in order to simplify the sorting process. For books belonging to other libraries, current library distribution network requires them to be collected back to a sorting center and consolidated with new materials from Library Supply Center. Figure 5 demonstrates the scenario of returning books and sorting at operations room.

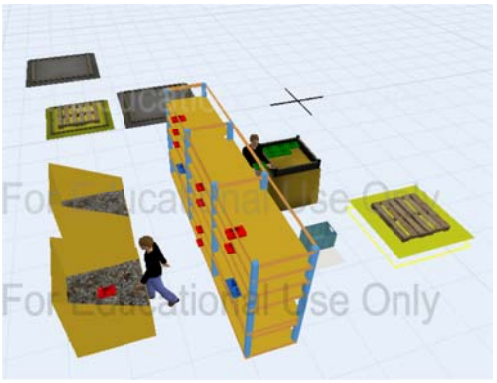

Figure 5. Case study on books returning and sorting process of public libraries of Singapore

Detailed requirements for model construction are described and provided to students for them to build up the model using the simulation software:

"The books will be returned via two 24-hour book drops that are located outside the library. The inter-arrival time for returning books is exponential (0,50,1) seconds. There will be two staff assigned for each book drop. Each of them will be in charge of one of the process lines.

Firstly, the staff will pick up all the books available from the book drops. The staff will only pick up the books when the drop box has accumulated at least 10 books or 10 minutes has elapsed since the last collection, whichever comes first. The maximum number of books that a staff can pick up at one time is 15.

Secondly, in order to identify the books, the staff will need to scan the books at the RFID reader. However, the materials can only be scanned one by one.

The scanning process takes 3 seconds/book on average. 70% of all returned books belong to their own branch.

Thirdly, after the books are scanned, it will be put either onto a shelf or into a wooden bin depending on whether the books belong to this branch or not.

If the books belong to this branch, it will be put onto a 6-level 3-bay shelf. If the materials belong to other branches, it will be put into a wooden bin. (The staff will carry all the scanned books at once instead one by one when they are going to put them into either the shelf or the wooden bin.)

The staff will only go back to collect the books from the book drops when all the previous books have been properly positioned either on the shelf or in the wooden bin."

Students are required to build this simulation model with given information and requirements, so that they could learn the process through the activities of model construction and make it as close as possible to real life operations. Then they need to do experiments with different parameters settings, generate simulation results, conduct results analysis, and make final presentation of their learning reflections.

Observation and Discussions

It was observed that, with such a case study, the students have a much better understanding of the operational processes and it also helped triggering their interests in solving real life problems.

Students provided feedback saying that such a case study using past major project brought their learning to a new level. Students were able to understand the problem described in the case study and especially helpful using the three dimensional simulation model. Through the learning to use the simulation software, students are able to figure out the way of modelling the process, setting up the parameters, defining key performance indicators, conducting experiments with different scenarios, and recommending solutions to improve the process efficiency and productivity.

After study of this case study at year two, a group of students was attached to Singapore National Library Board to do a simulation project on library logistics network and optimization. Because of the knowledge and skills they have already gained from the case study, the students were able to quickly understand the projects requirements and applied the simulation software to build the model. In the end, the project work was so well done that the results of the project were highly commended by the company management and adopted for implementation. In addition to the project success, a conference paper was written by the students based on the project work and accepted by IEEE conference of Industrial Engineering and Engineering Management 2012 (Li, H. *et al*, 2012).

Through the pilot running of our proposed model, the results showed that it could help students to close the potential gaps between the teaching syllabus and rapid industry development and emerging industrial requirements of new skills for our students.

Conclusions

The proposed experiential learning model described in this paper was designed to improve the two aspects of current learning issues of BZE course. Firstly, it helps to shorten the replenishment cycle of teaching case studies for year one and year two subject. Secondly, it applies simulation technics for active experiential learning with user friendly three dimensional animation effects. Students could also build, manipulate, experiment the models with different ideas and generate different scenarios for study and understanding purpose.

Initial positive results show that the students are well prepared before they are attached to companies for major project and internship. The future work is to roll out this model to more subjects which are involving business processes and systems analysis.

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References

Beaverstock, M., Greenwood, A., Lavery, E., Nordgren, W. (2012). *Applied Simulation: Modelling and Analysis using FlexSim*. Flexsim Software Products.

Boud, D., Cohen, R. & Walker, D. (1993). *Using Experience for Learning*. Buckingham: SRHE and Open University Press

Dewey, J. (1938). *Experience and Education*. New York, NY: Kappa Delta Pi.

Downing, J. & Herrington, J. (2013). Design Principles for Applied Learning in Higher Education. In Herrington et al. (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications*. (pp. 874-881).

Fraser, B., (2001). Twenty Thousand Hours: Editor's Introduction, *Learning Environments Research*, 4: 1-5

Kolb, D.A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Li, H., Lin, W., Chan, E., Tang, B., Chia, S., (2012). Optimization of Library Distribution Network of Singapore, *Proceedings of 2012 IEEE 19th International Conference on Industrial Engineering and Engineering Management*. (pp. 484-488)

EXPLORING THE IMPACT OF 3D SIMULATION-BASED LEARNING FOR HIGHLY COMPLEX ENGINEERING SYSTEMS

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Abstract

Simulation is a broad term used to describe any method of replicating real-world tasks, mainly for training or research purposes. In Engineering, this allows alternative exposure to real world tasks that are either difficult to access, too dangerous, or too costly to conduct in the real world. Simulation based learning (SBL) is widely used in industrial training programs and in educational programs to enhance textbook and theoretical learning. This pilot study investigates the impact of using simulations-based learning (SBL) for highly complex engineering systems, such as aerospace engineering, at the polytechnic level. The intervention involved the incorporation of SBL into the Gas Turbine Engine subject in the Aerospace Engineering diploma course in Temasek Polytechnic. Four SBL modules (engine thrust and propulsion, general operations, air inlet and compressors) developed in-house were used in a seven week empirical study. Each week, students have to go through two hours of lectures and two hours of either tutorial or lab which were conducted alternately. This resulted in seven lectures, three laboratory sessions and four tutorial sessions of two hours each in a term of seven weeks. These modules were slotted into the four tutorials. Each module consist of two major parts, the theoretical portion which allows the learner to interact with the simulation, leading to learning and the exploration portion which assesses the learner. Each SBL module took up forty-five minutes of the total tutorial time with the remaining seventy-five minutes was used for normal tutorial discussion and work. Two groups of students having similar academic ability took part in the study. Survey findings and a post-intervention test were used to assess the students' perceptions of their learning and motivation. Our findings showed that students who undertook SBL had higher mean performance scores and that students perceived that the simulations helped them become more competent in the subject, improving their confidence and hence motivation to learn. The data suggests that SBL could potentially enhance student learning for highly complex engineering systems such as those in the aerospace engineering diploma course.

Keywords: s*imulation-based learning, interactive digital media, aerospace engineering training, ICT, Technology enhanced learning*

Introduction

What is a simulation? Generally a simulation closely resembles the physical system while allowing learners to explore situations not possible with actual systems (Tan 2008). They are usually interactive visualisations which allow learners to vary input variables by entering data or by manipulating visual objects to observe the consequences of these changes via numeric displays, text labels and even changes in the visualisation environment. Simulation-based learning (SBL) is widely used in industrial training programs and in educational programs to enhance textbook and theoretical learning. Research suggests that SBL is generally effective in achieving greater knowledge gains (Lane & Tang 2000, Agnew & Shin 1990).

Previous studies by the authors in examining the impact of augmenting the learning process with SBL in lower order engineering tasks such as machining processes in Temasek Polytechnic have shown that it is possible to improve students' written test performance (Tan et al. 2009), skills transfer and training in the workshop (Fang et al. 2011, Tan et al. 2010), learning orientation and motivation (Koh et al. 2010). Polytechnics in Singapore have a strong focus on practice-oriented learning skills, skills training and the preparation of their students for the world of work.

The aim of this study is to build upon the previous research to investigate if SBL could be utilized for more advanced and highly complex subject learning in areas such as aircraft engines and systems that require higher order systemic knowledge. The findings are from a pilot study conducted between October 2013 and January 2014. The simulation objective focusses on both the theoretical and operational knowledge of gas turbine engines (GTE).

Methodology

It is hypothesized that SBL, which provides students with interactive learning experiences, will enhance students' performance through engagement and immersion. In this study, we explore the effect of SBL on students' perceived psychological needs satisfaction, motivation and learning and how it affected students' understanding and application of content knowledge. The simulation modules used were designed to augment teaching and learning.

The intervention involved the incorporation of SBL in the Gas Turbine Engine subject in the Aerospace Engineering diploma course in Temasek Polytechnic. The session selected was in the October 2013 term consisting altogether seven weeks. Each week, students have to go through two hours of lectures and two hours of either tutorial or lab which were conducted alternately. This resulted in seven lectures, three laboratory sessions and four tutorial sessions of two hours each in a term.

Figure 1: Screen captures of the four SBL modules

Four of the SBL modules (shown in Figure 1), namely the engine thrust and propulsion, general operations, air inlet and compressors were slotted into the four tutorials. These modules cover highly complex systems within the Gas Turbine Engine subject. Each module consist of two major parts, the theoretical portion which allows the learner to interact with the simulation, leading to learning and the exploration portion which assesses the learner. Each SBL module took up forty-five minutes of the total tutorial time with the remaining seventy-five minutes was used for normal tutorial discussion and work. 119 students in year two were selected to take part in the pilot experiment. 59 students participated in the intervention group while the remaining 60 were placed in the control group. The 59 students in the experimental group (the group undergoing intervention) took the same number of lesson hours as the control group except that each of their tutorial was shortened by forty-five minutes. The forty-five minutes was replaced by a SBL module.

The year two students were selected from four classes. Analysis of students' performance in terms of their academic scores in year one of their course showed that the experimental and control group were equivalent in terms of their academic ability. A t-test based on the students' mean GPA score showed no significant difference ($p = 0.12$) between the two groups. It was noted that the students taking this course have high GPA scores, averaging about 3.28.

Both groups were taught by the same lecturer except during intervention when SBL was used in the experimental group. The forty-five minute lesson was facilitated by an academic staff familiar with the software that was developed in-house.

