TEACHERS' PERCEPTIONS ON THE USE OF GAMES IN THE POLYTECHNIC TEACHING CURRICULUM

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Abstract

In recent years, the adoption of games in the field of education has become extensive and prevalent. Its multi benefits and advantages are vastly spoken for, evidenced from the researches and papers conducted by the educational academia. There is increased support from the Singapore Government, both infrastructure and monetary funding, to support the adoption of games in education and learning. Increasingly, local educational institutes are reviewing their course curriculums to examine how the adoption of games can complement their current teaching pedagogies and in doing so, add value to the students' learning experience. However, it is observed that the adoption of games in the teaching curriculum is low with few success stories being shared or publicised. With this in mind, an investigation was conducted with two groups of teachers from Ngee Ann Polytechnic (NP) to find out the factors that would influence the adoption of games as a learning strategy.

A quantitative research was undertaken through the use of survey to investigate the teachers' perceptions on the adoption of games as a learning strategy and the accompanying factors that influence these perceptions. The resultant statistical and co-relational analysis of the research yielded inferences on the perceptions of teachers that is consistent with researches conducted overseas. Teachers are found to be aware of the potential of using games in the teaching curriculum and know that they should adopt it as part of their learning strategy. The teachers also identified key barriers against them doing so, namely time for development and implementation, as well as the lack of knowledge and resources. The result of the research also hints that teachers with gaming experiences are generally more likely to adopt games in their teaching but as they gained more teaching experiences, the likelihood of them doing so gets less. With the analysed research data, this paper proposes an established approach for designing games and an outline for the implementation of games in the classroom. In doing so, it is with hope that more teachers will adopt the use of games in their teaching curriculum.

Keywords: *perceptions, games, polytechnic, teaching, curriculum, education*

Introduction

Since the first digital game was conceived in 1947, the games industry has rapidly grown and expanded its reach to worldwide audiences. Assisted by the technology boom of the 20th century, games have burst forth from traditional console platforms to high-tech gaming computers, interactive consoles and the socially popular online realm.

In 2009, digital games added $4.9 billion to the United States Gross Domestic Product (ESA, 2011). China's online games market is expected to reach $8.9 billion by 2013 (Alexander, 2009). In Singapore, the estimated worth of the digital games industry in 2008 is $285 million dollars (Luo, 2008) and increasing steadily. Recognising the potential of games, the Government has continuously pumped millions of dollars into the digital media industry to boost its strengths and reach (MDA, 2013).

Games have gained unprecedented access to the homes, minds and souls of people (Jayakanthan, 2002). With heavy investments pushing for its wide proliferation, games have gradually found their way to other areas apart from entertainment (The Economist, 2011). People are using games in various aspects of daily lives, such as training, communication, and research. It is without doubt that in the constantly evolving world of education that the adoption of games is on the rise.

A Shift in Learning Styles

The idea of play through games is important to students. Students are willing to be active participants and take ownership of their learning, implying an active learner's role and the adoption of a "learning by doing" approach (Felder & Brent, 2003; O'Neill & McMahon,

2005). Students appeal to a combination of audio, visual and kinesthetic senses to maximise their learning (Prem & John, 2001). Games can provide this platform that assimilates audio, visual and tactile elements together. This central role of experiential learning through play in the learning process (Kolb, 2005) provides a binding package that combines experience, perception, cognition and behaviour.

Teachers are constantly challenged to create an environment and culture that would effectively and efficiently facilitate the students' learning process (Spencer & Jordan, 1999). Teachers are gradually beginning to appreciate the attraction and educational values that games can bring to the students through play. (Koh, Yeo, Wadhwa & Lim, 2011). Cruickshank & Telfer (2001) maintains that the use of games is an ideal complement, not replacement, to current teaching methodologies. The rationale of using games can also be found in examining how social processes can be simulated and what educational objectives can be presented in this way (Boocock, 1968). People can acquire new knowledge and complex skills from game play (Federation of American Scientists, 2006). Research indicated that the use of games could be powerful tools to strengthen social and emotional learning (Garis, Ahlers & Driskell, 2002; Hromek & Roffey, 2009). The multiple benefits, from stimulating students' information assimilation and knowledge retention, increasing students' motivation, encouraging analysis, synthesis and evaluation of content, to enhancing motor coordination (Boye & Tapp, 2013), far exceeds any disadvantages from traditional mindsets on the use of games (Can & Cagiltay, 2006; Moizer, Lean, Towler & Abbey, 2009).

Teachers' Perceptions

With literature and research data pushing for the adoption of games, it should be no surprise that the use of games should be one that frequently complements and/or feature in a polytechnic' teaching curriculum, such as Ngee Ann Polytechnic (NP). On the contrary, there were only infrequent reports of the use of games over short time periods in NP. There could be many explanations for this as games are often viewed as a form of play or distraction to learners, that learners would not learn effectively and efficiently, or that developing games are difficult and often time consuming. Other issues are more cultural as Asian schools tend to be instructional-based.

It is with this background that this paper intends to investigate the perceptions of teachers on the use of games. This paper narrows the research to four specific questions:

1. What are the general perceptions of teachers towards the use of games?
2. What are the factors effecting these perceptions?
3. What are the obstacles to the use of games?

4. Should polytechnic teachers use games in the teaching curriculum?

Research Methodology

This research is conducted with the academic staff of the School of InfoComm Technology (ICT), an academic school of NP, and a group of NP staff undertaking the Masters of Education from Adelaide University (termed as MscEd). ICT was selected for this investigation, as the school is an ideal research ground as it is an established provider of information technology education with teachers from various professional backgrounds.

The survey methodology is chosen, as it would provide a cross-sectional overview of the respondents from a target population that is representative of the teachers in NP. In addition, the survey methodology is non-intrusive, allows for anonymity, and consumes less time and effort. The survey is conducted using the Google Docs platform for its ease of use, constant availability and accessibility to all respondents.

There are 21 quantitative questions and 7 qualitative questions in the survey. It serves to explore the impact of gaming experience and teaching experience, towards the attitude towards gaming. It would then explore the correlation between these three factors towards the teachers' perceptions towards the use of gaming in the teaching curriculum (See Figure 1.).
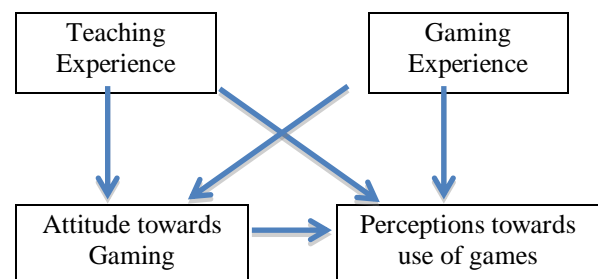

Figure 1: Factors correlating towards the perceptions on the use of games in the teaching curriculum.

Perceptions and Experiences

44% of the ICT teachers and 40% of the MscEd teachers responded to the survey. A breakdown of the survey demographics is shown in Table 1. 34.8% of ICT teachers and 42.9% of teachers from the MscEd group responded that they have experiences in using games in their teaching curriculum.

Table 1. *Survey Demographics*

		ICT (*N*=23)	MscEd (*N*=7)
Teaching Experience	0 – 10 years	30.4%	71.4%
	11 – 20 years	39.1%	28.6%
	21 – 30 years	30.4%	-
Teaching Expertise	IT-related	56.5%	28.6%
	Business-related	30.4%	14.3%
	Media-related	4.3%	14.3%
	Lifeskills	4.3%	28.6%
	Others	4.3%	14.3%
Ever play games?	Yes	87%	71.4%
	No	13%	28.6%
Ever used games in the teaching curriculum?	Yes	34.8%	42.9%
	No	65.2%	57.1%

Both groups of teachers adopt a healthy and positive attitude to the use of games in the teaching curriculum. Most felt that games fostered good engagement and interest with the students while maintaining a fun and learning environment. They are convinced that games are beneficial to students' learning and will increase the engagement during class hours (see Table 2).

Table 2. *Perception of Teachers on the Use of Games in the Teaching Curriculum*

Statements	ICT (*N*=23)	MscEd (*N*=7)
	M	*M*
Games are beneficial to students' learning	3.88	3.88
Games increase the students' engagement	4.25	4.0
Games better facilitate the students' learning	3.96	4.13

Some felt that games assisted with review and retention. Others observed that the occasionally competitive environment focused the students on learning through play, rather than be distracted by other concerns. Most felt that it assisted in achieving the intended learning outcomes and the students could better complete their coursework. Both group of teachers agree that there are adequate support from NP and the management to use games in the teaching curriculum. On being polled on the likelihood of the teachers continuing to use or adopt games in the teaching curriculum, the response is skewed towards the positive (See Figure 2).
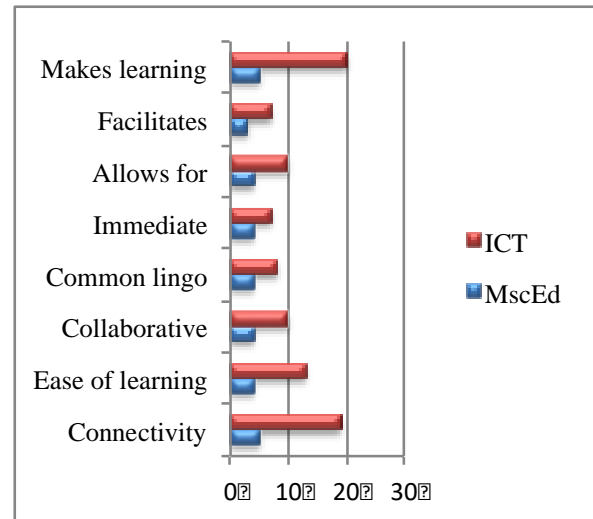

Figure 2: Benefits of using games.

Teachers also highlighted the difficulties in using games, citing key factors such as insufficient time during class hours, limited resources, high cost and limited knowledge (See Figure 3). Both groups of teachers found that games are likely to become a source distraction, especially the MscEd teachers. It is interesting to note that ICT teachers, though being more tech-savvy, felt that games were difficult to use or implement in their teaching curriculum.
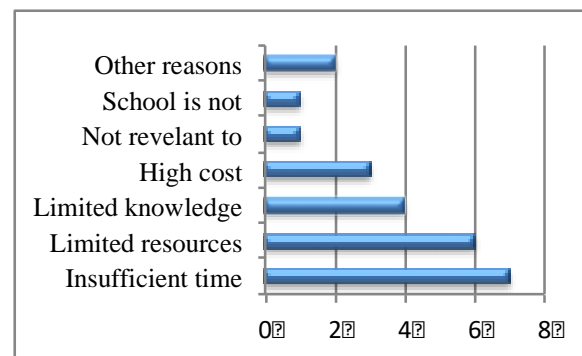

Figure 3: Barriers to using games.

A single-factor one-way ANOVA test is used to analyse the relationship between the teachers' teaching experiences and their likelihood to use games in the teaching curriculum. Teachers that have teaching experiences of 10 years or less have the most positive attitude towards the use of games, followed by those with teaching experiences of 21 – 30 years, and those with teaching experiences of 11 – 20 years. It can be inferred that as the teachers gain more teaching experience, they tend to see the use of games in a less positive light.

Evaluation of the Research

The findings and resultant analysis from this research are consistent with previously conducted research (Koh, Yeo, Wadhwa & Lim, 2011; European Schoolnet, 2009). The perceptions of teachers in NP are generally very positive towards the use of games in the polytechnic teaching curriculum. The teachers are enthusiastic about using it as a complementary tool in the classroom and they acknowledge the benefits that the use of games can bring to the students. They are aware that it can assist in achieving the intended learning outcomes and encourage high engagement from students.

Likewise with previous research, even with strong avocations and recognitions, the use of games in the teaching curriculum remains significantly low. From the quantitative and qualitative analysis of the survey, only one in three teachers have used games in their teaching curriculum. This disparity might possibly be greater if the survey is conducted on all the teachers in NP.

This research also established that gaming experience and teaching experience are significant factors that affect the teachers' attitude towards gaming and the perceptions of teachers towards the use of games in the teaching curriculum. The research is indicative that teachers with gaming experiences are generally more likely to use games in the teaching curriculum. However, it is also indicative that the use of games by these same teachers is low. This research also hints that as teachers gain more teaching experiences, the likelihood of them using games gets lesser. This is a peculiar behaviour, as logic would dictate that with growing experience, the use of games should increase. More research should be carried out to investigate further into the causes.

Moving Forward

With proper design, development and deployment of the game, the use of games as a complementary teaching tool can be maximised to achieve the students' intended learning outcomes. The following recommendations may or may not fully address the barriers identified earlier in the research but it may serve as a structure to the teachers who are considering the use of games in the teaching curriculum.

To boldly suggest, it is of the opinion of this paper that teachers must be willing to take the first step in using games in the teaching curriculum. They must acknowledge that in taking this first step, they will be sacrificing a fair bit of time, resources and effort in designing and developing games for their curriculum. They must concede that they will most probably not be successful in their first attempt but they must continue to try. The teachers must be willing to fail in order to succeed.

Designing and developing a game for the teaching curriculum is no small task. It is with this that this paper recommends Baker's (2006) six points for the design of educational games:

1. Be easy to use
2. Span learning stages – initial exposure to applying concepts
3. Adaptable to different levels of instructions, introductory, intermediate, and advanced
4. Accommodate different learning styles
5. Be flexible enough to fit into new updates
6. Not just a supplement but integrated into course

Conclusions

It is without a doubt that with the proper use of games, students can benefit greatly and achieve their learning outcomes. The perceptions of teachers in NP on the use of games in the polytechnic teaching curriculum are positive and yet the usage of games in the teaching curriculum remains low. Some barriers identified in this paper are worth further investigation.

To close with a quote from Albert Einstein, " I never teach my students. I only attempt to provide the conditions in which they can learn". Let the use of games be one of the conditions for learning.

Acknowledgements

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WHAT IS IT THAT LECTURERS DO THAT HELP STUDENTS PERFORM BETTER?

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Abstract

Research has shown that teachers play a significant role in student learning. What they know, do and care will have an impact on how well their students learn. Effective teachers help their students to progress while ineffective ones hold them back. What sets these two groups of teachers apart is believed to be the teaching practices they adopt in their classroom. Many teachers however are not sure about the effectiveness of their teaching. While there are several methods to assess teaching effectiveness, they are often perceived to be either subjective or unfair. It is important to have an objective and unbiased method to measure teaching effectiveness as it can convince ineffective teachers to improve their practice. This study sets out first, to propose and evaluate a method that can objectively measure teaching effectiveness, and second, to examine teaching practices adopted by lecturers in the School of Engineering (Electronic and Computer Engineering) in Ngee Ann Polytechnic with high teaching effectiveness (as measured using the proposed method) to uncover effective teaching practices for classroom teaching.

This study was done in two phases. In phase I, module scores of 628 students who had just completed Digital Logic module in the School of Engineering (Electronic & Computer Engineering) in Ngee Ann Polytechnic were regressed on their semestral GPA. The two variables were found to be highly correlated. Residuals of the regression were averaged to determine the teaching effectiveness index (TEI) for each of the 15 lecturers who taught the module. In phase II, the same group of students was surveyed for their perceptions on the level of utilization of various teaching practices their lecturers exhibited in classrooms. The survey data was analyzed in relation to TEI. The preliminary results of the study suggest that top TEI lecturers exhibit high utilization of the following practices: strong classroom management, setting of high expectations, teaching for understanding and caring for student learning. The conclusion can be drawn that teachers indeed make a difference and they do so through the teaching practices that they utilize in the classrooms. Following an in-depth analysis of the preliminary results, some recommendations in relation to teaching effectiveness will be presented.

Keywords: *teaching effectiveness, classroom practices, teaching evaluation, student performance, student learning, value added, student perception*

Introduction

Teachers make a difference in student learning. Research has shown that teachers account for about 30% of the variance of student achievement, second only to students themselves who contribute 50%, with the remaining 20% distributed among home, schools, principals and peers (Hattie, 2003). Clearly, the impact they have on students is significant – effective teachers help their students to progress while ineffective ones hold them back. Unfortunately, many teachers are not sure about the effectiveness of their teaching. As Hurban (2013) pointed out, the ineffective teachers often do not know that they are actually the ones who hinder their students' learning. While there are several methods to assess teaching effectiveness, they are often perceived to be either subjective or unfair. It is important to have an objective and unbiased method to measure teaching effectiveness as it can convince ineffective teachers to improve their practice.

This study sets out to explore (1) the appropriate method to evaluate teaching effectiveness and (2) teaching practices that help students learn better. It is hoped that by completing this project, a simple yet convincing method for evaluating teaching effectiveness can be formulated. With such an evaluation tool, the lecturers will be able to gauge the effectiveness of their teaching and improve it through training in the areas as identified in this study.

Measuring Teacher Effectiveness

One common problem with the traditional measures of teacher effectiveness such as Student Evaluation of Teaching (SET) and Classroom Observation is that the personal feelings and the preconceived notion of the observer can interfere with the fairness and objectivity of the evaluation (Murphy, 2012). While using student achievement for this purpose appears to be more appropriate, factors such as student academic abilities can significantly influence the outcome.

One way to reduce such influences is to use Value Added Models (VAM) to statistically calculate the gains the students achieve by comparing their current test scores with their scores in the previous year. Sanders and Horn (1998) argue that many factors that influence students' current test scores are already included in their prior years' test scores and the effects should therefore be reduced when the two scores are compared. Several studies show that student achievement can be increased when they are taught by higher value added (VA) teachers (Chetty et al., 2011; Hanushek, 2009). Critics however pointed out that students are not randomly assigned to teachers and their effectiveness cannot therefore be accurately estimated (Murphy, 2012).

Relating Teaching Practices to Student Achievement

More recent studies on the topic use growth or VA score as a measurement for student achievement. Haynie et al. (2006) for example use growth, termed as residual score in their study, as a measurement of student achievement to identify the most and the least effective biology teachers in their schools. By correlating the result of teacher survey, classroom observation and teacher interview on classroom practices with their class average residual score, the effective classroom practices are identified. Similarly, Kane et al. (2011) use growth as student achievement and in combination with data from high-quality classroom observation of teaching practices. The researchers find that the two are substantively related.

Empirical study on the topic of relating teaching practices to student achievement in higher education setting is scarce. Perhaps it is due to the difficulty in measuring student achievement at higher education level. As Cunha and Miller (2012) pointed out, the simple and practical way of estimating student achievement using VA is not possible in higher education because year-on-year standard test score is unavailable. Hence, many studies have instead based on student evaluation to identify effective teaching practices. Examples are studies by Clark (1995), Ralph (2003), and Delaney et al. (2010). However students may not be objective evaluators of teaching as they are not trained to do so. The accuracy of such studies based solely on student evaluation may therefore not be an accurate reflection of teacher's effectiveness.

Purpose of the Study and Research Design

This study investigates the relationship between teaching practices, as perceived by students in terms of utilization, and their academic achievement in the higher education setting. Although many studies have found significant relationship between the two, few studies have done so in the higher education setting.

This study was conducted in two phases. In Phase I, student academic performance data was analyzed and the VA score for each student was computed based on his final score of an identified module and his semestral GPA. The VA scores of all the students taught by the same lecturer were averaged and defined as Teaching Effectiveness Indices (TEI). Top and bottom TEI lecturers were then identified. In Phase II, a survey was conducted to gather student perception on how frequently their lecturers exhibit each teaching practice listed in the questionnaire. Teaching practices between the top and bottom TEI lecturers were compared. Practices that were exhibited more often by the top TEI lecturers were correlated with VA scores and effective teaching practices were then identified.

