ADAPTIVE E-LEARNING MODEL FOR ENHANCING CONSTRUCTION MANAGEMENT EDUCATION

ABSTRACT

Construction management educators face numerous challenges in designing and delivering courses characterised by high levels of student engagement, interactions, motivation, flexibility and feedback. As a pedagogical strategy for overcoming the challenges, an adaptive eLearning model that emphasises a constructivist approach to learning, was developed, implemented and tested in a construction management degree program through action research. Student feedback advocated that the novel approach enhanced student learning by raising engagement, motivation, interaction, flexibility and real-time feedback. Furthermore, students desired the availability of the new learning method in other courses of the degree program too.

Keywords: Construction management education, Pedagogy, Adaptive eLearning

INTRODUCTION

Graduate attributes based teaching has become a prime focus of universities. The graduate attributes include: creativity, problem solving skills, professional skills, communication skills, teamwork and lifelong learning. Universities are expected to offer courses that nurture these attributes. Learning and teaching literatures identify several essential components in university teaching that can result in the desired graduate attributes, including: student-centred active learning tactics, interactive learning environments, feedback on student progress, and motivating learning tasks (Biggs & Tang 2011; Kember & McNaught 2007).

Lecturers face many challenges for designing courses with these qualities. First, Kember & McNaught (2007) suggested using such active learning tactics as case-based teaching, problem-based learning, reflective journals and experiential learning to facilitate deep learning. Yet, these approaches require more efforts from students than the traditional style. Since most students work while studying, they prefer courses that require less time on campus and less efforts. This expectation conflicts with the nature of the active learning tactics. Second, active engagements and interactions are two requisites for deep learning (Ramsden 2003). But, these are difficult to achieve in large classes, which have become the norm in universities due to increasing student numbers and limited resources (Freeman & Blayney 2005). Third, providing feedback to students is crucial for effective learning. Feedback is typically provided through graded homework sets, quizzes and tests.

These techniques suffer from the shortcomings of being too slow and too tedious to apply frequently or in large classes. Finally, motivation is an important factor for learning; it is positively correlated with students' willingness to learn, high-level cognition and performance. A vital part in the role of lecturers is to motivate their students to learn (Kember & McNaught 2007). Gavrin & Novak (1999) critiqued that it is one of the fundamental challenges for lecturers; many students work hard, but often the motivation is a grade rather than understanding.

Recently emerged adaptive eLearning paradigm that emphasises a constructivist approach to learning, giving control of learning to the learner, is claimed to have the potential to address the aforementioned challenges and improve learning (Beldagli & Adiguzel 2010; Shute & Towle 2010). Hence, this study aimed to design and implement an adaptive eLearning task in a Construction Management degree program and evaluate its effectiveness for improving student learning.

RESEARCH METHODOLOGY

The study adopted action research approach, which is a systematic process that allows educators to try out different ways of doing things in the classroom, until they find something that really works for them and students (Laycock & Long 2009). Mertler & Charles (2008) argued this approach is more practical for lecturers as it: (1) deals with their own problems, not someone else's; (2) can start whenever they are ready—providing immediate results; and (3) provides them with opportunities to better understand, and therefore improve their educational practices.

Riel (2011) defined action research as a cycle, involving four distinct stages in a closed loop, as shown in Figure 1. The author traversed through these stages in undertaking the research study. The author learned about adaptive eLearning and computer systems available for it, designed an adaptive e-tutorial for his course, launched it for students' practice, conducted a questionnaire survey to measure the efficacy of the new mode, analysed data, and finally reflected upon the new method.

Figure 1: Action research cycle. *Source:* adapted from Riel (2011)

CONSTRUCTIVIST PEDAGOGY AND ADAPTIVE LEARNING

Learning is defined as a process where knowledge is created through: acquiring information, facts, skills and methods that can be retained and used as necessary; making sense or abstracting meaning; and

interpreting and understanding reality (Smith 2003). There are two broader paradigms of learning (Eklund 1995):

- behaviourist pedagogy – where learning is regarded as an organised transfer of knowledge with a structured learning strategy, and the learning is teacher-centred.
- constructivist pedagogy – where learners create mental models of understanding, supported by collaborative learning and group work, and the learning is student-centred.