A post intervention test was conducted at the end of the four modules and the test scores were compared. Furthermore, a survey was conducted at the end of the four modules to assess the students' perception of their learning.

Instruments

Two instruments were administered, a post intervention written test and a survey. The post intervention test consists of twenty multiple choice questions (two marks each) and one short application question on propulsion and thrust generation of the engine (ten marks). The total score breakdown of the test consists of 32% recall type questions, 32% knowledge based questions and 36% application based questions. The aim of the test was to assess students' understanding and application of what they had learned.

The aim of the survey was to assess students' perception of their motivation and learning orientation. The survey questionnaire was based on self-determination theory. The survey items, corresponding to eleven subscales, were adapted from a number of established instruments that were used and validated by other researchers. For example, to assess students' self-efficacy, three items (e.g. "I can solve most problems in the subject if I put in the necessary effort.") were adapted from the General Self-efficacy scale by Schwarzer and Jerusalem (1995). Likewise, three items on self-regulation (e.g. "When studying the subject materials, I stop once in a while and go over what I have learned.") and three items on metacognition (e.g. "The subject material provided helped me to perform self-assessment before moving on to the next task.") were taken from Pintrinch and De Groot (1990). To assess students' perceived psychological needs satisfaction, one item on autonomy support (e.g. "I am able to freely make use of the subject material provided by my instructor to perform well in the subject") from the Learning Climate Questionnaire (Williams and Deci, 1996), one item on perceived competence (eg. "I feel confident in my ability to learn from the subject material") and one item on relatedness (e.g. "The subject material helps me to interact more often with my classmates") from the Intrinsic Motivation Inventory (IMI, McAuley, Duncan and Tammen, 1989). Two items on intrinsic motivation were adapted from the Academic Self-Regulation Questionnaire (SRQ-A, Ryan and Connell, 1989) for the measurement of intrinsic motivation (e.g. "I enjoyed doing the subject

activities"). Three types of motivational regulations were used to assess extrinsic motivations; one item each on identified regulation (e.g. "I do my work in this subject because I want to understand the subject."), introjected regulation (e.g. "I do my work in the subject because I want the other students to think I'm smart."), external regulation (e.g. "I try to do well in this subject because that's what I'm supposed to do.") and one item on amotivation (eg. "I do my subject material but I don't see the need for it.") were adapted from the SRQ-A and from a modified version of Harter's (1981) scale for the measure of individual differences in motivation (Lepper, Corpus and Iyengar, 2005). Additionally, one item was added to find out if the overall learning experience was fun. A five point Likert type questionnaire was used with a score of 1 indicating "Strongly Agree" to 5 "Strongly Disagree". Hence, in scoring the survey, a lower mean score indicates a better result.

Results

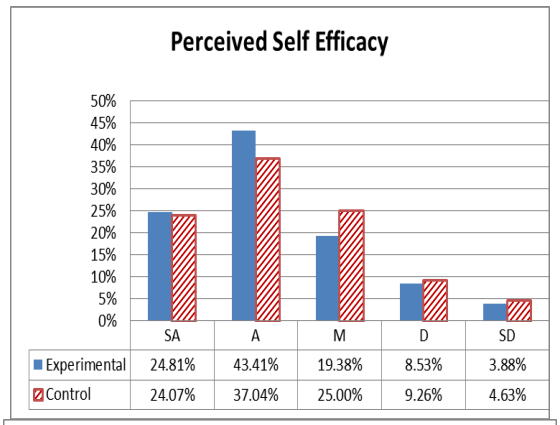
There were 9 absentees from the experimental group and 3 from the control group during the post intervention test. The post intervention test showed that there was a significant difference between the mean test scores of the experimental and control group. The t-test used showed that the scores of the experimental group (M=32.58; SD = 6.376) were significantly higher than those of the Control group (M=30.04; SD=6.086); equal variances assumed (Levene's test, $p > 0.05$); $t(105) = 2.11$; $p < 0.05$ (two-tailed). Cohen's $d = 0.41$, a small effect. Further analysis of the individual components of recall, knowledge and application based questions showed that there was a significant difference between the means scores of the Experimental group (M=11.64, SD=2.671) and Control Group (M=9.97, SD=2.12); equal variances assumed (Levene's test, $p > 0.05$); $t(105) = 3.61$; $p < 0.05$ (two-tailed). Cohen's $d = 0.7$, a medium effect in the knowledge based questions. There was no significant difference between the two groups in the recall and application based questions.

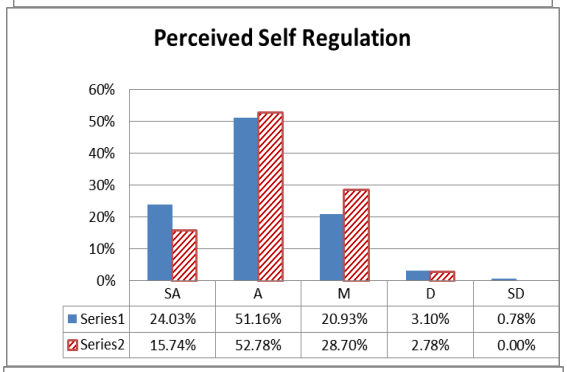
Seventy-nine students took part in the survey (43 from the experimental group and 36 from the control group). Tables 1 to 3 show the survey results distribution for learning, psychological needs satisfaction, motivation and learning experience.

An individual sample t-test analysis of individual sub-scales, equal variances assumed (Levene's test, $p>0.05$) in each area showed that there were significant differences in only two of the subscales :

- Perceived competence. Experimental Group (M = 1.86, SD = 0.71) and Control Group (M = 2.33, SD = 0.80) : $t(77) = -2.796$, $p < 0.05$ (two-tailed). Cohen's $d = 0.63$, a medium effect
- Amotivation. Experimental Group (M = 3.11, SD = 1.16) and Control Group (M = 3.61, SD = 0.90) : $t(77) = -2.085$, $p < 0.05$ (two-tailed). Cohen's $d = 0.47$, a small effect.

Table 1: Survey results on learning





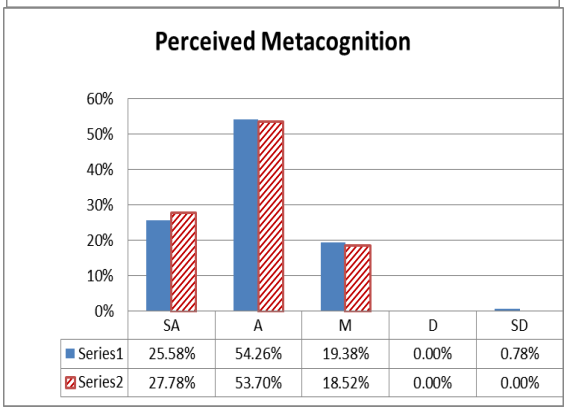
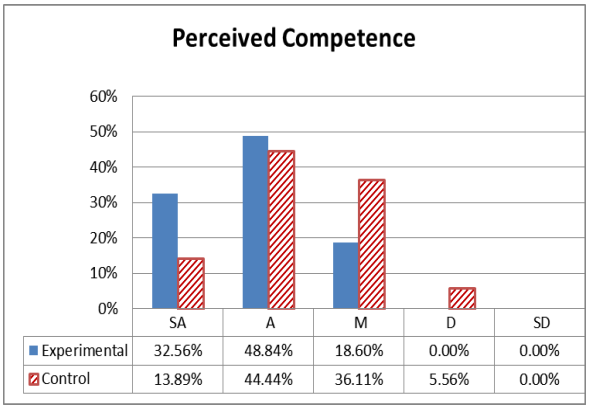
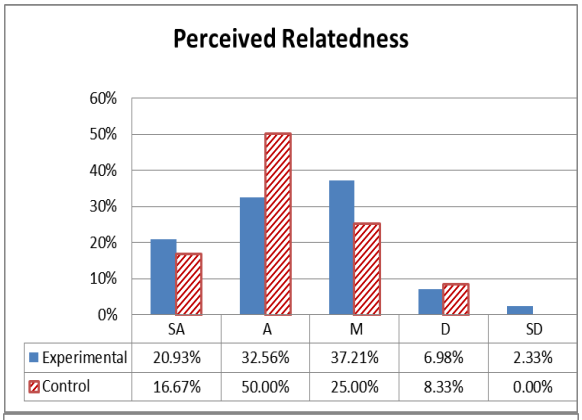