Phase I: Estimating Teaching Effectiveness

Phase I Sample Selection

The sample consisted of 628 students and 15 lecturers from the Electronic and Computer Engineering (ECE) division, School of Engineering (SoE), Ngee Ann Polytechnic (NP). The students were grouped into 31 classes to attend Digital Logic (DIGLG) module taught by the lecturers. Table 1 presented the number of students taught by each lecturer together with the means and standard deviations of the Semestral GPA.

Table 1. Average semestral GPA of students by lecturer

Lecturer	n	%	Semestral GPA	
			M	SD
L01	24	3.8	3.69	0.20
L02	40	6.4	2.90	0.72
L03	99	15.8	3.00	0.61
L04	87	13.9	3.47	0.50
L05	38	6.1	3.27	0.72
L06	46	7.3	3.03	0.61
L07	22	3.5	2.52	0.79
L08	58	9.2	2.77	0.64
L09	35	5.6	2.43	0.95
L10	60	9.6	3.08	0.80
L11	19	3.0	2.46	0.89
L12	43	6.8	3.21	0.69
L13	19	3.0	3.26	0.45
L14	21	3.3	2.22	0.67
L15	17	2.7	2.91	0.48

n: number of students, M: Means, SD: Standard deviation
*Maximum number of students in a class was 24. Lecturers with higher number of students indicate that they taught two or more classes.

Phase I Method

This study estimated teaching effectiveness of individual lecturers using average VA score of all the students taught by the same lecturer. The VA score for each student was obtained by subtracting the score predicted using student GPA from the actual one. Semestral GPA was used instead of Cumulative GPA because it represented the most recent condition the student was in for learning and would therefore predict the final score more accurately.

The equation of the prediction model is as follows:

$$P_n = aG_n + b$$

where P_n and G_n are the predicted score and semestral GPA for student n respectively while a and b are the coefficient for variable G and the intercept of the prediction respectively. A linear regression analysis was used to determine the values of the two constants in the equation. When the prediction model was found, the VA score for each student was computed using the equation below:

$$V_n = S_n - P_n$$

where V_n and S_n are the VA score and DIGLG score for student n respectively. The teaching effectiveness of individual lecturer was then estimated as follows:

$$T_i = \left(\sum_{n=0}^{m} V_{n,i} \right) \div m$$

where T_i is the estimated teaching effectiveness for lecturer i, $V_{n,i}$ is the VA score for student n taught by lecturer i, and m is the total number of students.

Phase I Result and Analysis

The bivariate linear regression analysis was conducted to evaluate the prediction of DIGLG score (P) from semestral GPA (G). The scatterplot of the two variables presented in Figure 1 shows that DIGLG score and semestral GPA are linearly related in such a way that when one increases the other follows. The regression equation for predicting DIGLG score was found to be:

P = 12.523 G + 32.737

As the 99% confidence interval for the slope (from 11.530 to 13.515) does not contain zero, the semestral GPA is therefore significantly related to the DIGLG score. As hypothesized, students who have higher semestral GPAs are likely to achieve higher DIGLG scores. Accuracy in predicting DIGLG score is fairly high given that the correlation coefficient between the two variables was 0.704. Nearly half of the variance of DIGLG score was accounted for by its linear relationship with semestral GPA ($R^2 = 0.495$).
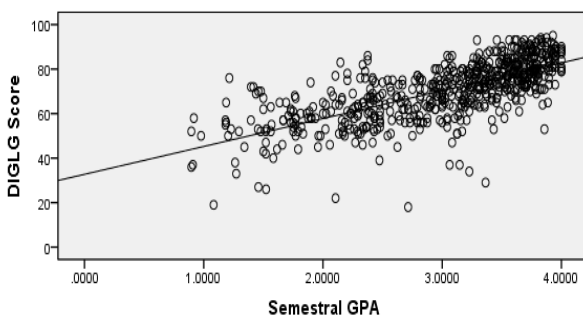

Figure 1. Scatterplot for DIGLG score

Based on the equation for the prediction model found earlier, the predicted DLGLG scores and subsequently the VA scores for all the students were computed. Results showed that the distribution of the VA scores had almost no skewness (- 0.197) and only slight positive kurtosis (0.340). The values ranged from -28 to 28. A Kolmogorov-Smirnov test for normality indicated that VA scores did not depart significantly from a normal distribution ($p = 0.2$).

Teaching Effectiveness Indices (TEI) estimated by taking the average of the VA scores of all the students taught by the same lecturer is ranked and presented in Table 2. The value of TEI for DIGLG ranged from -5.81 to 11.60. This means that in general the students taught by the lowest TEI lecturer scored 5.81 marks less while the students taught by the highest TEI lecturer scored 11.60 more, as compared to what they were expected to achieve based on their semestral GPA. Despite the unusual high of TEI of lecture L07, a Shapiro-Wilk test for normality indicated that TEI did not depart significantly from a normal distribution ($p = 0.299$).

Table 2. Means and standard deviations of TEI.

Lecturer	Size	Mean (TEI)	Std. Dev.
L07	22	11.60	7.11
L04	87	6.57	7.31
L14	21	3.17	5.95
L01	24	3.15	7.66
L11	19	2.77	6.92
L05	38	2.08	6.96
L08	58	-0.08	7.96
L10	60	-0.15	5.64
L02	40	-1.44	8.53
L06	46	-1.66	9.09
L03	95	-2.10	8.16
L15	17	-3.98	5.63
L12	42	-4.32	5.86
L09	34	-4.51	9.83
L13	19	-5.81	7.97

*Maximum number of students in a class was 24. Lecturers with higher number of students indicate that they taught two or more classes.

A one-way analysis of variance was conducted to evaluate the relationship between lecturer, the independent variable and VA score, the dependent variable. The ANOVA was found to be significant with $F(14, 607) = 12.91$ and $p < 0.001$. As indicated by η^2, the strength of relationship between lecturers and VA scores was strong, with lecturers accounting for 23% of the variance of VA score.

Follow-up analysis was conducted to evaluate pairwise differences among the means of VA score between the highest and the lowest TEI lecturers (i.e. L07 and L13), the second highest and the second lowest lecturers (i.e. L04 and L09), and so forth. Only three pairs had a significant difference in their TEI. Based on this observation, lecturer L07, L04 and L14 were identified as the top TEI group while lecturer L12, L09, L13 the bottom TEI group.

Phase II: Identifying Effective Classroom Practices

Phase II Survey Instrument

The survey instrument used in this study consisted of twenty three teaching practices that were perceived to be effective either by the education researchers, the students or the teachers. The participants were required to evaluate on how frequently their lecturer exhibited each of these teaching practices in a 7-point likert scale ranging from 1 ("never") to 7 ("always"). The survey was constructed based on the four dimensions of effective teaching that Stronge et al. (2011) synthesized from a meta-review of literature and the nine teachers' behaviors associated with effective teaching as perceived by students in higher education (Delaney et al., 2010). The four dimensions covered (1) Instructional Delivery, (2) Student Assessment, (3) Classroom Environment, and (4) Personal Qualities while the nine teaching behaviors included (1) Respectful, (2) Knowledgeable, (3) Approachable, (4) Engaging, (5) Communicative, (6) Organized, (7) Responsive, (8) Professional, and (9) Humorous. Table 3 summarized briefly what each item of the survey set out to evaluate.

Table 3. Brief description of survey items

Survey items	
Q1 Arrive early	Q13 Give alternative explanation
Q2 Classroom management	Q14 Set high expectation
Q3 Organized and clear	Q15 Care for students
Q4 Relate to previous lesson	Q16 Help to set goal
Q5 Relate to real life	Q17 Timely feedback
Q6 Emphasize on understanding	Q18 Help outside classroom
Q7 Change mode of learning	Q19 Humorous
Q8 Encourage to try	Q20 Friendly and approachable
Q9 Use technology	Q21 Respect students
Q10 Check if student understand	Q22 Interested in teaching
Q11 Encourage questioning	Q23 Patient
Q12 Listen to understand student	

The questionnaire was administered approximately 12 weeks after the students took their examination. They completed the paper questionnaire in about 15 minutes. In the survey, the participants would provide identification so that the survey result could be linked to the student DIGLG score. Their identities were then coded for anonymity as soon as the data collection was completed.

Table 4. Survey responses of student perception on lecturer' teaching practices

Item	M	SD	r_p	Item	M	SD	r_p
Q1	5.12	1.57	0.53	Q13	4.94	1.71	0.80
Q2	4.86	1.65	0.64	Q14	4.76	1.79	0.64
Q3	4.83	1.71	0.76	Q15	4.83	1.77	0.84
Q4	4.70	1.62	0.74	Q16	4.07	1.83	0.74
Q5	4.21	1.73	0.67	Q17	4.18	1.73	0.81
Q6	4.81	1.69	0.83	Q18	4.72	1.85	0.70
Q7	3.95	1.81	0.74	Q19	3.83	1.99	0.69
Q8	4.69	1.76	0.81	Q20	4.97	1.81	0.79
Q9	4.03	1.76	0.56	Q21	4.86	1.85	0.76
Q10	4.72	1.73	0.85	Q22	5.14	1.68	0.83
Q11	4.77	1.74	0.82	Q23	4.98	1.83	0.73
Q12	4.70	1.70	0.84				

Cronbach's alpha: 0.97   N = 491

Phase II Result and Analysis

The means and standard deviations for each item of the survey, together with the item-to-overall correlations (r_p), were presented in Table 4. The twenty-three-item scale was found to be internally consistent (cronbach's alpha = 0.97) and the item-to-overall correlations (r_p) were all positive and at least moderate, indicating that the scale captured the essence of teaching effectiveness. As none of the items was identified as unreliable, the instrument was considered reliable and valid in measuring teaching effectiveness in this study.

An independent-samples t-test was conducted to evaluate the differences in teaching practices between the top and the bottom TEI groups. Table 5 presented the six survey items that have the highest positive means differences between the two groups.

Table 5. Mean differences between teaching practices of top and bottom TEI groups

Item	M	SE	t	Item	M	SE	t
Q14	1.53	0.22	6.97	Q10	0.94	0.23	4.04
Q16	1.12	0.26	4.29	Q6	0.90	0.24	3.76
Q2	1.00	0.20	4.88	Q15	0.90	0.22	4.00

The teaching practices identified above, though used more often by the top TEI lecturers, might not necessarily bring about the VA scores. To evaluate whether there is indeed such a relationship, correlation coefficients were computed between VA scores and teaching practices. To control for Type I error across 23 correlations, Bonferroni approach was used. In this case, a *p* value of less than 0.002 (0.05/23 = 0.002) was required for significance. As can be seen from Table 6, all teaching practices except Q1 were statistically significant. In general, the result suggested that if lecturers are more often in managing the classroom well (Q2), setting high expectation for their students (Q14), emphasizing on understanding (Q6), regularly checking students' understanding (Q10), and being concerned with student learning (Q15), their class will tend to perform better in term of VA scores.

Table 6. Correlations between VA and teaching practices.

Item	r	Item	r	Item	r	Item	r
Q1	0.12	Q7	0.23	Q13	0.27	Q19	0.17
Q2	0.34	Q8	0.28	Q14	0.31	Q20	0.17
Q3	0.29	Q9	0.17	Q15	0.30	Q21	0.21
Q4	0.26	Q10	0.31	Q16	0.29	Q22	0.26
Q5	0.23	Q11	0.26	Q17	0.27	Q23	0.17
Q6	0.31	Q12	0.25	Q18	0.23		

For Q1, *p* = 0.006; All other items, Q2 – Q23, *p* < 0.001;

Discussion and Implications

Teaching Effectiveness

In this study, the process of estimating teaching effectiveness of individual lecturers consists of three steps. In the first step, the final scores were regressed on semestral GPA to find the score predicting equation. The result confirms that semestral GPA is a good predictor of student final score for DIGLG module. In the second step, VA scores were computed by subtracting the predicted scores from the actual scores and were not found to depart significantly from a normal distribution. The result further confirms the validity of the prediction model formulated in this study.

In the last step, teaching effectiveness of individual lecturer was computed by averaging the VA scores of all the students taught by the same lecturer. The one-way analysis of variance between lecturers and VA scores was found to be significant with lecturer accounting for 23% of the variance of VA scores. This result is not far from the finding of a major study in which teachers were found to account for about 30% of the variance of student learning (Hattie, 2003). The general conclusion is that semestral GPA can be used as a reference with which VA scores – which are subsequently averaged to teaching effectiveness – contributed by individual lecturer can be estimated.

Effective Teaching Practices

The overall finding of this study has indicated that there are significant differences in teaching practices, as perceived by students, between the more and the less effective lecturers. The result confirmed previous finding by Kane et al. (2011) and Hattie (2003) who found differences between teachers with high and low teaching effectiveness in their teaching practices. This study further identifies five effective practices.

Classroom Manamgement
The top of the list of teaching practices that correlates with the teaching effectiveness in this study is classroom management (Q2). This teaching practice was also identified as one of the effective teaching practices in the studies conducted by Haynie (2010) and by Stronge et al. (2011).

Setting High Expectation
Setting high expectation (Q14) for all students is also identified as one of the teaching practices that the more effective lecturers exhibit in their classrooms and correlates with student performance in this study. This is supported by previous findings by Haynie (2010) who reported that top teachers held high academic expectation for students. This is hardly surprising as researchers have long been holding the view that teacher

expectations can increase student achievement (Spiegel, 2012).

Emphasis on Understanding
Another teaching practice that the more effective lecturers exhibit prominently in this study is that they emphasize on understanding (Q6) and students taught in that way tend to gain higher VA scores. This finding agrees with the students' views (Delaney et al., 2010) as well as the experts' view (Hattie, 2003) on effective teaching. From Table 1, it can be observed that the students taught by the two top TEI lecturers L07 and L14 are generally weaker (means of GPA are 2.52 and 2.22 respectively) as compared to the rest. Yet they gained higher VA score when taught by the two lecturers who emphasize on understanding. This debunks the common misconception that weaker students only want to memorize instead of understand.

Exhibition of concern with students' learning
In this study, the more effective lecturers are found more likely to be concerned with student learning (Q15). This is consistent with the findings from a survey study in which students view 'showing concern for student learning' as one of the seven elements for effective online teaching (Young, 2006). When teachers show genuine concern for student learning, not only can they cultivate more productive learners but also motivate at-risk students to continue instead of dropping out of college (Brocker & Lara, 2008).

Regular checks on Understanding
Lecturers who are more effective tend to check their students' understanding more regularly (Q10), as this study has found. This appears to be a logical progression from the previous two practices. When the lecturer emphasizes on understanding and is concerned whether his students are learning, he will naturally check their understanding more regularly. This is similar to what Hattie (2003) has found in his study that expert teachers are better in monitoring and assessing student understanding and progress and be able to provide more relevant and useful feedback.

One would notice that the five teaching practices discussed above actually cover the four dimensions of effective teaching Stronge et al. (2011) identified in their study, i.e. Instructional Delivery (Q6), Student Assessment (Q10), Classroom Environment (Q2), and Personal Qualities (Q14, Q15), signifying the importance of holistic approach to effective teaching practices. Another observation is that four of the five practices (Q2, Q10, Q14, Q15) are not found in the effective teaching behavior list identified by students in the study by Delaney et al. (2010). This implies that the student views on effective teaching practices could be rather limited.

Conclusions and Recommendations

One conclusion that can be confidently drawn from this study is that teachers indeed make a difference, and they do so through the teaching practices that they utilize in the classrooms. In this particular case, a student taught by the most effective lecturer could score 12 marks higher than another student with the same GPA taught by an average lecturer. In comparison, a student taught by the least effective lecturer would score 6 marks less. If this student were to be taught by the most effective lecturer, he would have had his marks increased by 18 points. Such is the difference a teacher can make!

The choice of teaching practices used in the class also has a significant impact on students' learning. The most effective group of lecturers in this study exhibited high utilization of practices in all four dimensions of effective teaching, suggesting that there is a need for holistic approach in effective teaching. In this case, the lecturer must be able to manage the classroom well, convey the expectation clearly, explain and check for understanding, and care about student learning. The study further suggests, judging from the correlation coefficient, that classroom management is of paramount importance.

It can be concluded that semestral GPA can be used to estimate teaching effectiveness of individual lecturers through the use of VAM which predicts DIGLG scores. However, it should only be used as feedback to improve teaching, rather than for high stake decisions such as promotion, salary increment and dismissal. There are still issues such as the effect of non-random assignment need to be addressed.

Recommendation & Further Studies
Based on this study, the following are recommended for the division to consider:
1. The simple VAM can be used to analyze common test (midterm test) result for the purpose of identifying classes that have low VA scores. This provides an objective way to feedback to the lecturers that the method is not effective and that they need to improve it in some way. As compared to using average mark or passing rate to judge effectiveness in teaching, this is more convincing.
2. This study has shown that classroom management is extremely important to effective learning and yet most lecturers do not exhibit high utilization of such practice. There is a need to develop lecturers to acquire effective skills in classroom management.

Further studies are needed to answer several questions arise from this study. For example, what is the effect on non-random assignment for this model that uses semestral GPA? Will it produce biased result the same way the critics claim the traditional VAM will? What about for year 1 students who do not yet have GPA? What can be used to as a reference to calculate VA score? In ECE division, most of the classes have different lecturers for lecture, tutorial and practical. In a situation such as this, how can class performance be fairly attributed to different lecturers? These are the important questions that upon answered will have a clearer picture of which and how lecturers make a difference.

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MATHEMATICS ONLINE – A LEARNER CENTRED TUTORIAL SYSTEM DEVELOPED BY AND USED AT NGEE ANN POLYTECHNIC

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Abstract

Mathematics is an important subject that all Engineering students need to master as it serves as foundational knowledge for many engineering disciplines. The mathematical abilities and learning styles of the students at polytechnic level are very varied. To harness the advancement in technology and computer assisted learning, add value to the learning experience of students and promote independent learning, Ngee Ann Polytechnic (NP)'s team of mathematics lecturers spearheaded the development of the Mathematics Online (MOL) system. The system has undergone several phases of enhancements since it was first launched and it is still actively in use today.

MOL is a self-paced, learner-centred tutorial system, comprising tutorial questions with worked examples, as well as an assessment component. It allows students to attempt unlimited practices of basic-level questions to strengthen their mathematics foundation.

This paper will present and discuss key features of the effectiveness and efficiency of MOL which include the following:
1. Customisable practice question sets
2. Empowerment of learners
3. Immediacy of feedback to learners
4. Self-monitoring feature for students
5. Progress monitoring feature for staff
6. An adaptive assessment system

This paper will also share how the features of MOL have benefited students' learning. Quantitative data from a student survey demonstrate the impact of MOL on students' perception of their learning in areas such as thinking and self-directed learning.

Keywords: *mathematics, online tutorial, independent-learning, adaptive assessment, customised practice, immediate feedback.*

Introduction

Teaching methodology is always evolving, especially in the 21st century, the age of technology. In Ngee Ann Polytechnic (NP), the teaching of mathematics was no longer restricted to chalk and board when the idea of an online tutorial system in mathematics was first mooted in the 1990s. Thus, Mathematics Online (MOL) was designed to embrace e-learning for borderless teaching and learning. This also supports business continuity by moving away from traditional face-to-face lessons confined to a classroom.