The conventional behaviourist pedagogy has been used for centuries, which works on the premise that "one size fits all". In reality, students' backgrounds, knowledge levels and learning capabilities can vary, and can have an impact on their learning experiences and outcomes. In contrast, in the constructivist pedagogy, individuals create their own new understandings by interactions between what they already know and new ideas and knowledge that they come in contact (Resnick 1989). This modern approach has gained popularity in higher education. Richardson (2003) characterised the constructivist pedagogy with the following:

- attention to individuals and respect for students' background (this could also be described as student-centred)
- facilitation of group dialogue that explores an element of the domain, with the aim of creating an understanding of a topic
- planned and often unplanned introduction of formal domain knowledge into the conversation through direct instruction, reference to text, exploration of a web site or other means
- Providing opportunities for students to determine, challenge, change or add to existing beliefs and understandings through engagements in tasks that are structured for this purpose
- development of students' meta-awareness of their own understandings and learning processes

Beldagli & Adiguzel (2010) held that recently emerged adaptive learning paradigm embodies these characteristics, and enables the development of teaching toward a dynamic learning process. It is characterised by diversity and interactivity.

Adaptive eLearning

eLearning systems have been used in education since mid-1990s to overcome the constrains of time and place in the traditional face-to-face learning. They also offer many other advantages to universities and lecturers, including: reduced cost and time, consistent delivery of contents with asynchronous presentations, on-demand availability, interactivity and proof of completion and certification (Kruse 2004). These eLearning systems, however, do not allow the individualisation of learning contents or style to suit student situations and preferences. An alternative form, called adaptive eLearning system, has recently emerged to address

this concern (Chen 2009). An adaptive eLearning system personalises and adapts e-learning contents, pedagogical models and interactions between participants to meet individual needs and preferences of learners if and when they arise (Stoyanov & Kirschner 2004). These systems are of two technological types: intelligent tutoring systems and adaptive hypermedia systems (Surjono 2009).

Intelligent Tutoring System (ITS)

eLearning systems have a lot of advantages, but they still lack the presence of a teacher, who in a traditional classroom environment deploys various tactics to retain a student's attention and provides appropriate guidance to students based on their weaknesses and strengths in a particular subject. ITSs attempt to simulate the "teacher", applying artificial intelligent techniques, and provide the benefit of one-on-one instructions to students, automatically and cost effectively.

Adaptive Hypermedia System (AHS)

Brusilovsky (1996) defined AHSs as "hypertext and hypermedia systems which reflect some features of the user in the user model and apply this model to adapt various visible aspects of the system to the user". Applications of AHSs range from educational hypermedia systems to information retrieval systems with a hypertext interface. For example, in an adaptive educational hypermedia system a student will be given a presentation that is adapted specifically to his/her knowledge of the subject, and suggested most relevant resource links to proceed further.

DEVELOPING AND IMPLEMENTING AN ADAPTIVE E-TUTORIAL

This study experimented with the intelligent tutoring system. An adaptive e-tutorial was deployed by the author in his first year course, namely Construction and Property Economics, a core course in the Construction Management degree. The deployment decision was driven by few factors:

- The class was relatively large and it was difficult to have ample one-on-one interactions with all students
- A mix of abilities was noted among students to understand basic principles and concepts of the topics covered
- Many students work while studying; a tendency to skip lectures to go to work was noticed among them. It was therefore necessary to provide them with an alternative, yet effective opportunity to learn
- Most students preferred off-campus learning at their convenient time and place more than on-campus learning in a classroom

Smart Sparrow™ was used for the implementation of the innovative strategy. The platform offers the following functionalities:

- Authoring tool – enables lecturers to create e-tutorials with rich media contents, simulations and in-built intelligent feedback
- Learning environment – where students can engage in authentic problem solving with simulations, interactions and virtual worlds. Real-time feedback is provided to scaffold student learning
- Analytics engine – provides data mining capabilities for lecturers. It allows them to recognise students' learning paths, performance across questions and tasks, common mistakes and generate reports

An adaptive e-tutorial, containing multiple choice questions and in-built feedback, was created with the aim of enhancing students' understanding of such topics as the time value of money, project economic appraisal and cost benefit analysis for public projects. The following steps were involved in developing the adaptive e-tutorial:

- Firstly, appropriate questions to cover the topics with their possible answers were set; altogether 15 questions were set and each question had four options of answers with only one being correct
- Secondly, feedback for answers in the questions were developed; each question had four feedback comments, making a total of 60
- Then, the adaptive e-tutorial was authored on Smart Sparrow
- Finally, students were added to the e-tutorial, as users, using the analytics engine and the e-tutorial was then launched for practice.

Below is a sample question and corresponding feedback for different answer options. When a student selects wrong answers, possible mistakes are highlighted, guiding toward correct understanding. In contrary, when the selection is correct, the student is encouraged to boost confidence.