Table 2: Survey results on psychological needs satisfaction





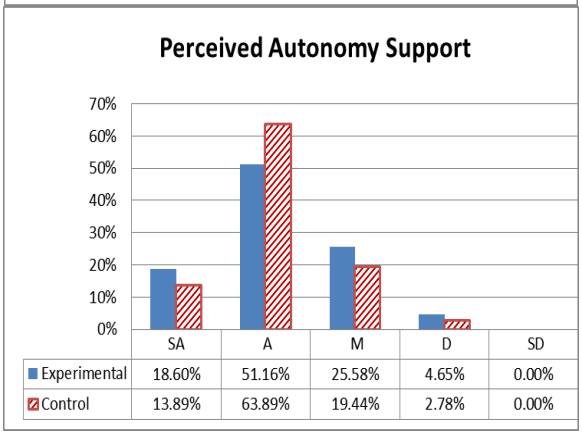
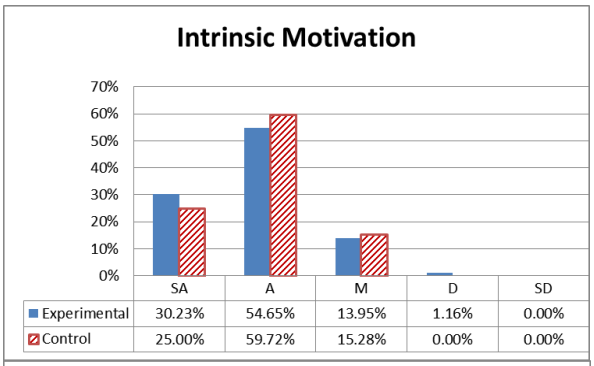
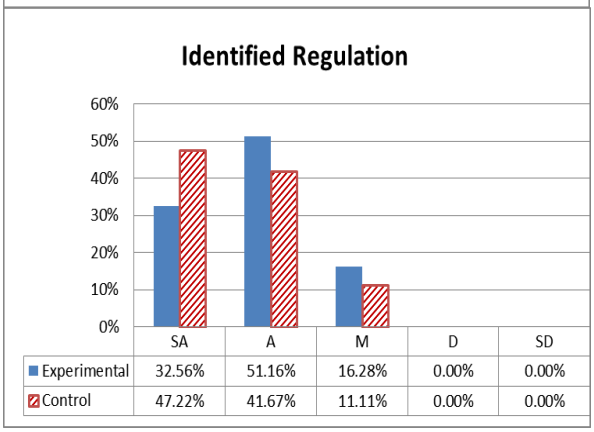
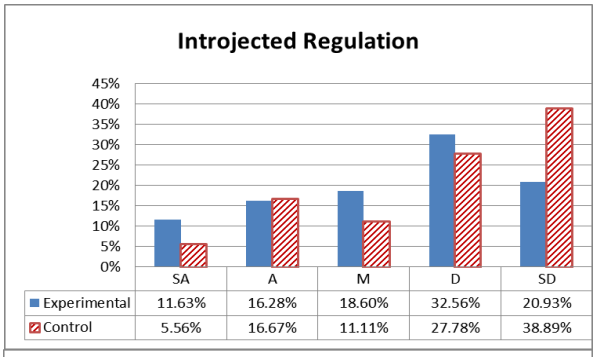
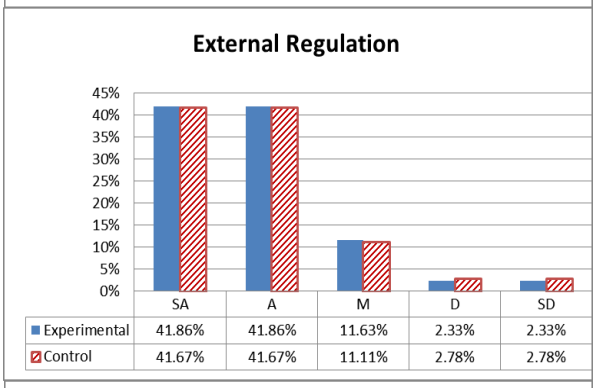


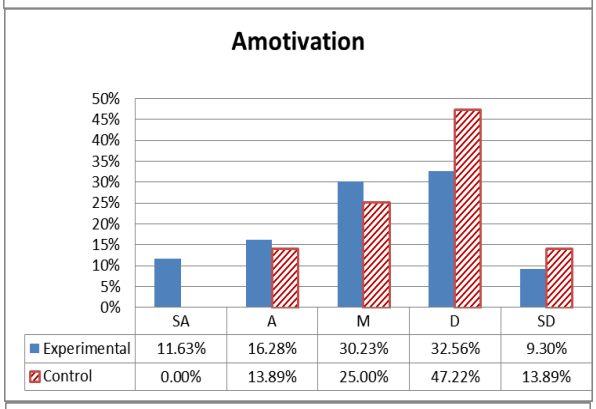
Table 3: Survey results on motivation and learning experience

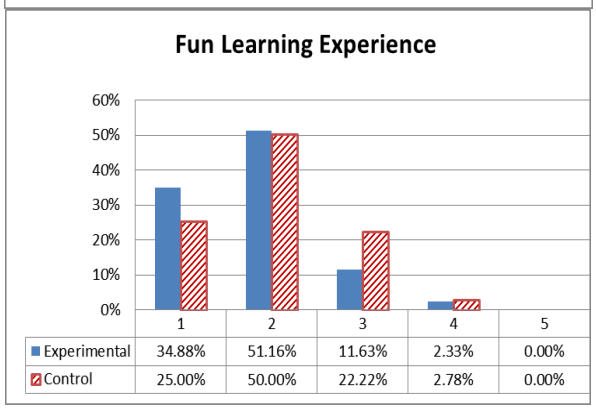












Findings & Conclusions

Our findings in the performance test suggest that the students using SBL performed better in answering knowledge based questions. There was no significant difference in recall or application based questions in the test. One reason could be that the SBL modules developed was designed to help students understand the complex gas turbine engine systems as opposed to helping them in recall or to apply the knowledge in other areas. The "Exploration" portion in the SBL

module pushed the students to use the knowledge within the context of the module content, for example, the various combination of parameters needed to control propulsion for lift off or the action needed to de-ice the air inlet.

Both groups of students perceived that they have high self-efficacy, high self-regulation and metacognition ability. However, whereas the Control Group obtained lower percentage for perceived self-efficacy and self-regulation, they have a slightly higher percentage of scores on metacognition (SA + A = 81.5%) versus the Experimental Group (SA + A = 79.8%). The fact that these students chose aerospace engineering is an indication of their interest. Also, it appears that the course entry level is much higher due to the nature of the course. The high GPA scores from the student sample also seem to indicate that these students have higher academic ability. Hence, there is also no surprise that they perceived their psychological needs to be satisfied with the Control Group experiencing higher satisfaction in autonomy support and relatedness and the experimental in perceived competence. The Experimental Group expressed significantly higher satisfaction in perceived competence (SA + A = 81.4%) than the Control Group (SA + A = 58.3%), possibly due to the fact that they were able to use the SBL modules to scaffold their knowledge. The Experimental Group expressed lower satisfaction in autonomy support because students could have felt imposed to use the software during the lesson. The Experimental Group also had to sit in front of the computer to interact with the SBL modules leading to less satisfaction in relatedness. Perhaps more effort could have been put into collaborative strategies (e.g. recording students' interaction with SBL as discussion points with the group) but these are constrained by the time slots for the experiment.

Both groups obtained high percentage of scores for intrinsic motivation, identified regulation, and external regulation but low scores for introjected regulation. This could be that the two groups of students were highly motivated to do well in the demanding course, most likely for the acquisition of skills and knowledge required for future employment or higher studies. The low scores for introjected regulation could be explained in the Asian context. Students may have used the SBL module because they want their peers to think highly of them but may have chosen to give a more sedate response in the survey.

The low percentage of both the Experimental Group and the Control Group in the amotivation subscale showed that both groups were less amotivated. However, the Experimental Group expressed a significantly higher amotivation levels than the Control Group. According to literature (Vallerand 1997, 2004) one of the reasons for amotivation could arise from a belief that the task is too demanding and requires too much effort. Firstly, the subject taught was a highly complex one. Secondly, the simulation difficulty level could have been pitched too high. It was noted that many students could not complete the complete simulation on the first try. Although the students may have enjoyed using the simulation modules in their learning, they could have found it more troublesome or difficult to learn from, especially when direct solutions could be found from notes. This is also shown by the lower proportion of amotivated response in the Control group.

The authors recognised that there are a number of limitations to the study. Firstly, due to the nature of the subject and annual intake of students, only a small sample size was available. This could have interfered with the research outcomes and obscured the actual impact. Secondly, due to time constraints in administering the survey, the number of items in the subscales was kept to a minimum. Finally, a qualitative study for this project has just started and the findings would provide additional understanding of the impact. Moving forward, the extension of SBL to more modules would increase the sample size and lead to evening out the student distributions.

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References

Agnew, D.M. & Shin, G.G. (1990). Effects of simulation on cognitive achievement in agricultural mechanics. *Journal of Agricultural Education* 31(2), 12-16.

Lane, D.M. & Tang, Z. (2007). Effectiveness of simulation training on transfer of statistical concepts. *Journal of Educational Computing Research*, 22(4), 383-396.

Fang, L., Tan, H.S., Thwin, M.M., Tan, K.C. & Koh, C. (2011). The value simulation-based learning added to machining technology in Singapore. *Educational Media International* 48(2), 127-137.

Harter, S. (1981). A new self-report scale of intrinsic versus extrinsic orientation in the classroom: Motivational and informational components, *Developmental Psychology*, 17, 300-312.

Koh, C., Tan, H. S., Tan, K. C., Fang, L., Fong, F. M., Kan, D., Lye, S. L & Wee, M. L. (2010). Investigating the effect of 3D simulation-based learning on the motivation and performance of engineering students. *Journal of Engineering Education*, 99 (3), 237-251)

Lepper, M. R., Corpus, J. H. & Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the

classroom: Age differences and academic correlates, *Journal of Educational Psychology* , 97(2), 184-196.

McAuley, E., Duncan, T. E., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, 60, 48-58.

Pintrinch, P. R. & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82(1), 33-40.

Ryan, R. M., & Connel, J. P. 1989. Perceived locus of causality and internalization: Examining reasons for acting in two domains. Journal of Personality and Social Psychology 57: 749-761.

Schwartzer, R. & Jerusalem, M. (1995). Generalized self-efficacy scale. In J. Weinman, S. Wright & M. Johnston (Eds). *Measures in health psychology: A user's portfolio. Causal and control belief* (pp. 35-37). Windsor, UK: NFER-Nelson.

Tan, H.S. (2008). Learning and motivational aspects of using interactive digital media (IDM). In P. Towndrow, C. Koh & H.S. Tan (Eds). *Motivation and Practice for the Classroom* (pp. 315-340). Rotterdam: Sense Publishers.

Tan, H.S., Tan K.C., Fang, L., Wee M.L. & Koh, C. (2009). Using simulations to enhance learning and motivation in machining technology. In S.C. Kong et al (Eds). *Proceedings of the 17th International Conference on Computers in Education* (pp. 864-871). Hong Kong: Asia-Pacific Society for Computers in Education.

Tan, H. S., Koh, C., Fang, L., Tan, K. C. & Wee, M. L. (2010). A model for simulation-based learning. International *Conference on Learning and Teaching 2010*, Temasek Polytechnic, Singapore.

Vallerand, R. J. (1997). Toward a hierarchical model of intrinsic and extrinsic motivation. In M.P. Zanna (Eds.) *Advances in experimental social psychology* (pp. 271-360). San Diego: Academic Press.

Vallerand, R. J. (2004). Intrinsic and extrinsic motivation in sport. *Encyclopaedia of applied psychology*, 2, 427-435.

Williams, G. C. & Deci, E. L. (1996). Internalization of bio-psychosocial values by medical students: A test of self-determination theory. *Journal of Personality and Social Psychology*, 70, 767-779.

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THE 21ST CENTURY LEARNER AT PFP@TP

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Abstract

Commencing in April 2013, students who have performed very well in the Singapore-Cambridge GCE N-level Examinations can opt for a one-year Polytechnic Foundation Programme (PFP) at Temasek Polytechnic. The PFP is a one-year programme which offers a practice-oriented curriculum to better prepare polytechnic-bound N(A) students for entry into one of the relevant polytechnic diploma courses.