Literature reviews released over the last decade verify that there are good reasons to develop an online learning system in mathematics, riding on existing computer software with mathematical capabilities. MOL was ahead of its time when it was created in the late 1990s.

Computer algebra systems (CAS) are well-established software for performing manipulation of mathematical expressions (Naismith & Sangwin, 2004). CAS has the ability to correctly assess whether two expressions that are presented in different forms are algebraically equivalent. CAS is also able to mark an answer by checking it against each required condition separately, a procedure that could be extremely laborious if done manually (Sangwin, 2003, 2004). In addition, a CAS is also able to generate unlimited questions with random parameters. By using random parameters, each student can receive a unique set of questions, which may assist in reducing plagiarism (Naismith & Sangwin, 2004). MOL was developed with all the above capabilities and features in mind using Scientific Notebook which has a built-in CAS (Maple in earlier versions and/or MuPAD in later versions).

The increasing availability of computers and internet technologies has thus led to a surge in the number of online mathematics portals which allow students to learn mathematics independently such as Khan Academy, Purplemath, IXL Math, National Library of Virtual Manipulatives, and ASKnLearn.

On the other hand, in designing effective e-learning systems, it is necessary to understand the target population (Liaw, 2004). Learner characteristics, such as self-efficacy, self-directed behavior, and autonomy need to be identified (Passerini & Granger, 2000). Environmental characteristics, learners' attributes and instructional structure should be taken into consideration when developing e-learning systems (Liaw and Huang, 2007).

Advocating the above views, MOL was developed as an integrated learning system that has dual purposes, as (i) an online tutorial platform and (ii) an adaptive assessment tool. It stands out from other typical e-courseware as it has an adaptive assessment component that are lacking in many free courseware available on the internet.

According to Bechard, Kahl and Hill (2004), adaptive tests are structured such that items are presented in an increasing order of difficulty. Students may continue taking the test as long as they answer items correctly or do not respond with a certain number

of incorrect answers in succession. The underlying assumption is that the student is unable to correctly answer any other more difficult items once one or more incorrect answers were given. It is with this design approach in mind that the MOL adaptive assessment component was conceived.

MOL as a comprehensive online tutoring system

MOL was developed by NP mathematics lecturers with a question bank of around 2350 mathematics problems. Being an online platform, students are able to access it at their own time, and have control over where, when and how often to access MOL for practice.

Promoting self-learning

Independent learning takes place when students study an example with detailed solution that is available on MOL before attempting to solve associated exercise questions. Figure 1 shows a sample of a typical MOL example with full solution.
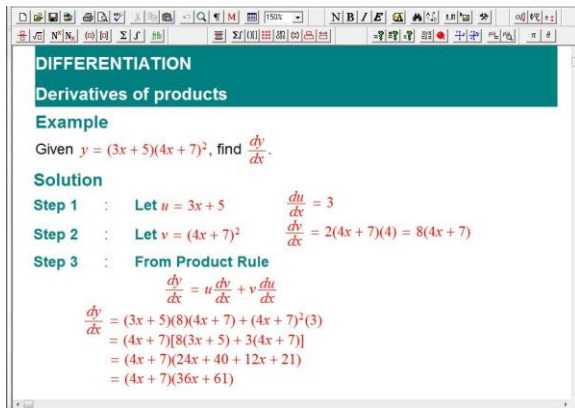
Figure 1. A sample example in MOL

As this helpful guide is made available for every topic on MOL, students may choose any topic(s) to learn, providing them the opportunity and space for effective self-learning.

Customising practice question sets

MOL was developed to meet NP mathematics requirements of various diplomas offered across different disciplines of Engineering, Health Sciences and Life Sciences.

In practice, the lecturer in-charge of each module will select exercise topics for his/her module at the start of each semester. This customization means that the exercises can be selected according to the specific module syllabus and also pitched at the right level of difficulty for that cohort of students.

Providing immediate and specific feedback to learners

MOL is able to provide unlimited questions for students who wish to have more practice to better grasp concepts learnt and be familiar on how to apply them in solving mathematics problems.

Each time a student attempts a question in MOL, the system generates the question from a fixed template but with randomised parameters. In this way, two students doing the same exercise will see different questions that test the same skillset. Even if the same student attempts that particular question again for the second time, he will see a new question. Figure 2 shows a sample question in MOL.
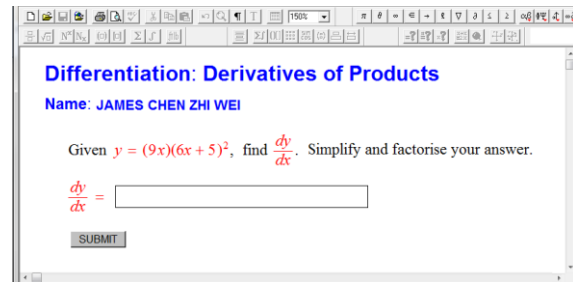
Figure 2. A sample question in MOL

Students may repeat the practice as often as they wish until they are satisfied with their level of proficiency. The practice is marked immediately by the system and students receive instant feedback for every answer. The system, together with its huge pool of related examples, is available 24/7, to help students reinforce their mathematical skills.

When an answer is submitted, the system acknowledges whether the answer is right or wrong for the student's reference. In the event that wrong answers are submitted, students receive immediate feedback and are given step-by-step solutions, including relevant formulae where appropriate. Figure 3 shows a sample of such typical response.
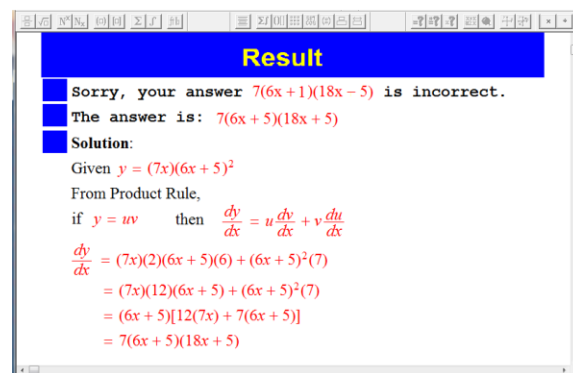

Figure 3. A typical response/feedback displayed in MOL upon receiving a wrong answer input.

Students may re-attempt the practice questions until they get the right answers. Therefore, with each attempt on an MOL exercise, students can clarify their misconceptions and hopefully, through enough practice, build their confidence in mathematics.

Monitoring students' progress

MOL also provides every student with an online progress chart with information on each question to be attempted. The progress chart indicates if each of these questions is answered correctly, incorrectly or yet to be attempted per topic. This feature allows students to plan their own learning and acquire skills at their own pace, time and place.

At the same time, staff tutors are awarded access rights to monitor students' progress. Tutors are also informed on the amount of time each student spent working on specific questions, thereby identifying the need to revise particular topics deemed difficult by the students.

Throughout the semester, tutors may opt to periodically display the entire class' progress to students to instill a sense of competition, motivating students to accomplish more. Good students feel a sense of satisfaction that their rapid progress has been captured by the system while slower students feel a sense of urgency to catch up with the rest of the class.

MOL as an adaptive assessment tool

Every topic in MOL ends with a 'Revision' component that is adaptive in nature. All questions in the MOL bank are pegged to one of the three difficulty categories with category 1 as the lowest difficulty. At the start of a Revision, MOL presents the student with a set of category 1 questions. If those are answered correctly, the student is allowed to move on to category 2 questions. On the other hand, if the category 1 questions are answered incorrectly, MOL will continue with questions of the current category of difficulty. This iteration continues until the learner has achieved the required standard set by the program. Thus, a stronger student will take a shorter time to complete the MOL Revision compared to a weaker student. Figure 4 shows the flow chart of the MOL Revision.

The adaptive assessment algorithm is good because our students possess a very diverse range of mathematics proficiency. At one end of the spectrum are international students and those who had taken Additional Mathematics in their secondary schools, both of whom have stronger mathematics background. At the other end of the spectrum, we have weaker students who might not have taken O level Elementary Mathematics. Thus, an adaptive teaching and assessment tool like MOL is very appropriate for our situation where it is common to find a very diverse mix of students even within one class. The stronger students enjoy the satisfaction from completing some tasks faster than others, allowing them to advance to further topics, while the weaker ones appreciate that they can have more time to practice on their demand.

Figure 4 also shows that if a student gives too many consecutive wrong answers, the system will automatically 'pause' the Revision and prompt him or her to seek remedial help. The staff tutor will then provide the said student extra coaching and upon

meeting some level of proficiency, grant him/her re-entry to the system.

This mechanism also serves to discourage students from trying their luck with mindless answers. MOL takes appropriate action against such learners by forcing them to work through solutions in a proper manner; otherwise, they risk going through the longer route in completing MOL Revision.
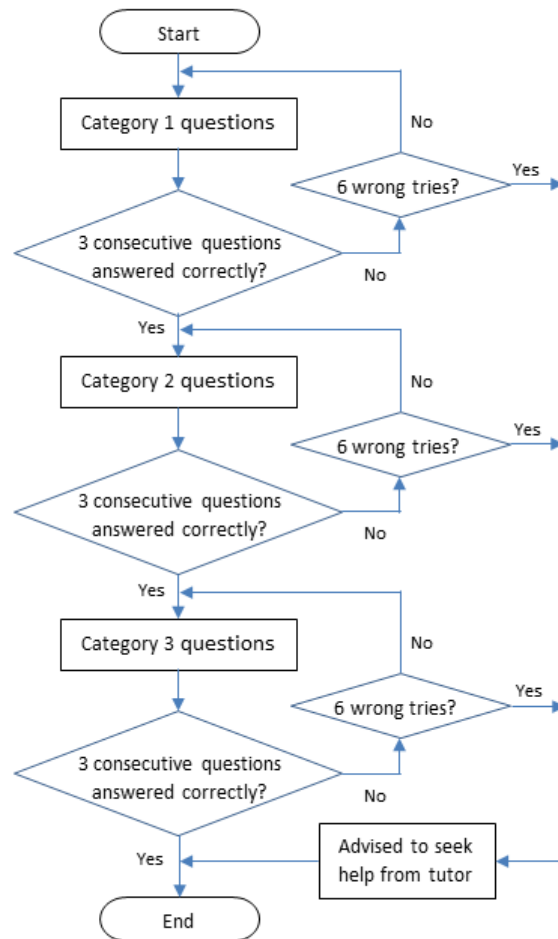

Figure 4. Algorithm of MOL's adaptive assessment.

Unlike the Exercises which can be practised at one's own time and pace, the MOL Revision component is attempted by students in the presence of their tutors during formal class time. This ensures that the Revision exercises are genuinely completed by students themselves and not by proxies. Tutors can verify the name of each student as it is displayed on the respective student's MOL page.

In summary, the MOL Revision is appropriately designed for today's classroom situation which sees a wide spectrum in the mathematics proficiency levels of students. It has an adaptive assessment mechanism that works well in managing a class of learners with varied-ability. It has features to incentivize and motivate, as well as a control system to discourage effortless and mindless answer inputs.

Students' feedback

A survey was conducted in June 2013 to gather students' views on the use of MOL. 743 students responded and the results of the survey are summarized in Figures 5, 6, 7 and 8.
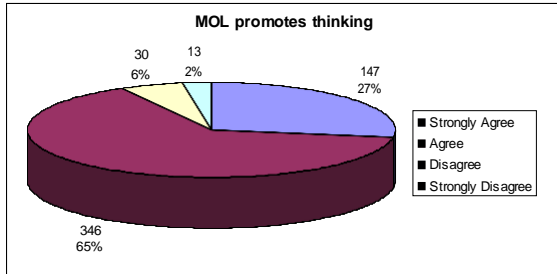

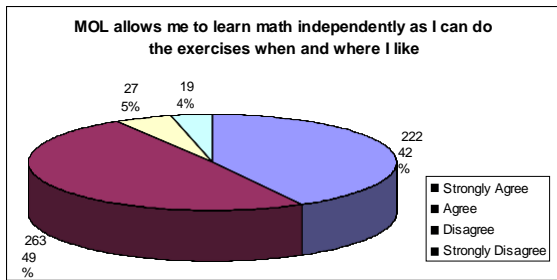Figure 5. MOL promotes thinking

Figure 6. MOL promotes independent learning

From Figures 5 and 6, more than 90% of students agreed and/or strongly agreed that MOL promotes thinking and helps them to cultivate independent learning habit. It is very encouraging because students feel a sense of ownership and take control of their own learning.
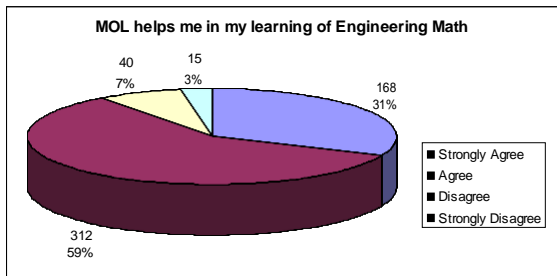
Figure 7. MOL is helpful in the learning of mathematics
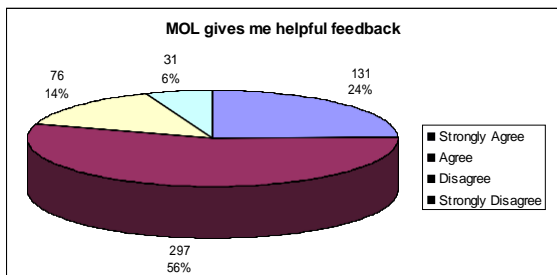
Figure 8. MOL provides helpful feedback

Figure 7 shows that 90% of students were able to appreciate the relevance and benefits that MOL offers in supporting their studies of Engineering Mathematics. The MOL is a source of help that is very practical especially when students need help outside the scheduled classroom meetings. This view is echoed again in Figure 8 that shows 80% of students agreed and/or strongly agreed that MOL provides helpful feedback.

Overall, the survey results indicate the effectiveness of MOL and its popularity with students, with more than 80% of them finding it a useful tool for thinking and learning. We are heartened by the positive response and appreciation by the students, which has in turn motivated us to enhance MOL further.

Future Development

Although MOL has served students well and attained some degree of success, there are two areas for potential development in the future.

Firstly, students and staff have to access MOL using notebooks or desktop computers at the moment. If MOL could be reconfigured to be more mobile-friendly, students will be able to access it from any mobile devices, which may translate to greater participation.

Secondly, we believe it is beneficial to tweak and enhance the adaptive nature of MOL assessment. With the current algorithm, students are always working from easy to difficult questions. It will be useful if students can start with middle-level questions and then move on to either easier or harder questions depending on individual student's ability.

Conclusion

MOL is a robust, integrated system that has dual purposes. As an online tutorial platform, it promotes a learner-centered mathematics learning culture in Ngee Ann Polytechnic. As an adaptive assessment tool, it helps educators set assessment that caters to different needs of students of varying abilities. It helps students to diagnose their weakness and then directs them to relevant questions for more practice to overcome the weakness before progressing to the next level.

Survey results have shown that MOL is well received by the students. Students find it useful in helping them to strengthen their foundations in mathematics and it certainly enhances their learning of Engineering Mathematics in the polytechnic.

In conclusion, MOL has proven to be a popular self-learning tool that is learner-directed and adaptive. It has supplemented classroom tutoring and has relieved the tutor with more time to guide those who need personal one-to-one coaching. The success in its design lies in its user-centredness, customisability and immediacy of feedback, amongst other strong features. It has made the learning of mathematics an effective and unique experience at Ngee Ann Polytechnic.

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REDESIGNING LESSONS TO MEET STUDENTS' LEARNING PREFERENCES

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Abstract

The Diploma in Aerospace Technology is one of 12 engineering courses offered by Ngee Ann Polytechnic. Good employment prospects and the lure of working in a niche industry have ensured that the course consistently attracts students with good academic quality. The majority of these students either have a strong interest in aerospace or aspire to work in the aerospace sector in the future. Compared to students from the other engineering programmes, the aerospace students should in general, be more academically motivated.

However, although the aerospace students appear to be academically stronger, they experience similar problems in learning as students in other engineering disciplines. One problem is the adoption of surface-approach to learning. Students seem only to want to focus on the information that is critical in helping them to do well in their assessments and thus adopt a "just-in-time" attitude to learning. They strive to do only what they see as really necessary to do well in their diploma. The ensuing lack of desire to invest more effort in the learning process often results in these students being disengaged in the learning process.

This paper proposes that a probable cause of student disengagement in the learning process is the mismatch in learner and instructor styles. This is supported by educational research that has shown that understanding the learning styles of students is one key area in promoting an effective learning environment. To manage the different learning styles of students, the teaching team in the Diploma in Aerospace Technology has introduced an inquiry-based learning approach to their curriculum. Results have shown that the redesign of the curriculum has promoted learner-directed learning which is an outcome of increased motivation and more engagement with curriculum.

Keywords: *Aerospace Industry, Engineering Curriculum, Learning Preferences, Learner Profiles, Enquiry-based Learning.*

Introduction

The Diploma in Aerospace Technology (AT) is an engineering course in Ngee Ann Polytechnic (NP) under the School of Engineering (SOE). It is focused on the discipline of aerospace applications. The course was initiated in 2003 as a result of a growing demand for aerospace professionals in Singapore and an initiative by the Economic Development Board of Singapore to increase labour supply in this sector.

Good employment prospects and the lure of working in a niche industry have ensured that the course consistently attracts students with good academic quality. The course admits 'O' Level graduates from the Science and the Design & Technology streams. These 'O' level graduates form the mainstream students of each cohort (approximately 80%). In addition, the course also admits students from the Institute of Technical Education and Direct Entry students with special talent in sports or other non-academic portfolio.

As compared to students from other engineering courses, the AT students possess a relatively stronger academic disposition. The GCE 'O' level aggregate scores for enrolment into the AT course was 13 points for the recent 3-year period from 2012 to 2014. Compared with the aggregate scores for other Mechanical Engineering courses that range from 16 to 22, the AT course attracts students with a stronger academic profile. Moreover, majority of the students who are enrolled in the AT course either already possess a keen interest in aerospace technology or have aspirations to work in the aerospace sector.

With the aforementioned factors it is, perhaps, natural to coorelate the academic and non-academic competencies to a relatively problem-free teaching and learning environment in the AT course. However, the fact is AT students experience a multitude of problems in learning similar to students in other engineering disciplines. In particular, it was observed that there is a steady emerging profile of students who has become disengaged with learning. From an inital loss of motivation affecting grades in the short term to eventual lost of interest in the course, if this issue is left unaddressed, the consequences is dire.

This paper explores the probable cause of student disengagement in the learning process and suggests that a mismatch in learner and instructor styles could be a key contibuting factor. The paper will futher descibe the

different strategies that are used by AT to transform the learning enviroment to suit students' learning preferences.

Reflection of Current Teaching Practices & Challenges

(1) Current Instructional Methods & Learning Environment

The adopted method of delivery in many modules within the AT course curriculum is consistent to an education in engineering. Engineering, being a specialised discipline, requires students to grasp threshold concepts as described by Meyer and Land in Fry, Ketteridge and Marshall (2009) before moving on to applications or higher levels of knowledge.

Felder & Brent (2005) reviewed various models that classify the way students learn and process information. Most lectures in the AT course, where important concepts and information are disseminated, are delivered in didactic engineering tradition. This style of teaching benefits students who possess a strong reflective learning disposition. These are the Type 2 learners (abstract, reflective) as explained by Kolb's experiential learning model while alienating the rest of the students (Felder and Brent, 2005).