All Foundation Programme students who enrol in one of the diploma courses in Temasek Polytechnic will go through a programme that is specially designed to lay a strong foundation in Language and Mathematics and give students a foretaste of their chosen diploma courses. Classes are conducted in small sizes of 20 to 25 students. PFP students are also engaged in a range of activities, which aim to develop them holistically.

This presentation focuses on the design and integration of the entire PFP curriculum and how they aim to equip students with the necessary knowledge and skills that would prepare them for the 21st century. In today's dynamic and fast-changing world, students need to learn independently, think critically and reflectively, communicate effectively and work collaboratively, in order to thrive in this globalised world we live in.

The PFP curriculum is designed with MOE's Framework for 21st Century Competencies in mind, with particular emphasis on the emerging competencies, and Student Outcomes. Interactive pedagogy such as collaborative learning and the use of technologies are adopted to facilitate the learning outcomes.

Students' works from the relevant modules will be displayed as a showcase of the 21st Century Competencies.

Keywords: *21st Century Competencies, Polytechnic Foundation Programme, interactive pedagogy, instructional strategies, curriculum design*

Introduction

The Polytechnic Foundation Programme (PFP) is one of the progression pathways introduced by the Ministry of Education in 2010 targeted at Secondary 4 Normal (Academic) students who aspire to continue their post-secondary education in a polytechnic. It is an alternative pathway to the Sec 5 year. Provisional places in the chosen diploma programmes are provided to the PFP students on a condition that they pass all the modules in the one-year PFP. Students who have performed very well in the GCE Normal Academic (NA) examinations namely the top 10% of the Secondary 4N(A) cohort, will have the option of completing the one-year PFP, instead of taking the GCE 'O' level examinations in Secondary 5.

Based on Ministry of Education (MOE) recommended PFP curriculum structure, as shown in Table 1, English Language & Communication and Mathematics are subjects that form the core part of the curriculum. Domain cluster modules consist of subjects from chosen diploma courses, which give students a foretaste of the diploma course. Lastly, PFP students are also expected to have 150 hours of PE/Sports/Wellness/CCA and Life Skills/General Education/National Education lessons.

Subjects/Modules	Total Number of Hours
English Language & Communication	210
Mathematics	180
Domain Cluster Modules	270
Life Skills/General Education/National Education	90
PE/Sports/Wellness/CCA	60
Total	810

Table 1. PFP Curriculum Structure.
Source: http://www.polytechnic.edu.sg/pfp/curriculum.html

PFP@TP

Unique to Temasek Polytechnic, the Centre for Foundation Studies and its team was set up in 2011 primarily to look into the curricula design, development and implementation of the Polytechnic Foundation Programme, and other foundational modules in the institution. Alongside, a steering committee was established to look into the academic and administrative issues of the PFP and a curriculum advisory team of institutional representatives comprising of lecturers and professionals from different disciplines, namely: engineering, applied science, business, design and information technology was set up to provide consultation and advice on curriculum.

In view of the recommend PFP curriculum structure recommended by MOE and to provide the fundamental knowledge and skills relevant to future diploma work, the curriculum advisory team proposed a PFP course structure which comprises of both TP Core (Common Modules) as well as School Core (Domain Cluster) subjects.

TP Core subjects, namely, Language and Communication (L&C), Research and Reasoning (R&R), Mathematics and Logical Thinking (M&L), Personal Development and Effectiveness (PDE) and Fitness and Wellness (F&W) are aligned with MOE's recommendation and students enrolled in the respective schools courses will take Domain Cluster subjects offered by the Schools respectively. The table below (Table 2) is an example of the PFP course structure for a student enrolled in any course offered by School of Applied Science.

Table 2. An example of PFP@TP course structure

Semester	Subjects	Type	CU	Hours
1.1	Language & Communication 1	Core	4	60
	Research & Reasoning 1	Core	3	45
	Mathematics & Logical Thinking 1	Core	6	90
	Personal Development & Effectiveness 1	Core	3	45
	Fitness & Wellness 1	Core	2	30
	Living Chemistry 1	Core	4	60
	Living Biology 1	Core	4	60
	Semester 1		**26**	**390**
1.2	Language & Communication 2	Core	4	60
	Research & Reasoning 2	Core	3	45
	Mathematics & Logical Thinking 2	Core	6	90
	Personal Development & Effectiveness 2	Core	3	45
	Fitness & Wellness 2	Core	2	30
	Living Chemistry 2	Core	6	90
	Living Biology 2	Core	4	60
	Semester 2		**28**	**420**
	Year total		**54**	**810**

In addition, PFP@TP's curriculum is also designed with MOE's Framework for 21st Century Competencies in mind. The following section provides a short overview of the framework.

With consideration of the learning environment and technological support, appropriate pedagogical model/approach and instructional strategies are then devised to support the aims and learning outcomes.

21st Century Competencies

Due to globalisation and rapid technological development, the numeracy, language and technical competencies which are the key skills set in the industrial era are no longer adequate to meet the ever-changing economical and societal demands of the 21st century. Silva (2008) emphasizes that the focus of 21st century essential skills is on what students can do with the knowledge that they acquire. Donna Harris, co-founder of D.C tech start-up incubator 1776, draws to our attention that "those who excel in the new economy are the ones who test new ideas with peers fluidly across the world" (Pennington, 2013). Over the past decade, the need for acquisition of these skills set has brought about the conceptualization of various 21st century skills theoretical frameworks by different countries and international organisations.

Reinforced by Dede (2010), the focus of education towards 21st century learning should shift to developing "complex communication" and "expert thinking" competencies supported by good foundation knowledge of the routine and procedural skills.

As shown in Figure 1, MOE's framework for 21st Century Competencies and Student Outcomes comprises of 2 broad categories of Competencies, namely, Social and Emotional Competencies and emerging 21st Century Competencies.

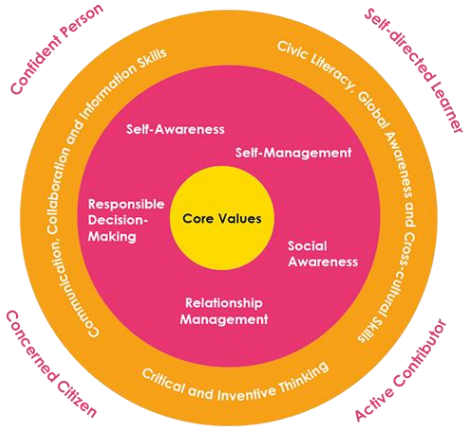

Figure 1. MOE's Framework for 21st Century Competencies and Student Outcomes
Source: http://www.moe.gov.sg/education/21cc/

The rest of the paper will discuss how the PFP@TP has integrated the 21st century competencies across its curriculum with particular emphasis on the emerging 21st Century Competencies.

Design of PFP@TP curriculum

After an analysis of a few 21st century skills implementation frameworks, Voogt & Roblin (2010) reported that for one to acquire the 21st century skills, 'pedagogic techniques, such as problem-based learning, cooperative learning, experiential learning and

formative assessment' could be incorporated into the curriculum.

Additionally, the team also note that the use of technology could enhance student learning and complement the finesse of 21st century skills.

Hence, when designing the curriculum, the team researched and adapted McTighe and Seif (2010) implementation framework's indicators to identify what student should experience to help them to develop 21st century skills. To align MOE's Framework for 21st Century Competencies and Student Outcome, the team has identified 4 instructional recommendations from McTighe and Seif (2010) implementation framework and incorporated to the instructions of certain subjects.

1. *Strategies/activities that actively engage students;*
   In the development of the Mathematics & Logical Thinking subjects started with focus on the core concepts, proficiency skills and how 21st century skills can be integrated in the process of teaching and learning. The conceptual understanding and proficiency is essential to lay a strong foundation for subsequent learning of more advanced mathematics modules when they progress to their diploma years. Guiding the development team forward in the integration of the 21st century skills are the learning experiences they hope to provide for the students, be it in the classroom or online.
   In the classroom, students are exposed to authentic problem situations which help them to see relevance of what they learn. Through working in teams with tutor facilitation, students learn how to sieve out information from a given problem, establish connections with the information and what the question ask for, work out a plausible solution and subsequently, presenting their methodology and solution to the class. Through the process of problem solving, students are given opportunities to share and build knowledge with other members, communicate their ideas effectively and reason and analyse logically.

2. *Explicit application of 21st century skills using authentic context;*
   The social and emotional aspects of the 21st Century Competencies are highly emphasized in the Personal Development and Effectiveness modules. Students gain first-hand experience through transferring their theoretical knowledge of project management to planning for a project for a fund-raising event for the campus. In the process of planning and working on a proposal, they learn to manage working relationship with their peers, negotiate ideas, make decisions and reach a consensus within their team. Towards the end of a term, every team will be expected to present their idea in the proposal which will be subjected to critique and evaluation by the class and tutor. The presentation and persuasion of idea proves to be a valuable and exciting experience for all, in which there is a constructive exchange of critiques, concerns and ideas between the team and the rest of the class. Culminating, the chosen idea is implemented for the fund raising event in the subsequent semester. In the span of two semesters, all PFP@TP students would have the opportunity to experience a culture of a different country and heighten their social awareness through a series of learning journey.

3. *Opportunities to self-manage and self-direct learning;*
   The 2 newly set-up free access computer laboratories and the affordance of Information and Communication Technology (ICT) has extended the teaching and learning spaces beyond the classroom. Capitalising on eLearning platform, students learn concepts and skills on their own through the use of digital video, animation and interactive flash activities, as shown in Figure 2. Course materials and supplementary resources are available online for students to access at their own free time. Designated Off Campus Learning Weeks at every semester are meant for students to access their lessons online anywhere without a face to face contact with the lecturers. To prepare students' readiness and sustain their interest for self-direction in learning online, lesson packages are designed with achievable learning outcomes, manageable concepts and skills which are authentic. In the process of independent learning, students develop personal responsibility whilst learning to manage the limited amount of time, available resources and tasks.