The current learning environment in AT is a typical classroom setting. Lecture size is typically kept to approximately 40 students while tutorial and practical classes are kept to approximately 20 students. This arrangement is adhered to as far as possible to ensure adequate interaction and efficient supervision. The practical component of the modules provides opportunity for experiential learning and builds on the knowledge the students have acquired in lectures. Thus, the method of delivery can be considered to be traditional as that described by Biggs (1999).

(2) Surface-approach to learning

Although the students appear to possess the academic competency required of the curriculum, they face the same multitude of problems like students in other engineering courses. One issue that shrouded the organic learning process is that many students have developed a surface-approach to learning. These "surface learners" are concerned with "important" information that will help them through the various tests and examinations and adopted a "just-in-time" attitude to learning. They have a tendency to want to "do the least" and "get the most" out of the education system. Their lack of motivation leads students to become disengaged in the learning process. Taking this (just-in-time) approach to learning is in stark contrast against cognitive constructivist theory which views learning as an active process that must be constructed from experience as outlined by Fry *et al.* (2009).

Understanding Learners' Learning Styles to Transform the Learning Experience

Felder, in his classic 1988 paper, acknowledged the fact that mismatch exist between the common learning styles of students in the engineering discipline and the traditional teaching styles of the engineering educators. The literature provides a wealth of well-researched data that has shown that understanding the learning styles of students holds the key in promoting an effective and efficient T&L environment (Felder, 1993; Montgomery and Groat, 1998; Aripin, Mahimood, Rohaizad, Yeop and Anuar 2008).

Understanding learning styles is especially important in recent times with the cohort of what Barnes, Marateo and Ferris (2007) termed the Net Generation. This is a generation who grew up in the forefront of technological changes - in an era epitomised by the availability of instant information at their fingertips fuelled by the development of digital technologies. This generation has "distinctive ways of thinking, communicating, and learning". (Barnes *et al.*, 2007; Prensky, 2006). If there exist a time where the amplitude of such mismatch between the learning styles and teaching styles is at its greatest, it has to be this moment.

Understanding the learning styles of AT students

The literature is littered with various instruments that are available to users to solicit and study students' learning styles. Many authors have attempted to summarise these instruments such as Felder and Brent (2005) and Montgomery and Groat (1998).

A more recent effort by Solomon, Tyler and Taylor (2007) has shown that a person learns best if the instructional settings match his or her learning style and type preference. This provides the impetus for the teaching team to embark on a fact-finding exercise to learn more about the prevalent students' learning style in the AT course.

For this exercise, the Visual-Auditory-Kinaesthetic (VAK) learning style model (Chislett and Chapman, 2005) was adopted over the more famous Myers-Briggs, Kolb or Felder-Silverman learning style models. The reason was due to its simplicity and ease of administration.

All AT students enrolled in 2012 was surveyed using a VAK questionnaire. The result of the survey was presented in the ISATE 2013 conference by Ong (2013). It is reproduced again in this paper in Figure 1. The results were not surprising and were expected from students who have chosen to embark on an engineering education. This served to provide an emphatic confirmation to what the course team already anticipated. Surveys conducted after 2012 at a smaller scale revealed results that were similar in order of magnitude.
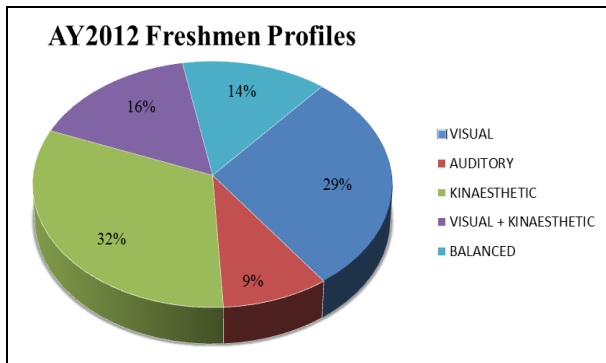
Figure 1: AY2012 Freshmen Profiling Results (Ong, 2013)

A high proportion of the students exhibited Kinaesthetic and Visual traits while a small number showed Auditory traits. This is in line with the observation of many authors in the literature including Felder (1988) who has explicitly mentioned "many or most engineering students are visual, sensing, inductive, and active..."

Redesigning of a Lesson to Bridge the Teaching and Learning Styles Mismatch

One of the strategies adopted in AT after understanding the learners is to redesign the learning experiences to better match student's preference. The Aerospace Maintenance and Manufacturing Practices (AMMP) is one such module that made the adjustments. This is an introductory coursework module to the aerospace industry for Year 1 AT students. It introduces essential aircraft hardware and maintenance processes. Taking into account that this will be the first exposure to the aircraft technical domain, the syllabus has been carefully selected and aligned to the industry standard. Although this is a first year module, the AT course pays particular attention to the performance of the students as a favourable learning outcome lays a firm foundation for sequential modules.

This module is "technical" in that the majority of the content is focused on definitions and description of aircraft terms and processes. Coupled with the fact that the delivery utilises the traditional approach of engineering education (lecture-tutorial-practical), a pre-existing mismatch is present between the students' learning and lecturers' teaching styles.

Student feedback from the polytechnic's module experience survey provided a glimpse of this mismatch. Unfavourable comments ranged from the module being too difficult, favouring students with high "memory capacity" and lengthy descriptions to boring lectures were common. This group of students were a minority but still a cause for concern. A consolation from the feedback was that a good number of students exhibited, to a certain extent, a deep-approach to learning (Biggs, 1999). They were able to appreciate the intent of the module and relate to their future working environment. These students showed a level of maturity among the Year 1 students. This, perhaps, is in line with the observation by Barnes *et al.* (2007) when they commented that one key characteristic of the Net Generation is that they are, in actual fact, education oriented and they treasure the value of education.

The key challenge for the team was not to change the basic content of the module to cater to the demand of the minority who appeared to have adopted a surface-approach to learning. This group of students was interested in knowing just enough to pass exams and has a tendency to want to "do the least" and "get the most" out of the education system.

The actions that were undertaken were to infuse a multi-style approach (Felder, 1993) to satisfy the multi-learning styles of the students in a class. In particular, the team was interested in addressing the group of students who exhibited Visual and Kinaesthetic learning styles.

(1) Change of learning environment

The first approach was to change the physical learning environment. Instead of lectures in the classrooms, they were now conducted in one of the laboratories located within the premises of the Aerospace Hub. The Aerospace Hub, as shown in Figure 2, is basically an aircraft workshop where retired aircraft, auxiliary components and aerospace equipment were housed. This change was an effort to bring the students closer to an "aircraft" environment and to create a more conducive teaching and learning atmosphere. The feedback from the students was positive as they commented that they felt "at-home" learning about aircraft in an aircraft environment. In fact, many were excited to be studying in an environment that did not resemble the classroom from their lower education school days.

Figure 2: Ngee Ann Polytechnic's Aerospace Hub

This strategy particularly benefited the Visual and Kinaesthetic students, as they were able to connect the information delivered with the sensory information such as sight, sound, and touch which they gathered through their exploration of real hardware on-site in the Aerospace Hub. More importantly, this change of environment was purposeful as it allowed the team to execute the next sequence of changes.

(2) Mini-lectures

The next approach was to modify the lectures to adopt a "mini-lectures" style of delivery. In the previous design of the module, each two-hour lectures was divided into two segments: the first hour was used to deliver threshold concepts (Fry *et al.*, 2009) and the second hour used for tutorials. The problem with this approach was that the first hour had a tendency to converge to a didactic session that catered mainly to the small number of Auditory students. This was a major mismatch to the predominant learning styles of students as indicated by the VAK survey results.

The first segment was broken up into "mini-lectures" each focusing on selected topics of the content to be delivered for that teaching week. The number of selected topics had to be kept small due to the constraint of time and to promote effective learner engagement. The team also took advantage of the new learning space in the Aerospace Hub by using relevant equipment to demonstrate concepts to the students enabling them to immediately connect, contextualise, and understand how the concepts learned were applied. This teaching style particularly benefited the Visual and Kinaesthetic students as they were able to relate better the sound, images and senses to the information delivered.

The second segment was kept unchanged deliberately to allow the students to reflect on what were learned in earlier. This segment was particularly important after the introduction of "mini-lectures" as the lecturer no longer adopt an intensive coverage of content in the selected topics. It was imperative that the students in this segment now take ownership of his learning, reflect on the discussions and organised the learnings that took place earlier.

(3) Inquiry-based Approach

An inquiry-based approach to discussions was adopted to encourage more engagement from the students. The lecturer would take on the role of a facilitator or what McWilliam (2008) termed as a "Guide-on-the-side". The discussion usually starts with the posing of open-ended questions by the lecturer to trigger the student's inquisitive behaviour. The discussion usually starts with simpler inquiry tasks to orientate students to the nature and dynamics of learning, which also allows students to experience success in these initial encounters with inquiry-based learning. This is critical as it helps students to become more comfortable with asking themselves reflective questions, seek possibilities, and explore answers. As students responded well to this approach and gained confidence, any cognitive barriers they may have faced were reduced. Students gradually became more meaningfully engaged in their learning journey.

For instance, students were shown an aircraft structure component known as a "frame" (Figure 3) on an existing airframe of a retired fighter aircraft. Through examining the orientation and layout of this component relative to the airframe, students were requested to infer its functions and to explain its roles. With the lecturer's assistance and after several rounds of discussions and iterations, the students eventually arrived at the right conclusion. What made this learning more interesting was that students tend to uncover new components when they get on to the "wrong" path in search for the answer. The learning outcome was achieved in a "fun" way, bypassing the "painful" process of memory work as the entire session left a deep impression in the students.

The inquiry-based approach was a step forward from the traditional engineering teaching approach. The approach had the students' learning style in mind and took on a student-learner-centred approach (Biggs, 1999; Wyatt, 2005; Oliver, 2007).

Figure 3: The aircraft frame on a fuselage

Changing Role of a Teacher

Traditional approaches to teaching involves the teacher taking on the role as the holder of knowledge, or what McWilliam (2008) refer to as the "Sage-on-the-stage", dictating and imparting packets of information to the students on a "one-way" highway.

This traditional role of the teacher tends to assume that all students, and not just the academically-inclined students, learn in the same way, at the same pace, and have the same preference for 'sage-on-the-stage' learning delivery. It assumes that all students are their own facilitators, and that once the information packets have been delivered to them, it is 'up-to-them' to achieve the learning outcomes.

The 'Sage-on-the-stage' role does not take into account the range of learning styles and therefore learning needs that are present in a class. This can hinder students from making a positive impact on their own learning, from knowing that they can make a difference in their own learning journey; and discourages the typical student from taking ownership of their own learning outcomes.

This is the root cause of many of the problems faced by a good number of students in the engineering discipline, some of whom struggle with being disillusioned with engineering and have lost confidence in their ability to learn while others push themselves to survive in the course by adopting a surface-approach, acquiring just enough to pass the examinations.

Pilot of their own learning journey

Lessons can be designed and facilitated to instil confidence in the students. Students are encouraged to take ownership of their learning journey and make a difference in the learning outcomes. Inquiry-based learning is a learning approach where learning is achieved through research and investigation activities in response to set problems and tasks (Wyatt, 2005; Oliver, 2007).

The role of the teacher, in this instance, takes on that of the facilitator. He shall set the problems, provide guidance and introduce appropriate techniques to assist the students to get to the solution. Most importantly, the teacher shall only intervene when he needs to allow exploration and, thus, facilitating a free experimental culture of learning (McWilliam, 2008). To be more precise, the teacher has shifted from being a "Sage-on-the-stage" to a "Meddler-in-the-middle" (McWilliam, 2005), at times throwing a "curve-ball" to students to initiate higher order thinking skills.

Conclusion

The responsibility of learning does not fall solely on the shoulders of students in the 21st century society. Instructors and institutes of learning are just as accountable in promoting an effective learning environment. This paper has sought to provide a method of delivery that aims to bridge the teaching and learning styles mismatch in an engineering domain. By incorporating an inquiry-approach in the curriculum, a learner-directed learning can be promoted. This approach is neither too invasive nor resource intensive.

While a formal feedback channel to track learning outcomes is a work in progress, anecdotal responses from students suggested that they have benefitted from the redesign. Students, in general, agree that it was a step forward from traditional didactic lectures. Active participation and interaction have also make it easier for them to connect threshold concepts to real-world applications.

That the outcome improves engagement of the students with the curriculum through a relative small investment in time and effort provides a resounding impetus in taking that first step to make a change. The hope is that through on-going efforts to alter how learning happens in any curriculum, students can be encouraged to adopt a deeper approach to learning that will help them experience success not just in academics, but in their onward journey as learners.

Acknowledgements

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VIRTUAL RELAY CIRCUIT BOARD FOR LEARNING

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Abstract

This paper presents the use of the *Virtual Relay Circuit Board for Learning* to enhance the student learning experience and outcomes in a practical workshop module for a first-year engineering course in Ngee Ann Polytechnic. Relay circuit control is the basis in automation where students are taught how relay circuits behave as switches to sequentially control the power on/off of devices. During these practical hands-on laboratory sessions, students are required to do wiring and testing of a control circuit within an allocated time. This limits the opportunities that students may have to practice their skills.

To overcome this limitation on time, a virtual relay circuit board was developed to create more opportunities for hands-on practice in a virtual manner. The introduction of this virtual relay circuit board supplements the physical laboratory sessions by providing flexibility for students to try out wiring a circuit anywhere and anytime through the use of their mobile devices outside of the classroom.

The virtual relay circuit board includes the following features:
- A FreePlay mode where users can manipulate virtual wires by drag-and-dropping and wiring up any of the components and devices in order to simulate its operation.
- A 2D schematic diagram design mode where users can design a ladder diagram based on specified test scenarios by drag-and-dropping the correct components to form a control circuit.
- A 3D virtual wiring mode where users can virtually create a control circuit by wiring up the components and devices on the board. Users can also set and adjust the timer's duration by clicking onto a test button to commence the operation.
- A Play-back option in the 3D virtual wiring mode where users are shown step-by-step how wires and devices are connected.

This study will show that the *Virtual Relay Circuit Board for Learning* tool has helped students to better visualize and understand the principles of the wiring circuit operation.

Introduction

Electrical & Electronics Practical Skills (EEPS) is one of the compulsory workshop modules for first year engineering students. Students are taught the basics of electrical wiring and circuit design using the conventional electromechanical relay and timer to do switching and sequential control of fans, lights and buzzers. Students learn by actually building and wiring up the control relay circuit which could be very time consuming and also depend on the physical laboratory availability. With this constraint, courseware on virtual relay circuit board was developed to simulate a real world relay circuit board. Thus students are not limited by the availability of physical lab space to practice wiring of control relay circuit boards.

Literature review

Studies have shown that the use of 3D and virtual reality as learning tools allow the students to experience an entirely new side of training. This type of technology breathes life back into traditional computer based learning and re-awakens the enthusiasm in users who are used to this technology in other circles outside of training. The basis for the Virtual Reality idea is that a computer can synthesize a three-dimensional (3D) graphical environment from numerical data. Using visual output devices, the users get to experience working with a model of a real-world object and interact with computer simulated environment; this is allowed by the use of external input devices responding to the user's reactions and motions. (Fitzgerald & Riva, 2001).

Simulation is a technique for practice and learning that can be applied to many different disciplines of Science. The use of simulation to replace and amplify real experiences with guided ones, is often "immersive" in nature, evoking or replicating substantial aspects of the real world in a fully interactive fashion. (Lateef, 2010). Simulated environments allow learning and re-learning as often as required to correct mistakes, allowing the learner to perfect steps and fine-tune skills to optimize experimental outcomes. Simulation-based learning also enhances efficiency of the learning process

in a controlled and safe environment. (Gaba, et al., 1998).

Based on the research and findings on the use of Virtual Reality in Engineering Education, we can see the positive impact it has on developing students' competency in Engineering. With these in mind, Ngee Ann Polytechnic's EEPS teaching team designed and developed the Virtual Relay Circuit Board.

Virtual Relay Circuit Board for Learning

Relay circuit control is the basis in automation whereby relay engages electrical contacts which either start or interrupt power to a device. It could be either a fixed sequence or a series of distinct operations with a definite condition to initiate each operation. The operation can be either a time-driven sequential process where each step is initiated at a given time or after a given time interval; or an event-drive sequential process where each step is initiated by the occurrence of an event. Ladder diagram is used to describe an event-driven process.

In a typical hard wired motor control circuit, a motor is started by pushing a 'Start' or 'Run' button that activates a pair of electrical relays. The lock-in relay locks in contacts and keeps the control circuit energized when the push button is released. Another relay energizes a switch that powers the device by connecting it to the main power circuit. All contacts are held engaged by their respective electromagnets until a 'Stop' or 'Off' button is pressed, which de-energizes the lock-in relay.

FreePlay Mode

FreePlay Mode allows learners to experience working with the virtual relay circuit board. Learners can virtually wire up any of the components and devices on the virtual relay circuit board by connecting it to the supply. They can then tap the play button and watch the animation output to understand how the selected component operates. This gives learner's an insight into circuit operation like no equation does.