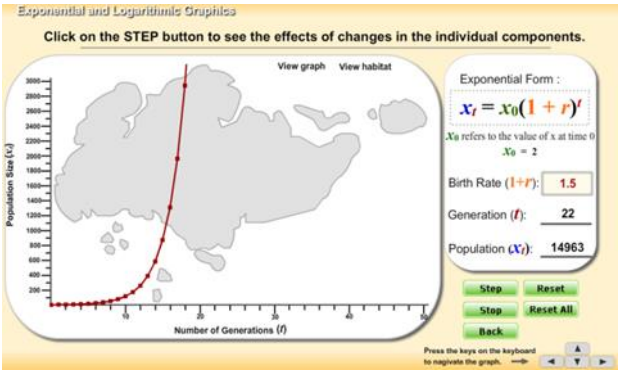

Figure 2. A screenshot of an interactive Mathematics & Logical Thinking activity which illustrates the concept of exponential growth through modelling of population.

4. *Establishment of learning environment culture and climate:*

The classrooms, termed learning spaces, for PFP@TP students were specially designed to facilitate the students' learning. The furniture was primarily selected and arranged in a circular cluster to maximise students' communication and exchange of ideas with one another. Walls around the learning spaces are writable to allow students to pen down their ideas.

Subjects like Research & Reasoning which aims to facilitate the students' search and use of information to support their learning and sharpen their reasoning skills, thus giving them confidence in using that information to make decisions in the research process, mainly requires students to work collaboratively in groups. The design of this subject also aims to support the students in acquiring the emerging 21st Century Competencies of 'Critical and Inventive Thinking' and 'Communication, Collaboration and Information skills' (MOE).

In groups, students are required to complete a project as lecturers facilitate their research inquiry process by questioning and students are expected to articulate their reasoning. This would require students to contribute actively and think critically.

Conclusion

As the pioneer batch of PFP@TP has since progressed to the Year 1 of their respective course, a detailed study to capture the academic performance and holistic development in order to determine the effectiveness of the preparedness they received through PFP@TP and the acquisition of the emerging 21st Century Competencies, is in the pipeline .

References

Dede, C. (2010). Comparing Frameworks for 21st Century Skills. In J. Bellanca & R. Brandt, Eds, 21st Century Skills, pp. 51-76. Bloomington, IN: Solution Tree Press.

McTighe, J. & Seif, E. (2010). An implementation framework to support 21st century skills. In 21st century skills: Rethinking how students learn, Bellance, J. & Brandt, R. (eds.), pp. 149-172

Pennington, M. (2013). *Millennials Seek 21st Century Careers with 20th Century Skills*. Retrieved from http://www.forbes.com/sites/maurapennington/2013/10/22/millennials-seek-21st-century-careers-with-20th-century-skills/

Silva, E. (2008). *Measuring skills for the 21st Century*. Education Sector Reports.

Singapore Ministry of Education. (2010). *MOE to Enhance Learning of 21st Century Competencies and Strengthen Art, Music and Physical Education.* Press release retrieved from http://www.moe.gov.sg/media/press/2010/03/moe-to-enhance-learning-of-21s.php.

Singapore Ministry of Education. *21st Century Competencies.* Retrieved from http://www.moe.gov.sg/education/21cc/.

Voogt, J. & Roblin, N. (2010). *21st Century Skills*. Discussion paper retrieved from http://opite.pbworks.com/w/file/fetch/61995295/White%20Paper%2021stCS_Final_ENG_def2.pdf.

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MOTIVATING STUDENTS TO DEVELOP CUSTOMISED SYSTEMS FOR MEDICAL INDUSTRY THROUGH COLLABORATIVE INDUSTRIAL RESEARCH

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Abstract

This paper provides an insight on the recent bioengineering techniques developed by the students of Temasek Polytechnic in the 'School of Engineering' under the 'Diploma in Biomedical Informatics and Engineering'. Ultraviolet rays have been widely used in providing antimicrobial environment in hospitals and also in certain sterilization procedures related to water treatment. With a collaborative research with National Kidney foundation NKF Singapore, the students undertaking the major project in their final year had the opportunity to investigate the design of an ultraviolet sterilization unit to work in conjunction with a fluid dispenser for dispensing fluids in measured quantities. The most important part of this study was focused on the qualitative assessment of the antimicrobial effects at various parts of the dispenser and also the variations of the antimicrobial effects at various depths of the fluid contained in the dispenser. The students under my supervision and also the industry came out with a protocol to study the efficiency of the system to have a real picture of the antimicrobial effects of ultraviolet radiation at various depths. The project provided holistic development to my students as they had to manage the engineering design work for biological application with guidance from industry on the safety issues in design. Though our project students had no background on microbiology and industrial standards at the beginning of the project, they were provided with the relevant knowledge by the industry and were also assisted by effective teaching and learning methods. The project students were encouraged to have knowledge-sharing sessions between the group members so that each project member can share their understanding with their project mates. The project was successfully completed and installed in NKF for use by the BME department.

Keywords: *Industrial attachment, Collaborative research, Antimicrobial effects, Fluid dispenser, Biological applications.*

Introduction

Purification and sterilization of water is considered important for all biological applications. Some of the conventional methods referred in practice are as briefly discussed. Filtration of the water is considered very important before any sterilization procedures and a wide variety of filters are available for filtration of water. Filters remove sand, clay and other matter as well as organisms by means of a small pore size. Filtration and sterilization is achieved by passing water usually through iodine exchange resins. In this method, when negatively charged contaminants contact the iodine resin, iodine is instantly released and kills the microorganisms without large quantities of iodine being in the solution. Boiling water is considered the most reliable and often the cheapest. Ideally, boiling the water for 5 minutes is considered safe in killing the microorganisms (Anthony T.Spinks, R.H. Dunstan, T. Harrison, P. Coombes, G. Kuczera 2006). Alternatively, sterilization using chlorine and silver-based tablets can destroy most bacteria when used correctly, but these are less effective for viruses and cysts. In recent years, the ultraviolet (UV) sterilization is gaining popularity as a reliable sterilization method and is environmental-friendly too (Yagi, N. Mori, M. Hamamoto, A. Nakano, M. Akutagawa, M. Tachibana, S. Takahashi, A. Ikehara, T. Kinouchi, Y. 2007). UV disinfection technology is of growing interest in the water industry since it was demonstrated that UV radiation is very effective against certain pathogenic micro-organisms of importance for the safety of drinking water (W.A.M. Hijnen, E.F. Beerendonk, G.J. Medema 2005). In most of the sterilization equipment, the light source is a low-pressure mercury lamp emitting UV in the wave-length of 253.7 nm and this source is referred to as UVC (Mirei Mori, Akiko Hamamoto, Akira Takahashi, Masayuki Nakano, Noriko Wakikawa, Satoko Tachibana, Toshitaka Ikehara, Yutaka Nakaya, Masatake Akutagawa, Yohsuke Kinouchi 2007).Ultraviolet rays have been a known mutagen at the cellular level and it is used in a variety of applications, such as food, air and water purification (Janoschek, R., G. C. Moulin 1994).

Materials and Methods

Transmission of pathogens through drinking water is a well-known problem, which affects highly industrialized countries and also countries with low hygienic standards. Chlorination of drinking water was introduced to the water supply in the beginning of the 19th century in order to stop the spreading of pathogens. Disinfection of drinking water with chlorine has undoubtedly contributed to the reduction of typhoid fever mortality in many countries. Despite the worldwide use of chlorine for disinfection of drinking water, other safe methods of disinfection have gained popularity (Schoenen .D 2002).Ultraviolet disinfection technology is of growing interest in the water industry ever since it was found very effective against common pathogenic micro- organisms in water (W.A.M. Hijnen, E.F. Beerendonk, G.J. Medema 2005). Ultraviolet disinfection systems are commonly incorporated into drinking water production facilities be-cause of their broad-spectrum antimicrobial capabilities, and the minimal disinfection by-product formation that generally accompanies their use (Isaac W. Waita, Cliff T. Johnstonb, Ernest R. Blatchley2007). UVC rays are very widely used in sterilization procedures in hospital and clinics. UVC light (100-280 nm) has been reported to be very effective (Anne F. Booth1999) in decontamination of hospital-related surfaces, such as unpainted/painted aluminium bed railings, stainless steel operating tables, and scrubs laboratory coats (Rastogi VK, Wallace L, Smith LS. 2007). It has been reported that UVC lighting is an alternative to laminar airflow in the operating room and that it may be an effective way for lowering the number of environmental bacteria. It is also believed that this method can possibly lower the infection rates by killing the bacteria in the environment rather than simply reducing the number at the operative site (Merrill A. Ritter, Emily M. Olberding, Robert A. Malinzak 2007). As infections represent a major problem in dialysis treatment, dialyzing rooms need to be kept antibacterial to the extent possible. It has been reported that 15-watt UVC lamps installed for every 13.5m² on the ceiling for the purpose of the room disinfection used for 16 hours nightly after working hours provide an antimicrobial environment even in areas which were not directly exposed to the UVC radiations (Inamoto H, Ino Y, Jinnouchi M, Sata K, Wada T, Inamoto N, Osawa A 1979).

Ultraviolet Sterilization for Clinical Applications

Filtered water free from microorganisms and chemicals disinfectants is an absolute requirement for the preparation of solutions for certain biological applications in medicine. The process of reverse osmosis is an invaluable technology to provide filtered water free from pathogens. Since water filtered through the process of reverse osmosis is free from chemical disinfectants, it serves as the ideal solvent for the preparation of biochemical solutions used in biological applications. This paper will discuss briefly the various parts of the ultraviolet sterilization system developed for providing the solvent required for preparation of biochemical solutions used in biological applications through collaborative research with National Kidney foundation NKF Singapore.