Unity3D JavaScript was used to develop navigation control in free-play mode. Learners are given the freedom to explore, navigate and interact with virtual relay circuit board. Learners can use either the on-screen control, the mouse or the keyboard to zoom, pan and rotate all by selecting the whole virtual relay circuit board as shown in Figure 1.
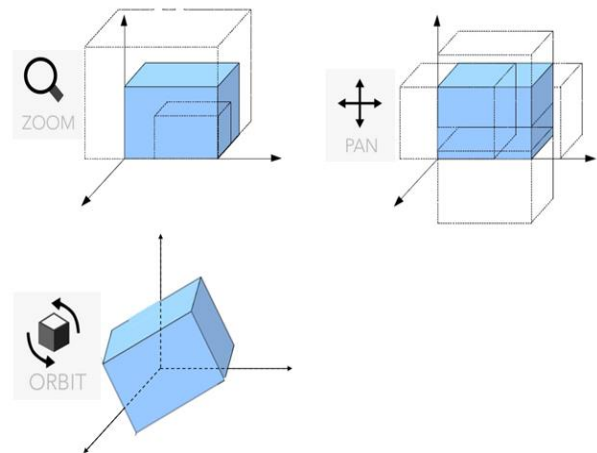

Figure 1 : Pan, rotate and zoom using mouse

Learners can easily create interaction with the components on the virtual relay circuit board by simply clicking on the component of interest. The selected component will have a faint box bounding it and a property window will appear for learner to input the settings of the selected component. Learners are prompted to input the time setting for the timer relay and the corresponding turning-dial on the timer will be moved to the correct position to reflect time setting as shown in Figure 2.
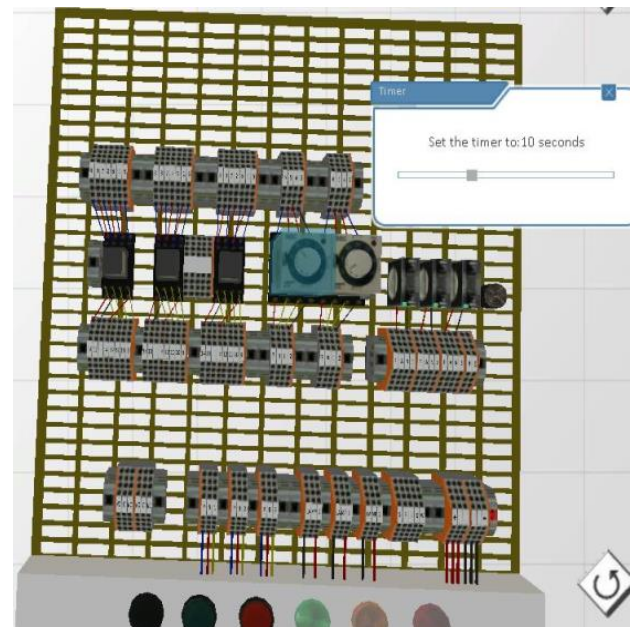

Figure 2 : Learner Interaction with components

Once the virtual relay circuit board is loaded, learners can proceed to wire up any of the components and devices on the virtual relay circuit board by using a mouse to select the pin-hole of a component followed by selection of another pin-hole of next component. Virtual wires created are drawn overlapping one another

in 3D dimensional and different coloured wires can be used to differentiate the connections between components and devices as shown in Figure 3.
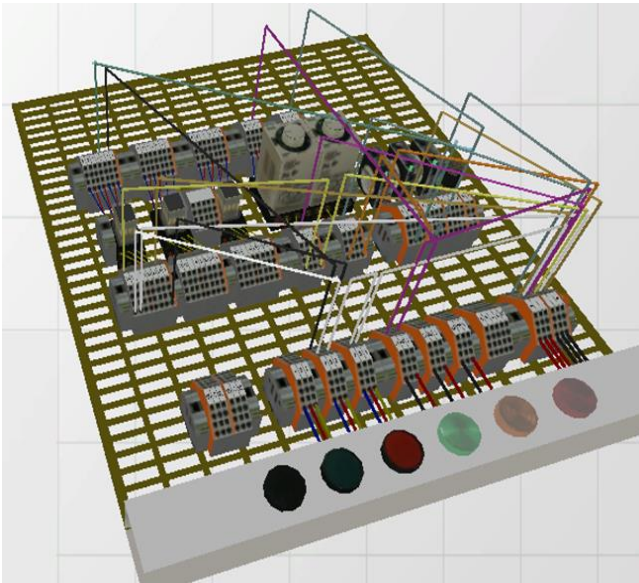

Figure 3 : Virtual wires created are drawn overlapping one another

Learners can tap the play button to see the animation output : lamps turn on/off, buzzer sounds and mini-fans rotate etc. This simulation output allows the learners to understand how relays, timer relays and other components on the relay circuit board operate.

2D Schematic Diagram

Ladder diagrams are 2D schematic diagrams commonly used to illustrate how electromechanical switches and relays are interconnected. They are called 'Ladder' diagrams because they resemble a ladder; The two vertical lines are called 'rails' and are attached to opposite poles of a power supply, 12V DC or 240V AC. Horizontal lines in a ladder diagram are called 'rungs', each one representing a unique parallel circuit branch between the poles of the power supply.
In ladder diagrams, the load devices, such as lamps, relay coil, fans, solenoid coils, etc are always drawn at the right-hand side of the rung. While it doesn't matter electrically where the relay coil is located within the rung, it does matter which pairs of relay's contacts, NO or NC contacts are used to turn on or off the devices sequentially.

    NO = Normally Open. Open means that no current can flow through.
    NC = Normally closed. Closed means that current can flow through.

Ladder diagrams are the most intuitive way to represent relay circuits. They are much easier to read & understand than wiring diagrams.

In the Quiz Mode, learner can design a ladder diagram based on specified test scenarios by drag-and-dropping the correct components to fill up a partially complete 2D schematic diagram in the order in which the sequence occurs. Learners are also prompted to key in the pin-numbers of the relay's contacts for the selection of normally open or normally closed contact to produce the desirable set of outputs, as shown in Figure 4.
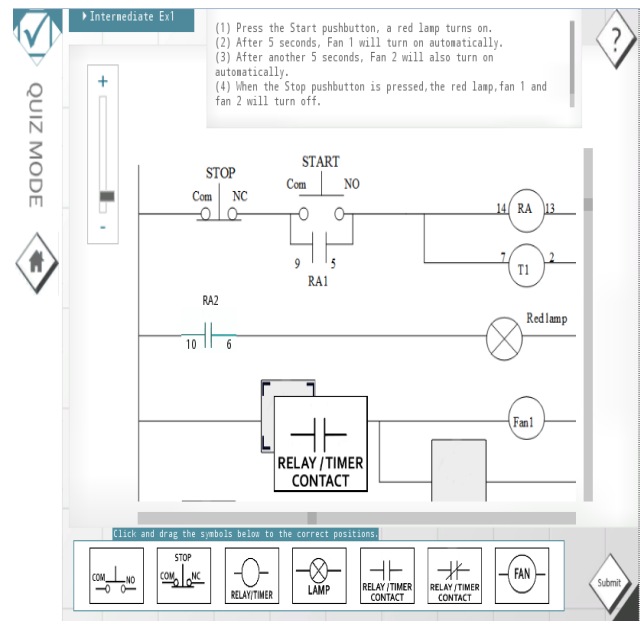

Figure 4 : Screen shots of designed 2D ladder diagram

Learners are given 3 attempts to submit their designed 2D ladder diagram. The system will then show the correct 2D ladder diagram before proceeding to the 3D virtual wiring mode.

3D Virtual Wiring

Unity3D game engine was used to develop the 3D virtual wiring mode. It features visual simulation capabilities with interactive functions and offers ease of use in the context of geometry data input and output.

In 3D virtual wiring mode, learners can virtually wire up components & devices onto the virtual relay circuit board, including power and signal connection. The workflow for the learner is to create virtual wires between pinholes of the components and devices on the virtual relay circuit board and set the right configuration setting for the components and devices to produce the correct output operations as dictated by the ladder diagram in the designing of 2D schematic diagram.

Learners are given 3 attempts to submit their 3D virtual wiring once they have completed wiring up the components. Upon submission, a dialog box will appear for the wrong wiring, to inform the learner of the wiring

configuration errors while the components or devices that were wired in-correctly will be covered with faint red bounding box. The dialog box also shows the number of attempts left for the learner to try again. Figure 5 shows an incorrect wiring submission, the dialog box indicates that timer 1, timer 2 and fan 2 are wired in-correctly and are covered with faint red bounding box, and the learners can proceed to amend his wiring if he has not exceeded 3 attempts.

Figure 5 : Wrong Wiring submission

Figure 6 shows an example of correct 3D virtual wiring submission. Here learners can interact by tapping the play button to see simulated output of the operation: lamps turn on/off, buzzer sounds and mini-fans rotate etc.
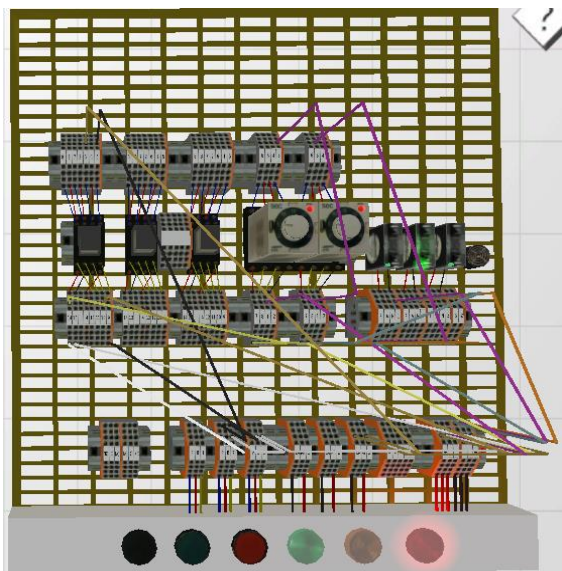
Figure 6 : Correct wiring submission. Learner can tap the play button to see simulated output operation

There is also a Play-Back [step-by-step] option in the 3-D virtual wiring mode which shows learners step-by-step how wires and devices are connected up,

including the configuration setting for the components and devices in order to produce the correct output operations. As can be seen in Figure 7, the play-back option has clearly shown the step and the order of wiring connection, *'wire the components and devices top-down, left to right, starting from line 1 of ladder diagram'.* This Play-Back [step-by-step] option is a very good learning tool for students to visualize how components and devices are connected to produce the desired sequential output operation and understand the circuit design.
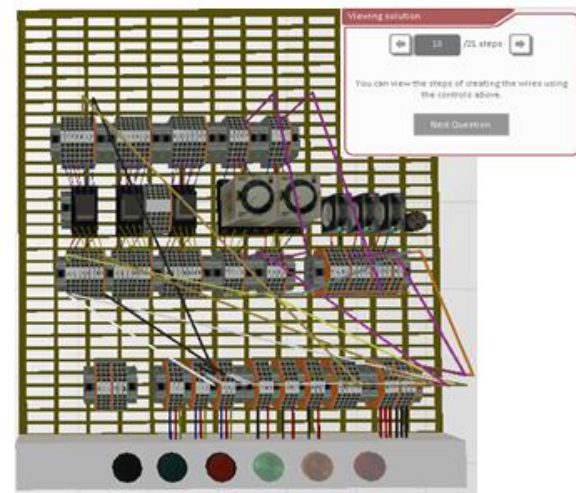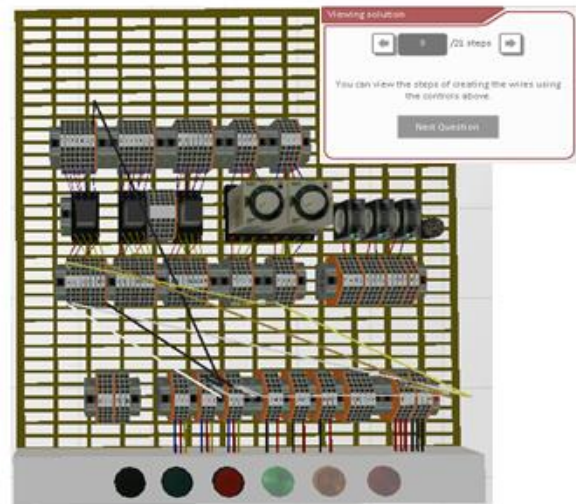

Figure 7 : Play-Back option, showing step-by-step how wires & devices are connected up

The *Order of wiring and Manner of connection are crucial in 3D* as it simplifies the trouble-shooting process. If the wired virtual relay circuit does not function or works partially, learners are able to zone it or zero into the particular component & device level to examine what has actually gone wrong rather than trying to figure out why certain wires (in the wrong order or sequence) were added which may result in short-circuit or malfunctioning of the circuit.

Survey & Discussion

As part of the learning experience in EEPS, students are required to participate in on-line quizzes on the wiring and testing of the virtual relay circuit board during the semester. The purpose is to allow students to evaluate their own understanding of the electrical wiring and circuit design after physically hard-wiring the relay circuit board in the experiment. Quizzes are conducted in two stages where students must first design and draft out the 2D schematic diagrams or the ladder diagrams based on specified test scenarios. Students will drag-and-drop the correct components to fill up a partially complete 2D schematic diagram in the order in which the sequence occurs. In the second stage, they will virtually wire up components & devices, including power and signal connection onto the 3D virtual relay circuit board to produce the correct output operations as dictated by the ladder diagram in the designing of 2D schematic diagram.

A courseware survey was conducted on 21 Nov 2012 with cohort size of 40 students who have taken the quizzes on the virtual relay circuit board. Table 1 tabulates the courseware survey results.

Virtual Relay Circuit Board Courseware Survey Results	Percent Agreed
(A) Learning value	
1. The activity helped me understand the topic.	100%
2. The activity stretched my thinking.	98.8%
3. The activity motivated my interest in the module.	96.8%
4. The activity/activities (e.g. case studies, games, simulations) is/are appropriate and relevant.	94.4%
(B) Visual Design	
5. The navigation was user-friendly.	88.8%
6. The visuals helped my learning.	83.3%
7. The instructions on how to use the courseware are clear.	94.4%

Table 1 : Courseware Survey Results

There were 2 key findings from the survey:

(1) Students had developed greater understanding through the use of the virtual relay circuit board. Survey results showed that all the students agreed that the virtual relay circuit board help them to understand the electrical wiring and circuit design.

Some comments extracted from students who had displayed satisfaction with the wiring & testing of the virtual relay circuit board are as follow :

"This software helps me to understand how relays, timers and other components on the relay circuit board operate."

"This software helps me to understand the module better, eg : designing the circuit & connecting them together."

(2) This virtual relay circuit board motivated the students and stretched their thinking. One of the key challengers in teaching engineering students is to motivation as the topics are often dry and technical. However, the use of virtual relay circuit board has increased students' participation. Survey results indicated that 98.8% of students felt that the programme has stretched their thinking and 96.8% said that they were more motivated to learn.

This has also been supported by written comments such as the following:

"This program motivates me and makes me understand this module better."

"3D wirings with different colours have stretched my thinking further as it gives me a clearer and more effective perception of how the components are connected."

To triangulate the results of the first survey, another comparison was made on test results before and after their learning experience with the virtual relay circuit board. Table 2 tabulates students' mean test marks before and after the implementation of the virtual relay circuit board courseware. A bar chart of students' mean test marks is shown in Figure 8. The chart shows that students' test marks have been increasing over time indicating improvement in performance after participating in the online quizzes on virtual relay circuit board.

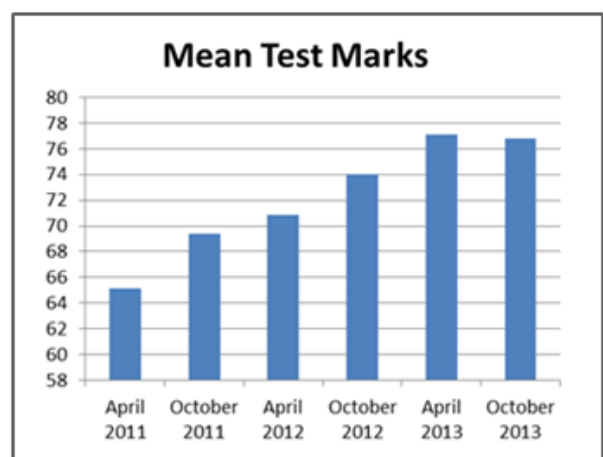| Relay Circuit Board Final-Test Marks		
Semester	**Mean Test Score**	**Remarks**
April 2011	65.17	Without Virtual Relay Circuit Board courseware
October 2011	69.41	
April 2012	70.85	
October 2012	74.01	Implemented Virtual Relay Circuit Board into module
April 2013	77.15	
October 2013	76.82	

Table 2 : Students' Mean Test Marks

Figure 8 : Bar Chart of students' mean test marks

While it cannot be concluded that the improvements in the test result is directly due to the virtual circuit relay board, the increased practice opportunities, the increased in understanding and motivation to think arising from the use of the system may be said to contribute to higher assessment results.

Conclusions

As evident from students' responses in the courseware survey and the students' final test on the electrical wiring of the relay circuit board, it is apparent that the use of the virtual relay circuit board has indeed enhanced the student learning experience and outcomes of Electrical & Electronics Practical Skills module. Learning is found to be more fun and engaging as students can practice wiring of the virtual relay circuit board anywhere and anytime with the use of mobile computers. Wiring up the virtual relay circuit board is as simple as drag-and-dropping of wire connections to any of the components and devices followed by testing its operations by tapping the play button. Students are motivated to participate in on-line quizzes and practices through the virtual wiring in multiple-attempts as a way to evaluate and test their concept and understanding of the electrical wiring and circuit design. By clicking onto the Play-Back option in the 3D virtual wiring mode, students can learn how wires and devices are connected up step-by-step, including the configuration setting for the components and devices in order to produce the correct output operations. In conclusion, the virtual relay circuit board provides students with the opportunity to practice wiring of control relay circuit in a fully interactive and engaging virtual environment.

Acknowledgements

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A SAFETY JOURNEY: INSTILLING A SAFETY MINDSET IN STUDENTS THROUGH BEHAVIOR-BASED LEARNER-CENTERED ACTIVITIES

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Abstract

Life Sciences and Chemical laboratories are inherently dangerous environments for inexperienced students. Statistics have demonstrated that one is more likely to get hurt in an academic lab than in an industrial lab[1]. The challenge in safety education is not only to impart the knowledge of safety so that students can manage their work competently, but also to inculcate an attitude, perception and commitment towards safety. The Safety Journey is a program devised by the staff at the School of Life Sciences & Chemical Technology (LSCT) in Ngee Ann Polytechnic. It is a comprehensive and holistic program that educates students in the area of safety and at the same time, inculcates a safety culture in LSCT using a behavior-based safety approach that is based on the principles of encouragement, enforcement, experience and education. As part of the Safety Journey, teaching and learning activities were redesigned to allow students to learn about safety and to apply this knowledge through scaffolded learner-centered activities. Opportunities were created for students to take responsibility for their own and their classmates' safety. Enforcement actions for safety violations were also firmed up and effectively communicated to students. Staff were also given additional training in safety and the need to be firm in enforcement actions.

The 4 Key initiatives of the "Safety Journey" program include:
- **Safety Communication: Safety Orientation Programs**
- **Safety Training: Formal modules in the curriculum on workplace health and safety.**
- **Application of Safety Knowledge and Responsibilities:** Students carrying out risk assessments and hazard identification as well as inclusion of reflections on safety in their internship reports and Final Year Project reports.
- **Creating Safety Awareness:** Safety campaigns such as an annual LSCT Safety and Health Week are launched to raise safety awareness.

The paper will also share evidence of the impact of these initiatives on students' and, ultimately, graduates' attitude, perception and commitment towards safety.

Keywords: *safety, mindset, learner centered learning*

Background

Safety Journey at LSCT

At the School of Life Sciences and Chemical Technology (LSCT), the teaching of laboratory safety has been in place for a long time. However, this was mostly instruction-based and did not require students to internalise and apply what they had learnt apart from following the safety instructions. It was also limited to the concepts of safety in the academic laboratory environment.

Following the introduction of the Workplace Safety and Health Act in 2006, LSCT embarked on a plan to further improve the safety education in our curriculum. We want to ensure that students are equipped with the necessary skills of practicing workplace safety when they graduate, and at the same time, to inculcate a safety culture within LSCT. We aim to make each student a leader in safety management within their own workplace.

This submission on the Safety Journey at LSCT describes the comprehensive program developed by LSCT to cultivate a safety culture in our School.

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[1] Chemical & Engineering News, Vol 88, Issue 5, pp 25-26, 2010.

The Workplace Safety and Health Act 2006

The Workplace Safety and Health Act came into effect on 1st March 2006 and covered the manufacturing and industrial sectors including laboratories in educational institutions. As at 2011, the Act now extends to cover all workplaces, including schools and educational institutions.

WSH 2018

The WSH 2018 was launched in 2009 as an enhanced national strategy for workplace safety and health. One of the key strategies of this vision was to build capabilities in WSH by enhancing pre-employment training (PET) to instil the value of safety and health in students. Phase 1 of this initiative involved institutions of higher learning (Universities, Polytechnics and ITE) from 2010 onwards, while Phase 2 involved Primary and Secondary Schools and Junior Colleges from 2012 onwards.

As commented by Mr. Lee Tzu Yang, Chairman of the Workplace Safety and Health Council, during the Workplace Safety and Health Award Ceremony 2007:
"Exposing our young early to safety and health before they begin working will help set expectations, drive change through the generations, and support raising of standards, as well as build a strong WSH culture."