Architecture of the System

The architecture of the system essentially consists of ultraviolet radiation chamber, a stainless steel fluid dispensing chamber, embedded adjustable profile, fluid inlet and outlet system and a microcontroller module (Kang,T.T., Ravichandran, S., Isa, S. F. B., Kamarozaman, N. K. B., Kumar, S. 2009). The block diagram of the architecture is shown in figure.1

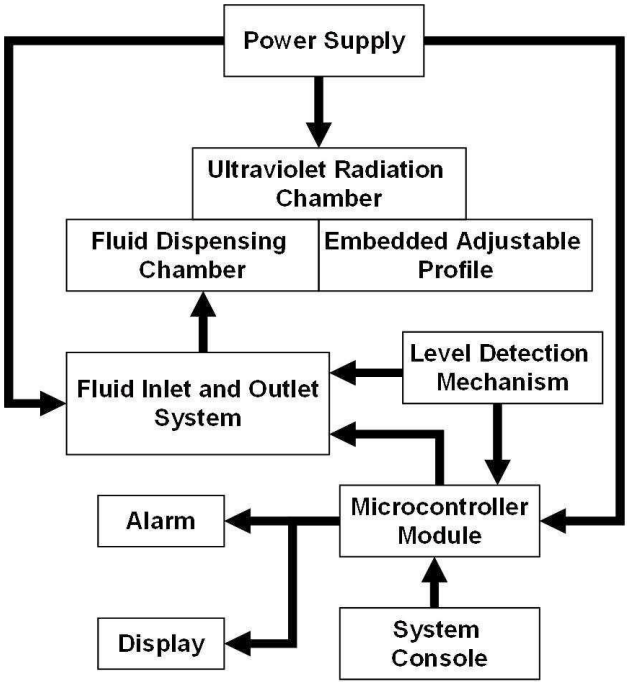

Figure. 1 Block Diagram of the Architecture

Ultraviolet Radiation Chamber: In order to provide an antimicrobial environment in the chamber, an ultraviolet radiation chamber was built. The ultraviolet radiation chamber has two ultraviolet lamps installed to provide maximal sterilization throughout the whole fluid dispensing chamber (Ravichandran, S., Begum, N., Siti, N., Then, T. K., Siti, F., Da, G. W. J., & Choon, O. W. 2010).

Fluid Dispensing Chamber: The material used for building the chamber has to be a medically approved material for biological applications. Medical grade stainless steel and food-grade polyethylene often meet the requirements. In our preliminary studies, we have made use of medical grade stainless steel sheet to build the fluid dispensing chamber (Kang, T. T., Ravichandran, S., Isa, S. F. B., Kamarozaman, N. K. B., Kumar, S. 2009).

Fluid Inlet and Outlet System: The system is installed with two solenoid pinch valves that control the filling and dispensing of the fluid into and also out of

the fluid dispensing chamber. Volume of the fluid is measured precisely by the level detection mechanism. A microcontroller module interfaces a level detection sensor to control the fluid inlet and outlet system (Kang, T. T., Ravichandran, S., Isa, S. F. B., Kamarozaman, N. K. B., Kumar, S. 2009).

Microcontroller Module: The architecture is built around PIC18F4520 microcontroller containing five ports. The ports are configured to support some of the modules such as display interface, keyboard interface, activation of the pinch valves and the level detection mechanism. The implementation of the microcontroller allows integration of the different sub modules of the system (Kang, T. T., Ravichandran, S., Isa, S. F. B., Kamarozaman, N. K. B., Kumar, S. 2009).

Filter modules for Dispensing Chamber: We developed the facility to introduce filters to find the suitability so that maximum transmission is assured during the sterilization procedure. The filters also provide a covering to the fluid containing tank and prevent foreign contaminants from entering the tank during usage. Our current design has been developed to accommodate filter modules which can be inserted for studies and this has given the scope to also access the net ultraviolet effects in the presence of filters.

Qualitative studies on Ultraviolet Irradiation

The object of this study was to qualitatively evaluate the antimicrobial effects of the UV radiation. In order to assess the effects, we have constructed the adjustable profile capable of holding the sealed Petri dishes at various positions in the fluid dispensing chamber. The sealed Petri dishes within the chamber contain the required environment for bacterial growth. In our studies, we have used Lysogenic broth (LB) agar for the bacteria to multiply and we have conducted studies using this medium extensively. With the help of this set- up, it was possible to conduct studies on the bacterial colonies after exposure to UV radiations at various positions inside the fluid dispensing chamber. Studies were conducted for various exposure durations to assess the antimicrobial effects of UV radiations on the bacterial colonies positioned at various levels of the fluid dispensing chamber.

Result and Discussion

Preliminary studies of ultraviolet radiations had clearly demonstrated the effects of ultraviolet on the bacterial colonies at various depths within the fluid dispensing chamber. These studies have provided a clear picture on the effects of the ultraviolet rays of a known intensity and its capability to provide an antimicrobial environment deep inside the fluid dispensing chamber. The Petri dish maintained within the fluid dispensing chamber at different levels shows the absence of bacterial growth in the agar medium after exposure. Thus the system architecture developed was found effective in containing the contamination in the fluid dispensing chamber

Conclusions

The students who were involved in the projects had no preliminary knowledge about sterilization procedures, in medical industries as it was not taught as a subject during their course of study. The students were provided with the necessary information and training to build up their competencies for executing the projects only during their project research in their final year. The project students were encouraged to have knowledge- sharing sessions between the group members so that each project member can share their understanding with their project mates. The project students also worked closely with their industrial consultants and supervisor to complete the project and successfully installed in NKF for use by the BME department. The students also presented and published their work in International conferences before graduation.

References

Anne F. Booth (1999) Sterilization of Medical Devices. Interpharm Press, Inc, Buffalo Grove, IL60089, USA.

Anthony T.Spinks, R.H. Dunstan, T. Harrison, P. Coombes, G. Kuczera (2006) Thermal inactivation of water-borne pathogenic and indicator bacteria at sub-boiling temperatures.DOI 10.1016/j.watres.2006.01.032

Inamoto H, Ino Y, Jinnouchi M, Sata K, Wada T, Inamoto N, Osawa A (1979) Dialyzing room disinfection with ultra-violet irradiation. J Dial. 1979; 3(2-3):191-205. PMID: 41859.

Isaac W. Waita, Cliff T. Johnstonb, Ernest R. Blatchley IIIc (2007) The influence of oxidation-reduction potential and water treatment processes on quartz lamp sleeve fouling in ultraviolet disinfection reactors. DOI 10.1016/j.watres. 2007.02.057.

Janoschek, R., G. C. Moulin (1994) Ultraviolet Disinfection on Biotechnology: Myth vs. Practice. BioPharm (Jan./Feb.), pp24- 31.

Kang, T. T., Ravichandran, S., Isa, S. F. B., Kamarozaman, N. K. B., Kumar, S. (2009). Qualitative Studies on the Development of Ultraviolet Sterilization System for Biological Applications. 13th International Conference on Biomedical Engineering (pp. 280-283).

Merrill A. Ritter, Emily M. Olberding, Robert A. Malinzak (2007) Ultraviolet Lighting during Orthopaedic Surgery and the Rate of Infection. The Journal of Bone and Joint Surgery (American). 2007; 89:1935-1940. DOI 10.2106/JBJS.F.01037.

Mirei Mori, Akiko Hamamoto, Akira Takahashi, Masayuki Nakano, Noriko Wakikawa, Satoko Tachibana, Toshitaka Ikehara, Yutaka Nakaya, Masatake Akutagawa, Yohsuke Kinouchi (2007) Development of a new water sterilization device with a 365 nm UV-LED. DOI 10.1007/s11517-007-0263-1

Rastogi VK, Wallace L, Smith LS. (2007) Disinfection of Acinetobacter baumannii-contaminated surfaces relevant to medical treatment facilities with ultraviolet C light. Mil Med. 2007 Nov; 172(11):1166-9. PMID: 18062390

Ravichandran, S., Begum, N., Siti, N., Then, T. K., Siti, F., Da, G. W. J., & Choon, O. W. (2010). Optimizing Filters for Ultraviolet Sterilization System Used in Biological Applications. 6th World Congress of Biomechanics (WCB 2010) (pp. 1401- 1404).

Schoenen .D (2002) Role of disinfection in suppressing the spread of pathogens with drinking water: possibilities and limitations. DOI 10.1016/S0043-1354(02)00076-3

W.A.M. Hijnen, E.F. Beerendonk, G.J. Medema (2005) Inactivation credit of UV radiation for viruses, bacteria and protozoan (oo) cysts in water: A review. DOI10.1016/j.watres.2005.10.030

Yagi, N. Mori, M. Hamamoto, A. Nakano, M. Akutagawa, M. Tachibana, S. Takahashi, A. Ikehara, T. Kinouchi, Y. (2007) Sterilization Using 365nm UV-LED, Proceeding of 29th Annual International Conference of IEEE/ EMBS, 2007, pp 5841-5844 DOI 10.1109/IEMBS.2007.4353676

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USING SOCIAL MEDIA FOR TEACHING, LEARNING AND COLLABORATING

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Abstract

The proliferation of social media technologies has provided educators with exciting strategies to engage students in their learning. Social media tools have also equipped students with the required skill sets to freely express themselves digitally and experience new ways of collaborating, socializing, engaging, sharing and networking with others via the ever-changing Internet landscape. This paper discusses the initiative undertaken by the author to interactively weave social media technologies into the curriculum of a cross-disciplinary module offered by the School of Informatics & IT at Temasek Polytechnic, Singapore. It also highlights the interactive, flexible and stimulating teaching and learning approach using Facebook, Twitter and Wikis to educate and engage students in their learning.

Keywords: Social media; Education, Engage, Facebook, Twitter, Wikis.

Introduction

The widespread use of the Internet and other digital technologies today has brought about the proliferation of social networks (eg *Facebook, Twitter, Instagram, WeChat, Snapchat*). This has led to the creation of virtual communities which not only serve as a means for socialising, but also as a tool for expressing and communicating ideas and discussions which brings about creative knowledge construction in a collaborative way (Lisboa & Coutinho, 2011). Despite widespread usage of social media by students and increased usage by instructors, there seem to be a lack of empirical evidence relating to the impact of social media use on student learning and engagement (Junco, Heiberger & Loken, 2011). This paper discusses the author's initiative to interactively weave social media technologies into the curriculum of a cross-disciplinary module called "Effective Internet Research (EIR)" offered by the School of Informatics & IT at Temasek Polytechnic, Singapore.

Social media in Education

Social media consists of Internet websites, services, and applications which support social networking, community building and collaborative learning and sharing. As noted by various researchers, the current proliferation of social media technologies has sparked the interest of faculty members in higher education institutions to find new ways of engaging and inspiring students toward becoming active learners. These faculty members, especially those inclined toward using newer technology in education, have integrated various social media tools (including blogs, micro blogs, video-sharing sites and social networking) into the teaching and learning process. Social networking sites such as *Facebook* and *Twitter* seem to constitute a major component of the social media activity and form an integral part of college students' lives. Researchers have noted that educators are more willing to integrate *Facebook* and *Twitter* as part of the learning process. This can be seen from research by the Higher Education Research Institute (HERI, 2007) which reported that 94% of first year college students use social networking websites. Another survey by Mastrodicasa and Kepic (2005) showed that 85% of students at a large research university have *Facebook* accounts. While *Facebook* is a very popular social networking site for American college students, *Twitter* is fast gaining popularity to be part of the learning process as it blends both blogging and social networking functions (Junco, Heiberger & Loken, 2011).

Social Media in Education: *Twitter*

Junco, Heiberger and Loken (2011) conducted a semester-long experimental study to determine the impact of using *Twitter* in education on college student engagement and grades. The outcome of their study revealed that the experimental group had a significantly greater increase in engagement than the control group, as well as higher semester grade point averages. As part of their study, the researchers analyzed samples of students' *Twitter* communications which revealed that students and faculty members were both highly engaged in the learning process in ways which transcended traditional classroom activities. This study gives the experimental evidence that *Twitter* can be used as an educational tool to add value to students by engaging them and mobilizing the faculty members to take on a more active and participative role in the learning process (Junco, Heiberger and Loken, 2011).

Social Media in Education: *Facebook*

The proliferation of *Facebook* use among students and teachers has brought about a new learning culture by creating innovative ways for teachers to facilitate and engage learners to participate actively in a variety of learning activities. Shraim (2014) conducted a study on the use of *Facebook* by faculty members to implement a social constructivist approach to facilitate student-centred learning amongst university students. The results showed that, *Facebook*, with its technological capability, played an invaluable role in facilitating the constructivist approach in the study. It revealed that a majority of the students in the study demonstrated a positive attitude towards learning via *Facebook*. This was because *Facebook* had given more opportunities for these students to engage personally, communicate and work collaboratively. *Facebook* had also allowed the students to construct their own learning and develop relevant life skills of learning through social interaction which are useful for living in today's highly inter-connected and technologically-oriented society (Shraim, 2014).

Social Media in Education: Wikis

Wiki (WikiWiki or Super-fast in Hawaiian), is a simple and user-editable data storage tool for gathering thoughts based on themes per page. These themes can be developed to include links to relevant references within the same page and to other websites. This open editing capability makes Wikis useful for multiple users to collaborate on a single document or work in an environment with continual updating of information. The simple and flexible nature of Wikis has increased its popularity and use in diverse fields such as documentation, reporting, project management, online glossaries and dictionaries, discussion groups and information systems. The ability of Wikis to facilitate collaborative finding, creating and sharing of knowledge, the delivery of rapid feedback on ongoing collaborative writing experiences, and improved teamwork and communication amongst users has attracted the attention of educators and teachers to integrate Wikis into the teaching and learning process (Klobas, 2006; Parker & Chao, 2007; Tonkin, 2005).

Using Social Media for Teaching, Learning and Collaborating: Case Study of Module "Effective Internet Research"

The social aspects of social media technologies including the ease of communication, co-ordination and online expression of personal identities have often attracted young people (Crook & Harrison, 2008). This observation is supported by the author's experience in teaching a cross disciplinary module titled "Effective Internet Research (EIR)" using selected social media tools to a batch of 48 youths aged 17-20 years old at the School of Informatics and IT, Temasek Polytechnic. EIR is an introductory course to the basic use of Internet as a research tool. The youths who chose to enroll in the EIR module were from different disciplines across the various Schools at Temasek Polytechnic, namely, design, engineering and information technology.

The author describes how integrating social media technologies into the curriculum of EIR has been instrumental in developing the students' cognitive ability and confidence in acquiring new methods of enquiry and new forms of literacy, allowing them to effectively and conveniently navigate the new knowledge space. The author documented her observation on how social media technologies has equipped her students with new skill sets necessary to effectively express themselves digitally and unravel a new learning experience of discovering new opportunities to learn, collaborate, socialize, engage and network with similar minds in cyberspace. This new learning experience goes beyond what students can experience through traditional methods of face-to-face classroom learning via lectures, tutorials and practicals. She also noted student feedback that these traditional teaching methods were passive, inflexible and lacked the opportunity to engage and provide them with a stimulating and independent learning environment.

In response to student feedback on the traditional teaching methods, the author implemented a more flexible and engaging teaching and learning strategy by incorporating social media technologies into the EIR subject curriculum. Selected social media technologies such as *Facebook*, *Twitter*, *Tumblr* and *Wikis* were incorporated into the curriculum along with e-lectures and face-to-face in-class activities such as oral presentations, role-playing, group discussions and evaluation of websites that the students relate to, all of which helped to add more vigour and fun to the subject curriculum.

At the end of the module, an online subject feedback was conducted to gather student feedback (quantitative and qualitative) on the effectiveness of the subject delivery and teaching methods based on the new flexible and engaging learning strategy which incorporated social media technologies. This survey also aimed to find out if the selected social media technologies have been effective in making the learning of EIR interesting and meaningful for students.

The sections below describe the author's teaching and students' learning experiences using social media technologies namely *Facebook*, *Twitter*, *Tumblr and Wiki*. *Facebook* and *Twitter* were used to encourage the EIR students to network and develop rapport amongst themselves and with the EIR tutors/subject leader. *Facebook* was also used as an interactive platform for students to share information about themselves and engage in tutorial discussions on Internet-related topics. The fostering of good rapport within the EIR subject community through social media has helped students to learn in a more supportive and less threatening environment resulting in higher motivation for students to participate in the activities

and do well in the subject. Some students continued to stay connected via the social media platforms with one another and with the tutor/subject leader even after the end of the EIR subject. *Twitter and Tumbler* were used for students to conduct peer feedback during the final presentations. *Wikis* were used to support students' collaborative work.

To a large extent, the module EIR has integrated the vital elements of education and entertainment which gave students the freedom to enjoy learning using social media technologies while simultaneously achieving the general and specific learning outcomes of EIR. This approach has proven to be successful in providing a convenient learning environment to support the dynamic learning needs of today's youths who represent our student population.

Social Media Application : Socialising, Sharing and Networking using *Facebook*

Working in small groups of 4-5 students, each group had to choose a research topic mainly related to current social, community and youth-related issues such as celebrity worship syndrome, youth crimes, human trafficking, computer and internet addiction, youth depression, educational deprivation, mobile culture, poverty and social gaming. In addition to achieving the academic objective of the module EIR, the research activity is also aimed at getting the students to think, reflect and discuss the implications of these issues on the community in general and in their own lives. Students had to set up collaborative and interactive *Facebook* advocacy sites using their research topics as their themes, publicise their groups' research findings, raise awareness and garner feedback about their research topic from the online community.

Social Media Application: Interactive Peer Feedback using *Twitter* and *Tumblr*

In order to stimulate more active and interactive peer feedback sessions during the face-to-face presentations of research findings, students were required to tweet live via *#EIRTalkBack* on *Twitter*, their thoughts and comments about their fellow classmates' on-going verbal presentation and sharing of their research findings. At the end of each group presentation, students in other groups were required to submit via *Tumblr* supportive and constructive group feedback about their peers' presentations. Students were also required to pose relevant questions for the presenting group to answer. The subject facilitator/tutor then summarised all student feedback and provided overall feedback/comments including strengths and areas for improvements to the groups who presented. Students were given class participation marks for active participation during this activity. The *#EIRTalkBack* was also used as an interactive Q&A site for the audience to pose questions to the presenters who would then select a few questions to answer.

Social Media Application: Collaborative Writing Using *Wiki*

Within each class, students from the different disciplines in the Polytechnic had to come together to collaborate on a graded group Wiki. Students worked in teams of 4-5 people, to contribute their opinions and analysis of research findings towards their group's Wiki on the research topic they had chosen to work on. Individual students in each group were required to conduct the research and update their individual findings onto the group's Wiki site. They had to observe the mannerisms and ethics of collaborative writing within a Wiki environment. Wikis was used for this purpose as it allowed all students in each class to collaborate virtually by researching on the topic and share the results with other students.

Social Media Application: Online Subject Feedback Results and Discussion

An online subject feedback was conducted at the end of EIR to get students' feedback on the effectiveness of the subject delivery and teaching methods. This survey also aimed to find out if the selected social media technologies used had been effective in making the learning of module EIR interesting and meaningful for students. A total of 35 students participated in this survey. Below are the quantitative results of this survey:

Feedback Results: Overall Subject Delivery

94.1% of students strongly agreed/agreed that overall, they are satisfied with the Cross Disciplinary Subject (CDS) "Effective Internet Research (EIR)". 91.2% of students strongly agreed/agreed that they enjoyed learning EIR. 85.3% of students strongly agreed/agreed that EIR is interesting and provides opportunity to stimulate their thinking. 91.2% of students strongly agreed/agreed that they had learnt a lot in this subject. 97% of the students strongly agreed /agreed that EIR has helped them in searching and evaluating Internet resources more effectively. 94.2% of the students indicated that EIR had helped them do better research on the Internet for their other subject assignments and Major Project in their respective Diplomas. 91.2% of students strongly agreed/agreed that the E-lectures were convenient and helped them learnt EIR independently. The e-learning activities were supplemented with face-to-face classroom activities to give students a holistic learning experience. 85.3% of students strongly agreed/agreed that the face-to-face activities in class to evaluate websites were fun, interesting and useful.

Highlights of students' qualitative comments about EIR:

- Evaluation of internet resources. I never knew that an evaluation on internet resources involved so many things and I almost always thought that the 'about us' page was near redundant, unless when I need to locate them or contact them.

- EIR is a very interesting CDS which taught me more about the usage of media platforms effectively and efficiently.
- This subject has taught me a lot not only about internet research but also some meaning quotes that the tutor teaches us. It helps us reflect on ourselves. It was a good experience."
- I enjoyed EIR as it was a nice subject with a nice lecturer teaching it! Ended off with a nice feel for my third subject.
- EIR has been really interesting and would aid me in further studies. I have learnt to research better in a strategic manner. Thank you to my tutor!