Impetus for the Development of the Safety Journey

In response to the greater emphasis on Workplace Safety and Health in Singapore, as well as the strategic thrust to improve safety education in schools, LSCT developed a comprehensive framework to incorporate safety in our curriculum in 2006.

Challenges in Teaching Safety

Our students join us directly from the secondary schools where they do not have much exposure to laboratory work and hence laboratory safety. In LSCT however, students regularly work in laboratories and are exposed to hazards which are new and unfamiliar to them. It is therefore necessary to introduce safety rules and teach them how to manage safety hazards gradually and in a way that was understandable to freshmen. Even after that, there is the issue of internalising what has been taught, and making safety a part of their work habit.

Traditionally, safety had been taught in an isolated manner in our various courses. Some diploma courses had modules on Workplace Safety and Health, which was taught in the second year and prepared students for internship and work. However, students often failed to see the relevance of this module until they were in the midst of their internship or when they graduated and started working in the industry. Therefore, the need for

safety training to begin early and to be introduced in a more holistic way where the training can be applied, especially in practical modules, was identified.

For diploma courses which did not have formal modules on safety, safety briefings were conducted before laboratory classes. These were mostly instructional briefings and did not allow students to apply their knowledge of risk assessment and hazard management during their studies.

Students also have the tendency to assume that the safety measures would all be in-place, and there was no need for them to be concerned about safety. It was a challenge to get them to take more responsibility for their own safety in the laboratory. This was especially important for students conducting their Final Year Project where students spend most of the time in the laboratories and were expected to work more independently. These students would be at higher risk of encountering hazards and it was important for them to learn the skills of independently assessing risks and implementing relevant control measures in their workplace.

Consistency in the application of safety rules and regulations can be a challenge across the seven courses in LSCT. As such, it is essential that staff are trained to be consistent in the enforcement of safety rules so that a safety culture can be established within the School.

Objectives of the Safety Journey

The Safety Journey aims firstly, to make safety education more integrated within the courses such that safety becomes a natural behaviour and secondly, to prepare our students with the necessary safety skills and mindset when they enter the workplace.

The project also aims to inculcate a safety culture in the School which involves the participation of both students and staff. This would ensure that LSCT provides a safe environment for studying and working.

Innovative aspects of the Safety Journey

Previously, lab safety was purely instructional, or taught in isolation in certain modules. Students were also generally less appreciative of the need to work safely. With the new framework, we have introduced vertical integration and scaffolding across the modules within each of the seven diploma courses. Through the use of a behavior-based safety approach via encouragement, enforcement and a scaffolded approach, the programme aims to inculcate the right attitude, perception and commitment towards safety in all LSCT students.

Students are exposed to safety training throughout the three years of their studies. The concepts and basic rules of safety are taught in their first year. In the

second year, they are given the opportunity to apply their safety knowledge within the laboratory in the practical sessions. In their final year, students are expected to independently demonstrate their grasp of safety issues and risk assessment and management through their final year projects and during their exposure to real world issues through their internships.

This strategy has also brought about changes and improvements to teaching and learning practices in the school. There is greater emphasis on using the **learner-centered** learning approach to help students appreciate the application of safety in their work. Students are taught the essential principles of safety and skills of Hazard Identification, Risk Assessment and Risk Control (HIRARC) and are then encouraged to demonstrate self-directed and independent identification and management of hazards.

The incorporation of student reflection on workplace safety in their internship reports has promoted **reflective thinking**. Students are encouraged to reflect, analyse and critique how these principles are being applied in the real world. From the internship reports highlighted, it is obvious that students have internalised the concepts of safety and were able to highlight hazards in the workplace and suggest appropriate measures for risk control. Evidence of the positive effect can be seen from the assessment of our Chemical & Biomolecular Engineering (CBE) students when they go for internship. Company supervisors judge the students on several criteria, one of which is the ability to 'Adheres to safety standards laid out by the company at all times'. Our students have scored an average of 87/100 and 85/100 in February 2012 and 2013 respectively for this particular criterion. These scores are significantly higher than the overall average of 79/100 for the internship module (both in February 2012 and 2013).

Finally, this approach emphasises on **learning for life**, where the students learn how to apply the safety knowledge and skills in any industry that they might enter in future.

THE SAFETY JOURNEY

A three-pronged approach was developed towards developing a Safety Journey at LSCT – **Students**, **Staff** and **System**. The concept of safety starts with the basic orientation but goes on to challenge students' thinking by getting them to identify safety hazards before getting them to reflect on safety issues in the workplace. This can be a model for developing & deepening student's thinking based on Bloom's taxonomy. The approach is reflected in the scaffolded training approach as well as key initiatives, which are described in the sections below.

Safety Training for LSCT Students

All LSCT students will undergo a holistic safety journey that enables them to appreciate safety as a vital and integral part of their work. As graduates of LSCT will work in an environment that requires them to 'think safety' at all times, LSCT has been at the forefront of a holistic safety culture. Over the years, LSCT has adopted new strategies to put in place a holistic approach to safety training for our students.

The Safety Journey begins with an orientation program for freshmen where they are given basic instructions to managing laboratory safety and ends in their final year of studies where students are able to identify safety hazards and recommend appropriate control measures.

The **Safety Orientation Program** teaches basic safety practices, such as the identification of various types of hazards and safe handling of hazardous substances. It provides students with sufficient knowledge to manage basic laboratory work for the first year of their studies. The orientation program is carefully integrated into a core module with a laboratory component for all first year students. Students are also assessed on the application of safety procedures during their laboratory work.

In their second year, the concepts of **HIRARC**, are taught in dedicated safety modules or incorporated into selected core modules. In the diplomas in Environment and Water Technology (EWT) and Chemical & Biomolecular Engineering (CBE) for example, core **WSH modules** equip students with the ability to conduct HIRARC as well as to manage specific hazards in a process industry. Other Life Science courses incorporate HIRARC into their relevant practical lessons to allow students to apply their knowledge to their daily work. Students are coached on applying HIRARC in their laboratory sessions.

In their third year, students are expected to be able to manage their safety independently. Prior to the start of their final year research project, students undergo a final detailed hands-on training on conducting HIRARC for their Final Year Project. Students will need to submit their risk assessments for their project work through their supervisors before starting their actual research. Final year students in most diplomas also undergo internship at various workplaces. A **pre-internship WSH briefing** is conducted and students are also required to submit a reflection on safety management at their workplace in their final internship report.
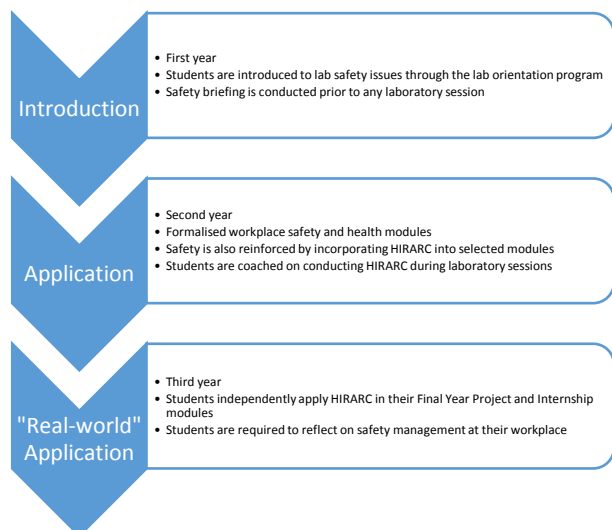
Figure 1: Three-step Safety Training Framework - Scaffolded Learning

The three-step safety training framework, illustrated in Figure 1, allows scaffolding of learning. Students are first given an introduction to the basic principles of safety. They are then encouraged to apply their knowledge of safety by performing simple HIRARC in a controlled environment under close supervision. Finally, they are prepared to handle hazards in the 'real-world' environment through their internship and their individual research project.

The highlights of LSCT students' safety journey are detailed below:

2.1.1 Safety Orientation program

An introduction to Safety is conducted as part of the Orientation program in the first year. All new students are required to attend a **safety briefing**. This briefing includes an easy to understand **safety video** that was developed specifically for Year 1 students. They are also required to pass a **safety quiz** and to sign a **safety declaration** before they are allowed to do any laboratory work.

When surveyed at the end of the first semester on the Safety orientation program, 98% of students surveyed were aware of LSCT's safety rules.

> *It was well structured and the briefing also provided examples of accidents that could be easily prevented emphasizing safety in labs.*
> *(Pharm Year 1 student)*

2.1.2 General Laboratory Briefing

For modules with a laboratory component, a general laboratory safety briefing is given at the start of every semester. Specific safety training is then repeated at the beginning of each lab session to highlight particular hazards and the respective safe work procedures in the experiments.

For example, flammable and toxic chemicals are a concern in modules such as Organic & Biological Chemistry and Inorganic & Physical Chemistry. For these modules, safety of such chemicals and their properties such as toxicity and flammability are addressed.

Biological experiments for the diplomas in Biomedical Science, Molecular Biotechnology, Veterinary Bioscience and Pharmacy Science undergo specific briefings related to biological hazards such as microbiological specimens and biological waste.

2.1.3 Formalized WSH training

Formal WSH training is incorporated into the curriculum of the EWT and CBE courses.

In these two modules - Occupational Health and Safety (CBE) and Workplace Safety and Health (EWT), students are provided with knowledge of the relevant legislation and standards pertaining to occupational safety. Topics include WSH Act, safety management systems (SMS), hazard identification, risk assessment, risk control, incident investigation, process safety such as HAZOP as well as personal safety topics covering specific hazards relevant for our graduates such as confined space, occupational diseases, electrical and fire safety.

Case studies, group projects, and presentations are used to get students to be aware of safety issues in their respective industries. CBE students carry out a group project on selected case studies while EWT students are also required to conduct risk assessments on EWT laboratories.

2.1.4 Incorporating HIRARC and Other Safety Training into Core Modules

Essential skills such as hazard identification, risk assessment and risk control are further embedded in the curricula of various diploma courses, especially in the second year of the course. The diverse nature of the courses allows students to apply their knowledge by identifying hazards and recommending risk control measures during their course-specific laboratory experiments under close supervision by the lecturers. Students need to demonstrate their understanding of the concept of safety by identifying safety issues within their domain of specialization. No longer are the students passive recipients of safety information, but are active participants in the process.

One example is given below.

Chemical and Biomolecular Engineering (CBE)

CBE students are required to address safety issues as part of the Year 2 Integrated Laboratory module. The topics covered in these laboratories include reaction engineering, transfer processes (heat, mass and fluid flow) as well as environmental technology. In one of the practical sessions, students design their own experiment for a given problem, and are required to submit a risk assessment as part of their design.

Besides personal safety, process safety is also important for CBE students. Third year CBE students taking Process Engineering Design (PED) carry out a design project to design part of a chemical production plant using risk assessment as well as Hazard and Operability Study (HAZOP) to justify their plant design. The students were able to apply the principles of hazard and safety management to their design project.

Coming to the end of this PED module, I have learnt that plant designing not only heavily depends on the discovery of the basic equipment and materials needed for its construction but also, process safety and safe working environment for workers. These have to be considered to increase the overall efficiency of the operation.

(Cai Zimin, CBE Year 3 student)

The importance of process and personal safety is also highlighted through case studies in several appropriate modules. For example as part of the modules Petrochemical Technology or Unit Operations, videos of incidents at oil refineries are used to highlight the specific hazards of such an industry. These case studies also help to remind students of the importance of a strong safety culture in a company and within the School.

2.1.5   Safety Training for Internship Placements

All students at LSCT undergo an internship placement in their final year. As a result of the diverse nature of the courses at LSCT, the type of internship workplace ranges from chemical manufacturing plants, hospitals, veterinary clinics, landscape design companies, plant nurseries, research laboratories to pharmacies.

All courses provide a general briefing (which includes safety issues) to students before they embark on their internship. In addition, the internship coordinators also liaise with the internship companies to provide specific in-house training on WSH for the interns. Students are advised to conduct their own risk assessment at their workplace and to feedback to their liaison officers should they have any concerns with safety at work. In order to reinforce their learning, students are also required to do a self-reflection about the safety aspect of their internship as part of the internship report/presentation.

In addition to internship, CBE students also undergo training at the Chemical Process Technology Centre at Jurong Island where they are given specific safety training in the pilot plant.

2.1.6   Safety Training for Final Year Project students

LSCT students may conduct their Final Year Project (FYP) in the LSCT laboratories or as part of their internship. As project work is usually carried out by students independently, it is important that they are aware of the potential hazards of their research methods and take the necessary risk control measures.

CBE students are required to complete the module Introduction to Research, where risk assessment for laboratory work is reinforced. Students need to apply what they have learnt and practiced in Year 1 and Year 2 by conducting a risk assessment for their own proposed research work. This is especially crucial as research work can be potentially more hazardous due to a lower level of supervision. Hence, students are required to submit a safety report to their supervisors prior to working in the lab.

MBIO, BMS and VBS students go through a FYP Safety Briefing before starting on their bench-work. As part of this module, students are required to submit a Safety Management Report containing risk assessment for their proposed research methods.

Enhancing LSCT Staff Safety Awareness and Training

In order to cultivate a strong safety culture in the school, it is equally important that all staff (including academic staff and technical support staff) should be competent in safety and fully aware of LSCT's safety procedures and regulations. This is to ensure that they are able to provide a consistent message to students on good safety practices and are able to handle safety violations in a consistent manner.

2.2.1   Staff Training

Training sessions were conducted on workplace hazard identification and risk assessment. The training also covered review of current risk assessments and LSCT's safety rules and regulations. Tools and resources were also provided for staff to help them conduct the assessments.

All staff are also encouraged to go for external training for safety in specific areas of their expertise so that they could guide students more effectively. For example, specific training courses include topics on pruning from heights (LDH), certified animal handling (VBS) as well as biosafety training (BMS and MBIO).

This training resulted in staff being able to guide the students better in areas such as identifying hazards and carrying out risk assessments. This is a crucial aspect as safety is being taught or applied in a lot of different modules.

2.2.2 Risk Assessment by Academic Staff

Academic staff and technical support officers are required to form teams to carry out risk assessment of their own laboratories to ensure that measures have been taken to control the risks. These risk assessments are submitted to the LSCT Safety Committee and management for their approval.

System

A safety management system has been set up in LSCT. With the system in place, LSCT aims to build a safety culture within the School through training, encouragement as well as enforcement. This system includes:

- **Safety Violation and Penalty system**

Penalty for the safety violations is staged, beginning with verbal and written warnings to debarring students from module practical sessions and FYP laboratory work for repeat offenders.

- **Safety Equipment and Facilities**

This includes proper signage for hazards, the availability of personal protective equipment (PPE) as well as first aid kits in the laboratories. Safety data sheets (SDS) for all chemicals are made available to staff and students in the laboratories and completed Risk Assessment forms are available for all experiments.

- **Laboratory safety audits**

Monthly audits of all laboratories are conducted by technical and academic staff.

- **Safety Committee**

The school has a **Safety Committee** which plans and develops strategies to continuously improve safety in the school.

Students' perceptions of the learning experience

Feedback from students has been positive. Through their feedback via internship reports, it is evident, that our approach helps to prepare the students for the workplace. By the time, the students join a company for internship, they are aware of the major issues and take a proactive role in safety training and awareness at the company. A survey conducted as part of a Graduate Survey in 2012 for CBE students showed that the majority agrees that the curriculum provides sufficient coverage of industrial safety and cultivates good safety practices.
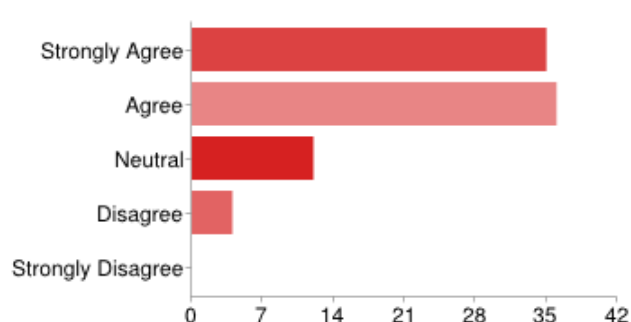

Figure 2: Survey results: Does the curriculum provide sufficient coverage of industrial safety and cultivates good safety practices.

CONCLUSION

The Safety Journey at LSCT has changed the way students approach laboratory and workplace safety training. From an instructional and instructor-directed approach, it has evolved to become a more holistic, reflective and learner-centered learning program. The safety concepts are reinforced through systematic scaffolding through their three years in the polytechnic so that students are better equipped to apply their knowledge to their laboratory work and workplaces.

This program also called on all staff to be trained and better equipped to support the students in this journey. The safety management system was also put in place to reinforce the safety culture throughout the whole School.

We are confident that with the Safety Journey in place, our students will be well equipped with the necessary skills, mindset and commitment to manage their safety in School and at work, and become leaders in workplace safety in their own field.

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i.Learn – A STAGED APPROACH TO DEVELOPING INDEPENDENT, SELF-DIRECTED LEARNERS

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Abstract

i.Learn is an innovative pedagogical framework created to promote the development of independent, self-directed learners. At the heart of the framework is an enhanced pedagogical model, SSDL+ which is based on the Staged Self-Directed Learning Model (SSDL) proposed by Grow, G (1991). The SSDL+ model provides specific metrics that enable an educator to determine the level of self-directedness of each student. The educator is then able to respond to the student in an appropriate capacity (coach, motivator, facilitator or consultant) with a view to providing an optimal learning experience for students. i.Learn provides a set of Teaching & Learning (T&L) techniques to implement the SSDL+ model in the classroom.

The i.Learn framework promotes the holistic development of students, not only in terms of skills and knowledge but also in terms of values such as giving back to the community, professionalism, accountability and responsibility. i.Learn achieves this by integrating community activities as well as infusing Innovation & Entreprising (I&E) skills. The framework has been implemented in the Information Security (INS) module of the Diploma in Information Technology at the School of InfoComm Technology, Ngee Ann Polytechnic, for the past five semesters. Evidences strongly suggest that the framework is effective in developing independent, self-directed learners. This paper will describe the i.Learn framework and the pedagogical techniques used, and discuss evidence of its efficacy.

Keywords: *Holistic Student Development, Learner-Centered Learning, Self-Directed Learning, Service Education, Andragogy.*

Introduction

In this information age, technology advances swiftly and information is becoming increasingly available at a rapid rate. The ability to self-direct to seek ways to take advantage of these changes and harness the available resources would enable people to solve new problems or handle new situations that they may encounter at any moment in their lifetime. In the teaching of Information Communication Technology, it has become increasing important to produce independent, self-directed learners so that these students can react quickly to the changes and continue to upgrade themselves. through self-directed learning.

This paper will present i.Learn, an innovative pedagogical framework for developing independent, self-directed learners. It will discuss in detail each of the components that make up the framework. The implementation and its results will also be discussed.

i.Learn Framework

i.Learn consists of four main components which are depicted in Figure 1.

Figure 1: Components of i.Learn

The SSDL+ is an enhanced pedagogical model that takes a staged approach to develop self-directed

learners. The model is based on the Staged Self-Directed Learner Model (SSDL) proposed by Grow (1991). These models will be explained in greater detail in the next section.

The teaching team has developed, adapted and used Teaching and Learning (T&L) techniques to implement the SSDL+ model in the classroom. The T&L techniques used and adapted are as follows:

- Open Assignment
- Lectorial
- Extras for the Extra Ordinary

More details on each technique & their efficacy will be discussed in the later section.