Feedback Results and Discussion: *Facebook*

Students provided encouraging feedback on the collaborative and interactive feature of *Facebook*. 91.2% of students strongly agreed/agreed that the feedback gathered from the online community via their group's *Facebook* page has provided them with more confidence for their research work. 79.4% of students strongly agreed/agreed that the sharing of their research findings with the online community via their group's *Facebook* page had helped them to expand their research ideas. 91.2% of students strongly agreed/agreed that they felt a sense of achievement that their team's research findings have benefited others from the "Likes" support given by the online community via their group's *Facebook* page. 91.1% of students strongly agreed/agreed that their team's *Facebook* page is an effective additional research method to engage the online community and create awareness about our research findings. 100% of students strongly agreed/agreed that collaborating with their team members on their team's *Facebook* page on their research topic helps them to enhance their knowledge and understanding about their research area. 91.2% of students strongly agreed/agreed that overall, the *Facebook* activities in module EIR were fun, engaging, interesting and allowed them to make more new friends. These survey results are congruent with the findings of Shraim's study that *Facebook* has helped students in developing relevant life skills of learning through social interaction that are useful in the context of living in today's highly inter-connected and technologically-oriented society (Shraim, 2014).

Feedback Results and Discussion: *Twitter* and *Tumblr*

Twitter was used as an interactive peer feedback platform for students to provide live commentaries and feedback on their fellow classmates' group presentations via *#EIRTalkBack*. *Twitter* also served as a good question and answer platform throughout the presentation session. 94.1% of the students strongly agreed /agreed that the feedback gathered from their fellow classmates via *#EIRTalkBack* is interesting and useful. 91.2% of the students strongly agreed /agreed that the *#EIRTalkBack* micro blogging experience via *Twitter* engaging and meaningful. At the end of each group presentation, *Tumblr* was used as a platform for students to provide consolidated group feedback on the strengths and weaknesses of their fellow classmates' group presentations. 88.3% of the students strongly agreed /agreed that they found it useful and meaningful to use *Tumblr* to provide feedback on other group's presentations. 94.1% of the students strongly agreed /agreed that the feedback from their fellow classmates about their group presentation is constructive and help them in improving their future presentations. 100% of the students strongly agreed/agreed that the questions from their fellow classmates about their research findings were constructive and useful. 97.1% of the students strongly agreed /agreed that asking questions to other groups after their presentations helped them to better understand and appreciate other research topics besides their own group's topic.

These survey results showed that *Twitter* can be used as a productive educational tool to add value to students by creatively engaging them as described in the study by Junco, Heiberger & Loken (2011).

Feedback Results and Discussion: *Wiki*

From the Wiki collaborative experience, 91.2% of the students strongly agreed/agreed that the Wiki experience was interesting and meaningful. 94.1% of the students strongly agreed/agreed that they had learnt to respect the opinions of others. 97% of the students strongly agreed/agreed that collaborating on Wiki with others with similar research interest helped them to enhance their knowledge and understanding about their research areas. 91.2% of the students strongly agreed/agreed that they had learnt helpful values of teamwork & community spirit of sharing & learning. 100% of students strongly agreed/agreed that they have learnt to accept criticism gracefully including when others corrected or deleted their Wiki submissions. Students reflected that Wiki helped improved communication skills amongst classmates, increased teamwork and provided flexibility and convenience in learning (Parker & Chao, 2007). Students were amazed that they were able to conveniently complete the Wiki group class assignment over a weekend without having to attend class or having to meet up with their classmates. They also appreciated the Wiki experience in giving them the opportunity to bond and team up to work together as a class even though they come from different Schools across the Polytechnic. The students experienced the powerful learning experience of using Wiki via the rapid feedback they could provide to fellow classmates on their contributions towards the class Wiki while having other fellow classmates edit their work in an ongoing collaborative writing experience (Klobas, 2006). However, some students admitted that they were not comfortable, initially, to have their fellow classmates edit their writing on the Wiki group assignment, but soon learn to live up to the Wiki community spirit of

collaborative writing when they realized that they too were free to edit their other fellow classmates' contribution to the class Wiki.

Challenges

The incorporation of social media technologies into the curriculum of higher education does provide various challenges for educators and administrators alike. Novice educators face the challenge of using the technologies while experienced educators find it difficult to adapt to the use of new technologies especially when they have been using the same familiar teaching methods for many years. They also find it challenging to invest time and effort to stay abreast of the rapid development in the fast-moving field like IT and the Internet. Educators face the challenges of designing and developing effective course curricular which blend social media technologies with face-to-face interactions. These are often very time-consuming to create, update and maintain to ensure the sustainability and reusability of these courses.

Based on the experience of the module *EIR*, tutors and students faced the challenge of having to learn new social media technologies. The teaching team overcame this challenge by providing practical worksheets and allocating time, in the face-to-face classroom sessions, for students to learn how to use these tools. Another challenge faced was related to the grading and assessment of group Wikis. The subject team overcame this challenge by getting students to talk about the extent of their contributions towards the group wikis during the final portfolio presentations at the end of the module.

The author who was also the subject leader for the module EIR, faced the challenge of having to invest substantial time and effort in designing and developing effective online activities which have to be deftly blended with relevant media resources and suitably-selected interactive social media technologies with sound pedagogy principles. The author/subject leader took on this challenge by getting out of her comfort zone to learn new technologies as she realized the need to engage her students using the new online learning landscape and changing the traditional classroom environment. This has opened up more opportunities for collaborative work and enabling students to personalize and take charge of their own learning by blending the use of social media technologies with face-to-face interactions. This echoes the 'YouNiversity' concept in higher education described by Jenkins (2007), suggesting the evolution of an intellectual and dynamic network involving the interaction of students with professors, industry and the community. This encompasses a change in the traditional classroom learning ecology and includes the collaborative broader perspectives that often occur within a learning environment which blends online interactions with traditional face-to-face learning experiences (Jenkins, 2007 as cited by Duffy, 2008).

Conclusion

Social media technologies have been useful and effective in educating and engaging youths in their learning as seen from the discussion above. Students were able to learn the module *EIR* interactively and conveniently, in a more fun, engaging and interesting way by sharing with fellow classmates about their Internet research experiences through their advocacy *Facebook* sites and *Wikis* and actively participating via *Twitter* in providing peer feedback during the final presentations of research findings. As a result, both students and staff morale were enhanced as students performed relatively well overall.

These exciting social media technologies resonate well with the understanding of knowledge and learning as socially constructed, which has been a cornerstone of recent pedagogical theory. Such interactive social technologies have encouraged and enhanced the visibility of the social construction of knowledge, and educators who embrace these tools must ensure that their use benefit both educators and students (Duffy, 2008). However, although social media technologies have opened up a wide range of possibilities for educational institutions, educators need also be mindful of the challenges in transmitting into their existing institutional contexts, the essential attributes of social media technologies such as trust, openness, voluntariness and self-organization (Rollett et.at. 2007). Educators also need to be mindful that the vital factor leading to the successful implementation of using social media technologies in education is to initiate institutional change to facilitate the dissemination of the new pedagogical culture (Shraim, 2014).

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References

Allam, C. (2008). 'Creative activity and its impact on student learning – issues of implementation'. *Innovations in Education and Teaching International.* 45(3), 281-288

Crook, C. & Harrison, C. (2008). Web 2.0 Technologies for Learning at Key Stages 3 and 4: Summary Report. Becta. Retrieved 12 July 2014 from http://dera.ioe.ac.uk/1480/1/becta_2008_web2_summary.pdf

Duffy, P. (2008). 'Engaging the YouTube Google-Eyed Generation: Strategies for Using Web 2.0 in Teaching and Learning.' *The Electronic Journal of e-Learning.* 6(2), 119-130

Hay, L & Pymm, B. (2010/2011). 'Real learning in a virtual world: A case study of the school of information studies' learning centre in Second Life'. *Education for Information*. 28, 187–202

Higher Education Research Institute (2007). College freshmen and online social networking sites. Retrieved 13 July 2014 from World Wide Web: http://www.heri.ucla.edu/PDFs/pubs/briefs/brief-091107-SocialNetworking.pdf

Hughes A. (2009). Higher education in a Web 2.0 world. JISC Report. Retrieved 12 July 2014 from World Wide Web: http://www.jisc.ac.uk/publications/generalpublications/2009/heweb2.aspx

Jarmon, L., Traphagan, T. & Mayrath, M. (2008). 'Understanding project-based learning in Second Life with a pedagogy, training, and assessment trio'. *Educational Media International.* 45(3), 157-176

Junco, R., Heiberger, G & Loken, E. (2011). The effect of Twitter on college student engagement and grades. *Journal of Computer Assisted* ***Learning***. 27(2), 119-132

Klobas, J. (2006). *Wikis:Tools for information work and collaboration.* Oxford: Chandos Publishing

Lisboa, E. S., & Coutinho, C. P. (2011). Informal learning in social networks: A study of the Orkut social network. *Issues in Educational Research*, 21(2), 162-174

McFedries P. (2007) All A-Twitter. IEEE Spectrum. Retrieved 11 July 2014 from World Wide Web: http://spectrum.ieee.org/computing/software/all-atwitter

New Media Consortium (2007) The Horizon Report. Retrieved 11 July 2014 from World Wide Web: http://www.nmc.org/pdf/2007_Horizon_Report.pdf

Parker. K. & Chao, J. (2007). 'Wiki as a Teaching Tool'. *Interdisciplinary Journal of Knowledge and Learning Objects.* 3, 57-72

Rollett, H., Lux, M., Strohmaier, M., Dosinger, G., & Tochtermann, K. (2007). 'The Web 2.0 way of learning with technologies'. *Int. J. Learning Technology.* 3(1), 87-107

Shraim, K. (2014). Pedagogical Innovation within Facebook: A Case Study in Tertiary Education in Palestine. *International Journal of Emerging Technologies in Learning***.** 9(8). 25-31

Tonkin, E. (2005). Making the Case for a Wiki. Retrieved 12 July 2014 from World Wide Web: http://www.ariadne.ac.uk/issue42/tonkin

Wang, C., Song, H., Xia, F. & Yan, Q. (2009). 'Integrating Second Life into an EFL Program: Students' Perspectives'. *Journal of Educational Technology Development and Exchange*. 2(1), 1-16

Wilson, K., Wright, H. Inman,T & Matherson, H. (2011). Retooling the Social Studies Classroom for the Current Generation. ***Social*** *Studies*. 102(2), 65-72