The framework promotes holistic development of students, not only in terms of skills and knowledge but also in terms of values such as giving back to the community, professionalism, accountability and responsibility. It also encourages the development of Innovation & Enterprising (I&E) skills in the students.

At present, i.Learn has been implemented for five consecutive semesters (including the current semester) in the Information Security (INS) module. INS is an introductory module for students who wish to specialize in Information Security and Forensics under the Diploma in Information Technology. The module approaches the field of information security from an end-to-end perspective covering 7 security layers. These layers are: Organization Security, End-User Security, Physical Security, System Security, Application Security, Network Security and Data Security. The module is assessed through continuous assessment, a common test, an assignment and a final exam.

The SSDL+ Model

SSDL+ is an enhanced model based on the Staged Self Directed Learning (SSDL) model. The purpose of Grow's SSDL model is to provide a systematic approach for teachers to influence the development of self-directed learning in students. The model proposes that learners can be categorised into four stages of self-directed learning as shown in Table 1.

In this model, learners advance through stages of increasing self-direction and teachers can help the development of students by performing different roles.

In stage 1, learners need an authority figure to give explicit directions and instructions on what to do, how to do it, and when it should be done. Learners view teachers as authority figures and treat teachers as experts in that field. The learner is almost completely dependent on the teacher for learning and as a result, learning is very much teacher-centred.

In stage 2, learners are interested and motivated. They respond to motivational techniques used by teachers. Here, learners are willing to tackle learning tasks and assignments on their own because they see the purpose of doing so, though they may not know how to proceed. At this stage, the teacher plays the role of a guide and motivator.

Stage	Degree of self-direction	Teacher	Examples
Stage 1	Dependent	Authority Coach	Coaching with Immediate Feedback. Drill. Informational Lecture, overcoming deficiency and resistance.
Stage 2	Interested	Motivator, Guide	Inspiring lecture plus guided discussion. Goal setting and learning strategies.
Stage 3	Involved	Facilitator	Discussion facilitated by teacher who participates as equal. Seminar. Group Projects.
Stage 4	Self-Directed	Consultant, Delegator	Internship, dissertation, individual works, or self-directed study group.

Table 1: Stages of the SSDL Model (Grow, 1991)

In stage 3, learners have the skills and knowledge to learn with minimum guidance. They see themselves as participants in their own education. They are ready to explore beyond what has been assigned to them. The learners see themselves as future equals to their teachers and as such, the role of the teacher at this stage is to facilitate learning. The teacher comes closest to being a participant in the learning experience.

In stage 4, learners are able to set their own learning goals and standards with or without the help of experts. Learners instead use the experts and institutions as resources to pursue these goals. At this stage, the teacher acts as a consultant to the learner. Ultimately, the epitome of self-directed learning is when the teacher becomes "unnecessary" in the learning process. Learners are completely independent to learn on their own.

The major pitfall of SSDL model is that it is focused on the role the teacher plays at each stage of self-direction. It lacks the student dimension – traits or behaviours exhibited by the student at each stage.

The SSDL+ model enhances the existing model with the student dimensionality. This enhancement proved to be critical when implementing the model in the classroom as it enables the teacher to consistently classify students at the appropriate stage of development. Table 2 illustrates the essence of the

SSDL+ model, i.e. the students' behaviours at each stage of the model.

The degree of Self-Management—concerned with task control issues which includes the social and behavioural implementation of learning intentions which are the external activities associated with the learning process (Garrison, 1997) is depicted by — · · ► (from low to high) on the table.

Stage	Student Behaviours
Stage 1	Unable to find the right resource to learn
	Unable to use the provided learning resource to achieve learning
Stage 2	Able to find some learning resource
	Need guidance to be able to use resource to achieve learning
	Some level of motivation
	Some level of time management
Stage 3	Able to find learning resource
	Able to use resource to achieve learning
	Able to time manage their own learning
	Motivated
	Unable to set learning goals & standards without help
	Unable of self-evaluation
Stage 4	Able to find learning resource
	Able to use resource to achieve learning
	Able to time manage their own learning
	Motivated
	Able to set own learning goals
	Able to self-evaluate
	Takes full responsibility of learning

Table 2: Stages of the SSDL+ Model (based on Garrison, 1997)

The degree of Self-Monitoring concerned with cognitive processes involved in the repertoire of learning strategies as well as the awareness and ability to think about thinking (Garrison, 1997) is depicted by — · ► (from low to high) on the same table.

In summary, the SSDL+ model provides specific metrics that enables the teacher to determine the level of self-direction of each student. In this way, the teacher is able to respond to the student in an appropriate capacity (coach, motivator, facilitator or consultant) which would result in optimum learning for the students.

Teaching & Learning (T&L) Techniques

This section will present the three Teaching & Learning (T&L) techniques that were developed, adapted and used to implement the SSDL+ model in the classroom.

Open Assignment

Open Assignment is one of the pedagogical technique that was used to facilitate self-directed learning. Students were allowed to choose an area of interest from the information security domain in which to carry out in-depth studies. The focal point of the Open Assignment is to allow coverage of content outside the syllabus. They were then required to produce a seminar paper, a poster and a working exhibit

to demonstrate what they have learnt. A sample of these deliverables is shown in Figure 2.
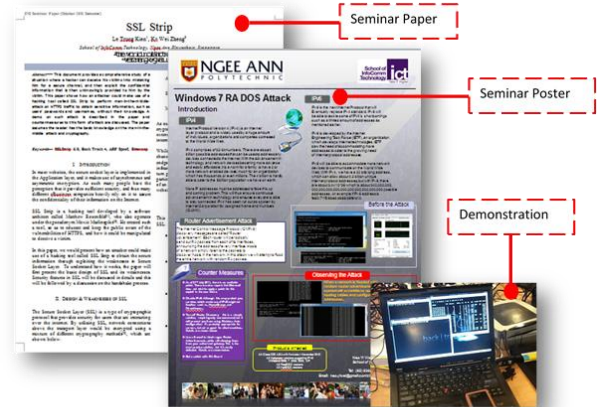

Figure 2: Deliverables of Open Assignment

The open assignment was also a solution to counter workload distribiution issues for students. Figure 3 illustrates how it was implemented.
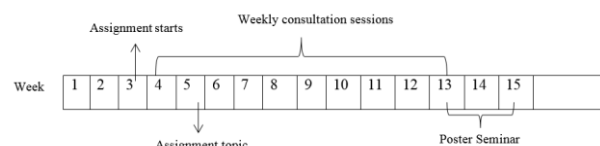

Figure 3: Implement Schedule for Open Assignment

The weekly consultation sessions vary depending on the stage of self-directed learning of the learner. For learners at stage 1 (dependent), the weekly consultation is compulsory while for learners at stage 4 (self-directed), the consultation is on a needs basis with the student taking initiative to arrange for the consultation. The teacher is able to determine the degree of students' self-directed learning based on the behaviours / traits displayed by the student as per the SSDL+ model.

The Open Assignment encourages students to progress through the stages of self-directed learning by providing the flexibility of (a) choosing their own assignment topic (setting learning goal), (b) managing their own time to achieve the learning goals and (c) taking responsibility of their own learning. At the end, the student learns beyond what is taught in class while developing their ability to learn by themselves. Figure 4 is one example of the many comments from students.

"I actually think that the module was well structured and the methods used for teaching depicts the working life where **independent learning is strongly encouraged**. Internet security is a very vast topic and I understand that it is impossible to teach everything with regards to Internet security within just the few hours of class time. I think that the **free topic assignment** in some ways compensate that as every team studies a different topic and **together we gained a lot of new knowledge**. We learned the core principles of internet security in class and then use it for our assignment."

Nur Sheila Binte Kamaruzaman
Dip. in MBS, Level 3.2

Figure 4: Feedback from Student on Open Assignment

Lectorial

Lectorial is a combination of lecture and tutorial in a single 2hr/3hr class session.

Prior to the lesson, short thinking questions were posted in the discussion thread in MeL, NP's Mobile eLearning platform to, firstly, trigger students to think about the topic to be discussed before the class session; secondly, create some excitement in the students community (as they interact in through the discussion forum prior to class session); and thirdly, motivate students to attend the class session to find out the answers to the questions posted.

During the Lectorial session, lectures are broken down into chunks of 15-20 minute sessions which are interweaved with activities (a hands-on session with a chosen software tool, a hands-on demonstration of certain concepts or a pop quiz) or media-related content (e.g. a video illustrating a concept, an animation depicting a complex or a real-case study of an incident which is related to the topic discussed)

Figure 5 illustrates a Thinking Question used in a Lectorial session.

Figure 5: Thinking Question used in Lectorial

Students enjoyed and engaged in Lectorial and gave many positive comments in their feedback. One such feedback is given in Figure 6.

" I feel that the teaching and learning approach that the teachers have adopted for INS is a highly beneficial and valuable to the students. With the in class lectorials combined with tutorials, **we were able to learn so much in so little time**. The **tutorial exercises on Mel** were also **very useful** as it allowed us to **ensure that we had grasped the necessary knowledge** and could then put it to use in testing ourselves in answering the related questions."

Ko Wei Zheng
Dip. IT, Level 3.2
Figure 6: Feedback from Student on Lectorial

Extras for the Extra Ordinary

The teaching team recognises that as we facilitate the development of students towards self-directed learning,

not all students are at the same stage at one point in time. It is likely the students are distributed throughout the four stages of self-directed learning at any point in time. In order to cater to this distribution of students, the teaching prepares a supplementary set of notes & reading materials for those students in stage 3 or 4 of self-directed learning.

These extra learning resources are posted in MEL as optional T&L materials that enable the stage 3 or 4 students to explore and learn on their own so as to achieve the learning goals that they have set for themselves.

Example of these posting is illustrate in Figure 7 below.

Figure 7: Examples of Extras

From written comments in the feedback, students find the extra materials useful and helped them in one way or another in developing them into self-directed learners.

Holistic Development of Students

The framework also promotes the holistic development of the student, not only in terms of skills and knowledge but also in terms of values such as giving back to the community, professionalism, accountability and responsibility by integrating community activities within the curriculum. The teaching team has built in within the curriculum, a mechanism for the student to be able to contribute back to the community.

Educating the Community

Leveraging on poster assignments produced by students, the InfoSec Student Interest Group (SIG) organised an awareness programme on End-User Security at one of the Community Centres. For one week, during the evenings, selected students displayed their posters at the Community Centre and gave demo sessions at specific time slots. During these sessions,passers-by could view the students' posters and the students would stand-by to explain the concepts as depicted by the posters and suggest possible measures to be undertaken to protect the end-user from potential ICT threats. Figure 8 shows such an activity at a Community Centre.

Figure 8: Educating the public on End-User Security at a Community Centre

Similar programmes were also run by the students to educate secondary school students. Using the same resources, the team also collaborated with National Library to run an Online Safety Programme to educate the public on the importance and the do's and don'ts of Online Safety.

By weaving such community events within the assignment deliverables of the student, the teaching team was able to achieve the following:

- Inculcate the value of giving back to the community, professionalism, accountability and responsibility;
- Provide a sense of purpose to the assignment deliverable;
- Motivate the student to do well in the assignment.

These partnerships with the community have provided opportunities to develop our students holistically in terms of.developed knowledge, skills & values.

Infusion of I&E Skills in Curriculum

I&E skills were infused in the curriculum, especially in the open assignment assessment component to develop innovative & entrepreneurial students. Students were encouraged to be bold and creative in setting their assignment topic, to be confident that they will be able to achieve the learning they have set for themselves, to persevere when they felt lost and needed guidance, and to collaborate with one another to help each other in the problem-solving process. The teaching team paid particular attention to the development of the following traits in our students:

- Creativity
- Resourcefulness (to be enterprising in their learning)
- Peer Learning (mapped to collaboration, courage and confidence)
- Sharing and Teaching Others (mapped to collaboration, courage and confidence)
- Independent Learning & Breakthrough (mapped to courage, perseverance or character of strength)

Evidence of such traits can be gathered by the quality of assignment topics chosen by the students which were beyond what was taught in the classroom. The development of these traits in the students can be easily observed throughout the assignment period, in particular, during the poster seminar where students shared what they had learnt with their peers, tutors and visitors. The evidence of development can also be seen from the students' written reflections towards the end of the semester.

Figure 9: Evidences of Trait Development

Figure 9 illustrates the degree of motivation and confidence the programme has instilled in our students.

Results and Discussion

The implementation of the i.Learn framework facilitates the progress of dependent learners to independent learners by adopting a staged approach to developing self-directed learners.

The greatest strength of the framework is its effectiveness as evidenced by the long list of student comments across the different runs which repeatedly articulate the same message – they have learnt to learn by themselves.

Figure 10a, b and c are comments from our students which were extracted from their reflections, providing evidence of the effectiveness of the framework.

Overall, I feel that this module is a very useful module as it teaches students on the internet security which is neglected by many people. **The assignment motivates students to explore** more about the area of security that they are interested. This approach allow **student to feel interested and excited to complete the assignment** and therefore, **they learn** and absorb information **more easily**. By attending the INS module, it provides students with in-depth understanding of information security. In addition, the hands on practical give students a good understand on the topic that they are learning.

Chee Sok San
Dip. IT, Level 2.1

Figure 10a: Feedback on Module by Student

I think that this module is interesting as it has practical (hands-on) lessons for students to understand better about the topics, making it more interesting for students to want to study more on this module. Tutors have made a great effort **changing the way of learning by having lectorials**. This is good as we can **learn from different tutors** every week and have a feel of the way they teach. Topics were clearly simplified so that the students are able to understand them better, also with **the aid of videos that are shown during lectorials**. Tutors are not selfish with their information and always keep giving more feedbacks and information to the students, if they come across new ones. In addition to that, **tutors are willing to learn from students and vice versa**.

Illyana Bte Missawam
Dip. IT, Level 2.1

Figure 10b: Feedback on Module by Student

I think that the module is quite fun and very interesting to start with. The methods used to teach also depicts **that independent learning is highly regarded** during working life. In fact, information security contains many different topics, to be able to pick out a specific few for us to study is very hard indeed. I think that some of the topics that were not taught to us by the lecturers were mostly due to the fact that they think that it is not very important compared to the current ones they are teaching us and **that we could go find out about it ourselves** if we are interested. The assignment is a way to express that we needed to find out information about information security ourselves and **share the knowledge** we learnt to everyone.

Overall, I am very happy that I managed to enroll into this INS module.

Chua Song Han Jason
Dip. IT, Level 2.1

Figure 10c: Feedback on Module by Student

A tutor-estimate of the shift of distribution of students for the Apr 2011 run is shown below.
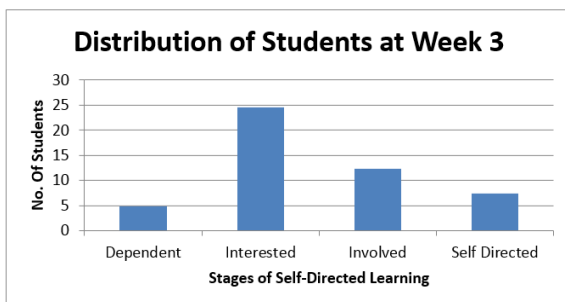
Figure 11a: Comparison of Self-Directedness (Before)
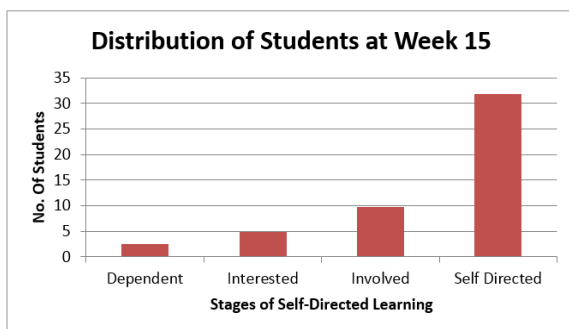
Figure 11: Comparison of Self-Directedness (After)

Conclusions

i.Learn is an innovative pedagogical framework created to promote the development of independent, self-directed learners.

The authors and their teaching team members facilitated the implementation of the framework by accomplishing the followings:

- Enhancement to an existing pedagogical model for developing self-directed learners to include student dimensionality based on student traits / behaviours
- Developed and adopted appropriate & relevant pedagogical techniques to implement the model.
- Integrated community activities within the curriculum so as to instil values in our student for holistic development, giving a sense of purpose to the assignment & for motivation.
- Infusion of I&E skills in the curriculum & as part of the assessment.

The framework was implemented in the Information Security (INS) module for the past five semesters (including the current semester), and the available data suggest that it has been effective in developing independent, self-directed learners. Further research could be carried out to investigate the effects of this innovation. The team is confident that the same can be performed for other modules for greater impact.

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USING IPAD APPS FOR ENGINEERING LESSONS

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Abstract

Engineering subjects are generally very technical. The conventional methods of teaching engineering studies can be monotonous and may not appeal to students. Engineering Educators have started to adopt technology in the classroom – from creating interactive presentations to polling to make lessons more engaging for the students. The introduction of mobile tablet devices such as the iPad, along with the vast number of apps which can used on it, has been redefining the ways lessons can be conducted. The Apple iPad and its sophisticated apps ecosystem have redefined the conduct of lessons and added significant learning value both within and beyond the classroom. This is especially so in Engineering Education where some dry and technical subjects were made more engaging and appealing to the students.

The School of Engineering (Electronic & Computer Engineering Division) in Ngee Ann Polytechnic has adopted some of these iPad apps to change the learning experience for the engineering students. The use of apps such as Keynote and Prezi are helping to change didactic lecture delivery into a more engaging, interactive learning experience. Other apps such as the "Socrative" app allows educators to conduct real time polling exercises with the students. The results of the polling exercises are used to engage students in discussions and gauge their understanding of the subject matter. Learning within the engineering classroom can also be made more interesting through apps such as "Explain Everything" and "Swivl" which can allow educators to create their own videos and audio recordings and share with their students. The ability to make annotations and insert technical diagrams onto the clips also creates opportunities for learning to be more interactive, engaging and participative. Specialized engineering applications such as Gyroscopes and Hardware Tools can demonstrate to students the practical use of sensors, mobile hardware platform and technology.

This poster presentation will share how these educational iPad apps are used to create a learner centred learning environment where Engineering students can be more participative and engaged in the learning process.

Introduction

Engineering studies can be very technical – a plethora of theories, concepts, mathematical equations, diagrams and flow charts. In a traditional lecture setting, the lecturer will dictate continuously while the students will be mindlessly scribbling notes, often not understanding what is being taught. And this monotonous learning environment certainly does not help make a technical topic any easier to understand.

The traditional lecturing methods appear to be losing its traction with students' learning. Bales (1996) in his research on learning pyramid estimates that students will remember approximately 5% of the information provided in a traditional lecture. This contrasts sharply with retention rates of 50% and 75% for discussion groups and practical exercises, respectively. Educators are also observing that students generally have short attention span and are easily distracted (Lanir, 2012).

To counter the short attention span of students in class, and to increase the engagement and retention rate of students, educators have started to look at the use of technology for a new approach to learning. Engineering educators have started to embrace technology in the classroom to increase effectiveness of learning – from using interactive presentations to polling, all in effort to make engineering lessons more appealing for the students. The iPad and its sophisticated applications or apps ecosystem have redefined the conduct of lessons and added significant learning value both within and beyond the classroom.

The iPad apps enable educators to engage a multipronged approach to facilitate teaching and learning. These aspects are shown in Figure 1.
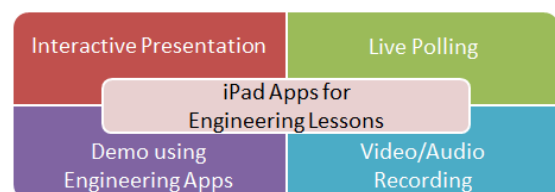

Figure 1: iPad Apps used in several areas to engage students in engineering lessons

Materials and Methods or pedagogy

Live Polling

Felder and Brent (2008) pointed out that one of the common mistakes made by educators is to turn their classes into PowerPoint shows. The educator narrates while the students spectate – an outright passive form of learning. However, when educators start to weave an interactive system cleverly into the slides, it elicits participation from students.

Tapping on the existing mobile system infrastructure, iPad apps, such as Socrative, allow educators to conduct real-time interactive exercises with the students. This online student response system is a useful technology that enables educators to post questions to students and gather responses immediately. Questions may be structured in simple true/false, multiple choices to the more complex open-ended formats.

Unlike the conventional clicker system which requires students to individually own a clicker, students can now transmit their responses through their smart phones which are just required to have an Internet connection. The Socrative app collects responses received from the students and tabulate the data into simple bar charts which educators will be able to share with the class (see Figure 2).

In the Telecommunication Principles (TP) module for year 2 students, Socrative app has been used during the tutorial session to gauge students' understanding of the module. Students' responses were set for discussion within their groups. The lecturer could further challenge the students to convince their peers who have chosen to poll different answers from themselves. A re-poll could be conducted to observe if there was a shift in responses. During this peer exchange, active learning is promoted as students learnt to articulate their thoughts and helped each other understand the subject matter better (See Figure 3). According to Felder and Brent (2009), active learning is any course-related activity that all students in a class session are called upon to do other than simply watching, listening and taking notes.

To assess students' understanding level in TP module, the lecturer has incorporated questions structured in an open-ended format, in between the lecture slides, to which students were required to respond using short phrases. With the anonymity of the responses, students found it easier to participate as it eliminated the fear of looking bad in front of peers for providing the wrong answers. The responses gathered also helped the lecturer gauge if there was a need for remedial actions - a need to slow down the pace of the lecture or revisit some of the topics covered earlier.

Figure 2: Socrative app allows the students to answer questions on their mobile phones and instantly view results on the screen
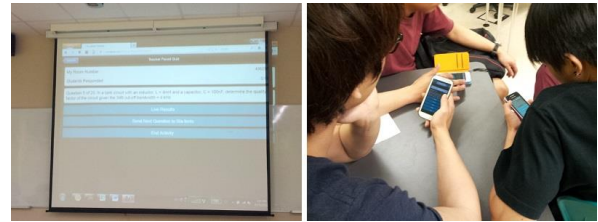

Figure 3: Students discussing in a group during a live polling session.

Poll Everywhere is another alternative student response application which is similar to Socrative. This application is used to conduct simple polling and demographic data gathering during the introduction of a new topic. For instance, in the Mobile Device Technology (MDTE) class for final year students, the lecturer has asked the students for the type of operating system used on their smart phone. The results of the poll were instantly tabulated and shown on the screen (see Figure 4). These results can be used for discussion and comparison with the actual demographics of the popular operating system used worldwide. The lecturer can then expound on the data and engage the students to examine the latest technological trends and how technology has evolved through the years.
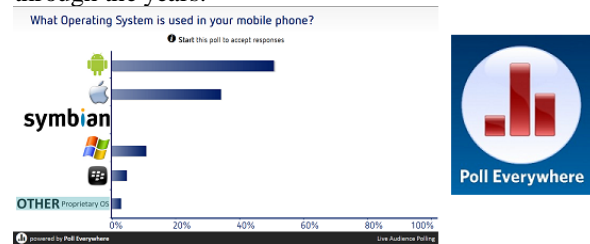

Figure 4: Poll Everywhere allows educator to instantly poll for answers to encourage student participation

Interactive Presentation

A traditional transmission approach involves a presenter inflicting content heavy slides on an increasingly passive audience (Koppi & Pearson 2005). The educator packs a colossal amount of information onto slides, and as Tufte (2003) criticized in his paper, the presenter unveils and reads aloud the single line on the slide, then reveals the next line, reads that aloud, on and on, as audience members impatiently await the end of the talk. While presentation software is a mere tool, it is the educator who has to use the tool to create presentations which are visually stimulating and interactive. One such interactive presentation tool available on the iPad is Keynote.

Keynote for Apple's iOS is an app which is able to create aesthetically appealing presentation slides. Its simple-to-use functions allow educators to construct stunning presentation slides as easy (if not easier) as it is to work PowerPoint. It works not only for iPad, but also works seamlessly between Mac and other iOS devices. In a classroom context, an iPad can be used as a teaching tool coupled with a MacBook connected to the projector. The Keynote presentation can be synced between these two devices through Bluetooth connectivity. With this convenience, the

lecturer is free to move around the classroom with an iPad in the arm and annotate effortlessly at the same time. This is especially useful in the TP module where the lecturer is able to write equations and illustrate correlation on the block diagrams as seen in Figure 5. In addition, with a simple point to the iPad, it now works as a virtual laser pointer.

Quoting writer and politician Jean-Nicolas Bouilly (1763 – 1842), "Whatever we possess becomes double value when we have the opportunity of sharing it with others", Keynote allows educator to share the slides with their students through iCloud.
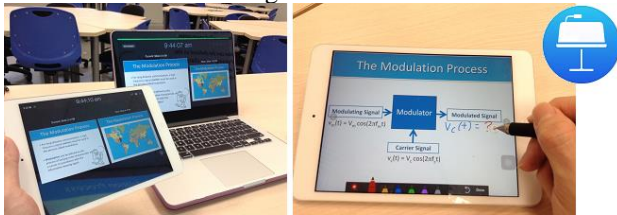
Figure 5: Annotation on iPad made easy with Keynote

Moving onto an online cloud-based presentation tool for presenting ideas on a virtual canvas is Prezi. Unlike typical slide-by-slide based presentation tools, Prezi has the capability to design dynamic, non-sequential and non-linear presentations. Educators will lay out the information to the subject matter on a simple canvas, before starting to arrange them in the way they like.

Prezi has a zooming user interface, which allows users to zoom in and out on any part of the presentation. This is especially useful for engineering studies that require students to understand relationships between concepts. Figure 6 below depicts one example of work used in Mobile Device Technology (MDTE) module. The presentation slides allow the lecturer to first provide the students with an overall view of a mobile device before progressing into the minute details of the important elements of the mobile device. As such, it is a very visually oriented presentation (Strasser, 2013).

Figure 6: Using Prezi in the MDTE module

Video/Audio Recording
Apps such as "Explain Everything", "Educreations" and "Swivl Capture" empower educators to create their own videos and audio recordings both in and out of class, and then share them with their students. Having additional video recordings reinforce learning as students would then be able to review them at their own pace and convenience (Coghlan, et al., 2007). Through this self-paced learning, the students can now pause, rewind, fast-forward and replay lessons when needed. The video acts as an

additional resource to complement the typical lecture notes provided. This can be beneficial to students who would want to revise engineering lectures with more challenging technical content.

Swivl is an innovative device which can be used to record audio and video in the classroom. Primarily designed to record video for conferencing, educators are now using this device to record their own lectures. Without the need for sophisticated video recording tools and a dedicated videographer, Swivl allows the lecturer to record his own lecture without much hassle. The Swivl has a motorized turntable that is able to track the user's movement anywhere within the classroom. An iPad or iPhone is mounted on the Swivl thereby replacing the need for a complex video camera (see Figure 7). It has the capability to move freely with 360-degree pan and 20-degree tilt. The Swivl hardware comes together with the Swivl Capture app which marries the lecture slides with the video recording. Students can then review the lecture captured in MDTE class using Swivl with the accompanying slides (see Figure 8).

Students, too, can make use of the Swivl to record their presentations. With the convenience of the videos automatically stored in the Swivl Cloud server, students can choose to share the video recordings with their classmates for peer feedback, thus promoting collaborative and student-centered learning.

Figure 7: Swivl Capture app on iPad integrated with the Swivl hardware
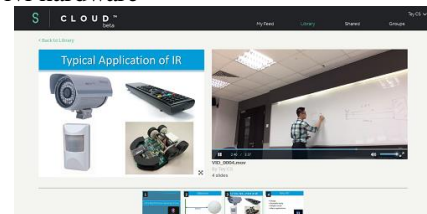

Figure 8: Using Swivl in the MDTE class

The multi-touch capability of an iPad has created more avenues for educators to design more engaging presentations. Explain Everything is one of the tools created that utilizes this technology to allow educators to annotate on the screen while doing screen recording. The recording comes in the form of screencast and audio recording. Unlike the conventional whiteboard app, multi-page presentation slides and graphics can be inserted easily into this app. This enables the lecturer to go through the slides and at the same time annotate the engineering diagrams (see Figure 9). This is especially useful in the TP module where there are many diagrams and equations. All these actions can be recorded and stored in the cloud server.

The ability to make annotations and insert technical diagrams onto the clips also generates

opportunities for learning to be more interactive, engaging and participative. Educators can expound and illustrate further on the presentation slides. With this app, educators no longer need to be stationed near a visualizer to annotate on a piece of paper. The educator is able to move around freely with the iPad once it is synced to the MacBook connected to the projector. It is definitely a cheaper replacement of the physical interactive whiteboard.
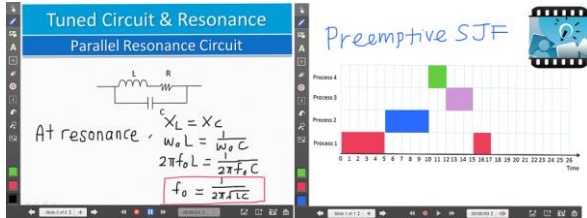

Figure 9: Multi-slides can be imported into Explain Everything and colourful diagrams can be drawn to explain technical concepts to the students

Another app that has similar capabilities to Explain Everything, is the Educreations app. It is a good personal recordable whiteboard that is able to capture voice and digital handwriting. One distinct feature of this app is the graph-like background which can be particularly useful for assisting engineering and mathematics educators in drawing graphs, saving them the need to repeatedly draw the x and y axes. This is particularly useful in the TP module where the lecturer uses it to illustrate specific communication concepts through graphs (see Figure 10). Like other apps covered so far, Educreations allows the recorded screencast to be saved and shared with the students. Students can download these screencasts as revision materials to aid their learning.
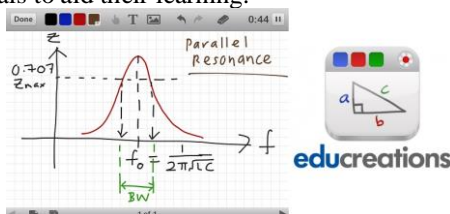
Figure 10: Using grid lines on Educreations to draw graphs in the TP module

Demonstrations using Engineering Apps

Conventionally, engineering educators had to bring in physical engineering products to demonstrate certain engineering concepts. Demonstrations to reflect specific concepts in engineering classes are believed to aid students to learn better.

With the abundance of iPad engineering apps, educators can now demonstrate things that could not be done many years ago. Due to its portability, the iPad gives flexibility to educators to conduct demonstrations both in and out of the classrooms.

Demonstrations will be merely show-and-tell unless students are actively participating in the process. According to the research by Crouch, Fagen, Callan and Mazur (2004), students who passively observe demonstrations understand the underlying concepts no better than students who do not see the demonstration at all. Therefore, to encourage active participation from students during demonstrations, the lecturer in his MDTE class gets the students to engage in reflective observation, by analyzing and answering questions related to the demonstration. The lecturer will then facilitate discussion to emphasize certain key points. This stimulates higher order thinking and creates better understanding of the concepts behind the demonstration.

Figure 11: MDTE demonstration using GPS Data app done out of the classroom

Figure 12: During a MDTE class demonstration, the iPad is tilted to a specific angle and based on the values of the accelerometer displayed on the app, the students are required to calculate and analyze the values based on the theoretical knowledge they have learned in class

There is no one-size-fits-all engineering app that caters for all engineering applications. Often, educators have to identify a few relevant apps and adapt them to achieve learning objectives of the lessons.

For the MDTE module, specialized engineering applications such as Gyroscopes, Hardware Tools, Data Collection and GPS Data are used to demonstrate the practical use of sensors, mobile hardware platform and technology (see Figures 11 and 12). Primarily designed to assist engineers in their work, these apps can also be utilized in class for educational purposes. Apart from engineering apps, the lecturer has also made use of game apps such as Showdown, which brings fun to the classroom, and also exhibits the fundamental use of sensors (see Figure 13). The lecturer first allows students to play the game followed by an explanation of the underlying mobile device sensors used in the game.

Figure 13: Examples of engineering and game app used in MDTE class to enhance student learning on mobile technology

Using these apps in the classroom converts the typical didatic lecture to a more engaging classroom where educators can demonstrate the application after delivering the technical knowledge of the specific topic.

Students' Perceptions and Academic Performance in an Enhanced Module (MDTE)

A small-scale survey involving 20 participants was conducted with the Mobile Device Technology module class, to check if students have benefited from the use of the iPad apps during lectures. The questions to the survey are as follows.
1. Do you think the student response system helps you understand the key concepts better?
2. Do you think the live polling session using Poll Everywhere encourages your participation?
3. Do you understand the concepts behind the demonstration using iPad?
4. The lecturer uses live annotation on the iPad. Do you think it is helpful?
5. Do you think presentation slides used by the lecturer help you understand the content better?
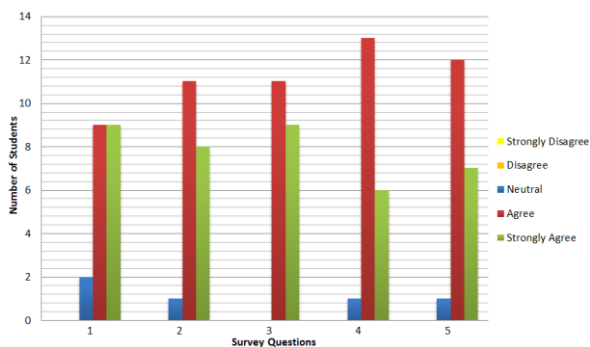
Figure 14: Survey on iPad usage in MDTE lesson

From the survey, approximately 95% of students agreed that the iPad apps have aided learning and encouraged them to participate in the class (see Figure 14). Specifically with regards to question 3, all the students agreed that demonstration helped them to understand the concepts better. This is most likely because demonstrations allowed the students to experience the practical application of concepts.
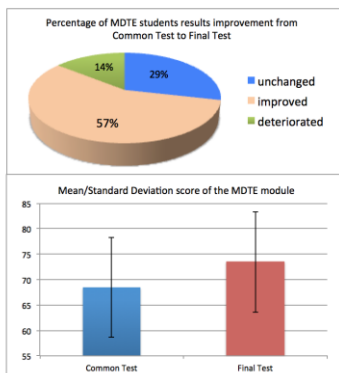

Figure 15: Academic performance of the MDTE class for April 2013 Semester

Students' academic performance in the module was analysed by comparing their results on the Common Test, Final Test and final grades (n = 21). As this module was newly introduced into the curriculum, comparison could not be done across more semesters. For a typical module in Ngee Ann Polytechnic, students will attend classes for about 8 weeks and followed by Common Test. Students will then continue for another 8 weeks of classes which will prepare them for the final exam. However, for the MDTE module, the final exam is replaced with a Final Test that has a similar weightage as the Common Test.

With this in mind, a comparison of the results obtained from the Common Test and on the Final Test was made. T-test analysis done had shown that improvement was statistically significant with two-tailed p-value of 2.61% ($p < 5\%$), confirming that students had shown progress in their results. In addition, more than 57% of the students had seen improvement in their results (see Figure 15). This might be attributed to the use of demonstration and active learning in the second half of the semester. This may also be cross-referenced to the survey results in Figure 14 where all of them agree that demonstration helps them to understand the concepts better.

Figure 16: Ngee Ann Polytechnic Module Experience Survey (MES) results on MDTE module for the April 2013 Semester
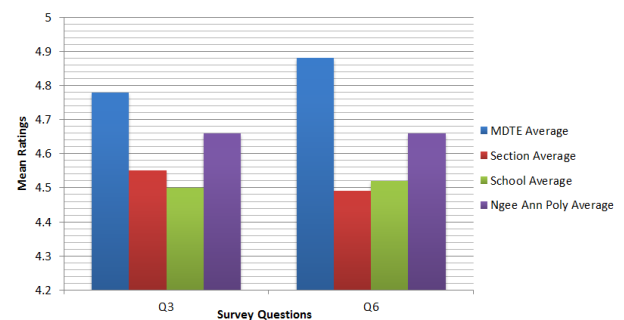

Figure 17: Mean ratings comparison of MDTE module versus other average for Q3 and Q6

Results from the institution-wide student feedback survey, known as the Module Experience Survey (MES), were also analysed. MES is conducted at the end of every semester to find out students' experience on the modules they have attended in that semester. The objective of this survey is to gather students' feedback of the modules through questions directed in areas namely students learning, teaching

and learning approaches used, module materials, activities and skills acquired. In Question 3, students were asked to rate the extent to which the teaching and learning approaches were appropriate for this module/project and in Question 6, whether the module activities enhanced their overall learning. Students from the MDTE module, in which iPad apps and activities were incorporated in classes, participated in the MES.

The results tabulated from 32 students' responses (70% confidence level) showed that for Q3 and Q6, the mean ratings were 4.78/6 and 4.88/6 respectively. This was higher than the average ratings for module section, school average and Ngee Ann Polytechnic average. This suggests that students agreed that the use of iPad apps and activities in class were appropriate and has helped them to understand and learn better.

Written feedback from the Student Evaluation of Teaching (SET) survey for the MDTE and TP modules also indicated that students found the use of apps in the lectures helpful for their understanding:

"The lecturer always goes the extra mile to do PowerPoint slides (using Keynote app), videos, questions (using Socrative apps) in every lecture. And all those PowerPoint slides, videos and questions really help me understand the chapter more."

"He has used various materials such as devices (demonstration using iPad apps) that allow us to incorporate well what we've learned in theory"

Conclusions

Engineering education has gone through an accelerated evolution in the last couple of decades, given how technology has advanced by leaps and bounds. This has also shaped the profile of students and the way they learn. Teacher-centred approaches may no longer achieve effectiveness in engineering lessons as the students today seek to be engaged in learning.

While we teach our children to be creative, there is also a need for today's educators to "think out of the box", continually seeking new methods to captivate an audience which live in a world with more distractions, compared to the past.

iPad apps are tools that are widely used by educators and its effectiveness is apparent and well supported by many surveys done by numerous academicians. Research on iPad usage in classroom from Learning Exchange (2011) and Gliksman (2011) have findings that concluded iPad usage had aided educators in producing positive learning outcomes and added educational value in the classroom. In the small study described here, student feedback results indicated that iPad apps helped them understand concepts better and encouraged participation in class. Therefore, this could have led to their marked improvement over the 2 tests' results.

Yet a tool remains merely a tool, until it is put to good use. Like a chisel in the hands of a mason creates nothing, until the mason puts the chisel to use; with each stroke and roughing of the surfaces, the mason transforms a piece of stone into a fine piece of art. Let's aptly end with an anonymous quote, "Never be afraid to try something new. Remember amateurs built the ark, but professionals built the Titanic."

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