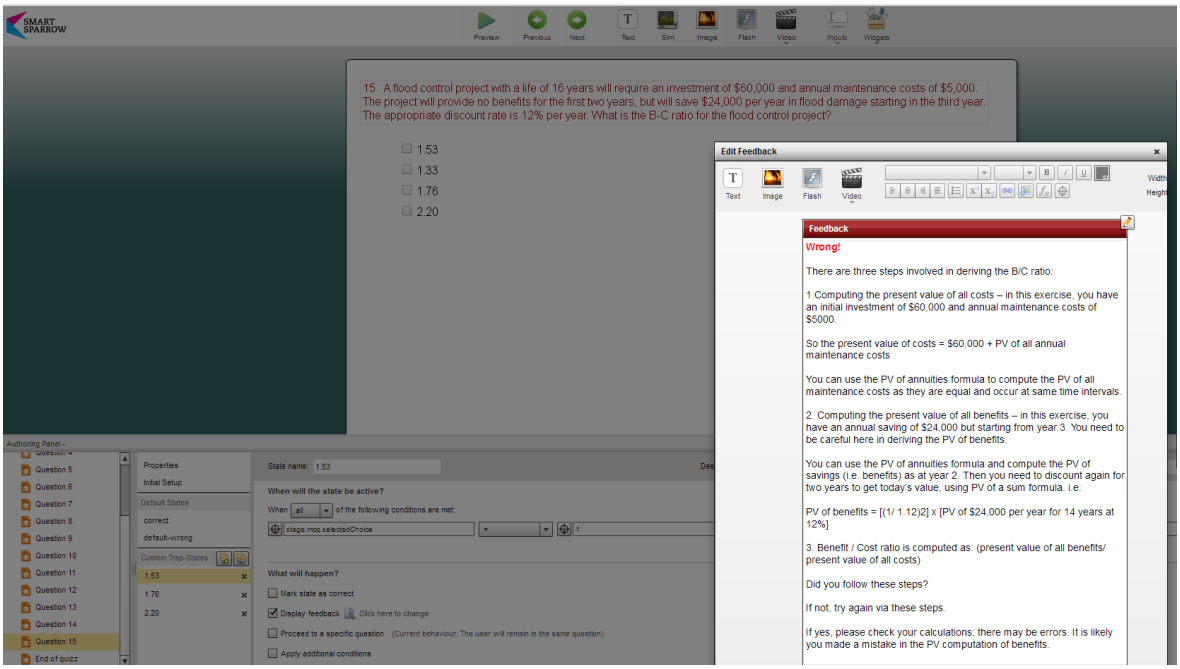
Question:

Which of the following will decrease the present value of the mixed cash flows for years 1 through 5 of $1,000; $4,000; $9,000; $5,000; and $2,000 respectively given a 10% discount rate?

a) Decrease the discount rate by 2%
b) Switch cash flows for years 1 and 5 so that year 1 is $2,000 and year 5 is $1,000
c) Switch cash flows for years 2 and 4 so that year 2 is $5,000 and year 4 is $4,000
d) Switch cash flows for years 2 and 5 so that year 2 is $2,000 and year 5 is $4,000

Feedback:

a) Wrong; this actually increases the PV of each individual cash flow and therefore the PV of the entire set of cash flows.
b) Wrong; this will increase the PV of year 1 and decrease the PV of year 2. The net effect is that the PV of the entire cash flow sequence will increase.
c) Wrong; this will increase the PV of year 2 and decrease the PV of year 4. The net effect is that the PV of the entire cash flow sequence will increase.
d) Well done!



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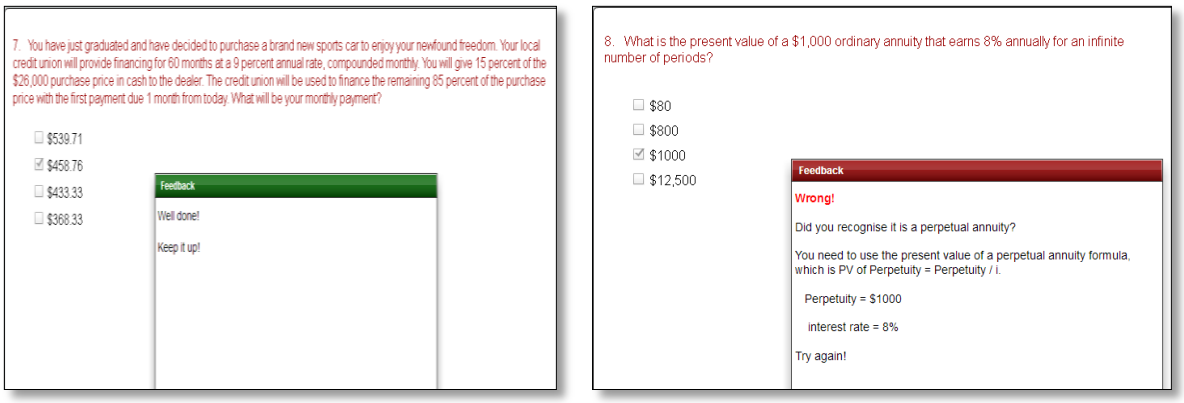

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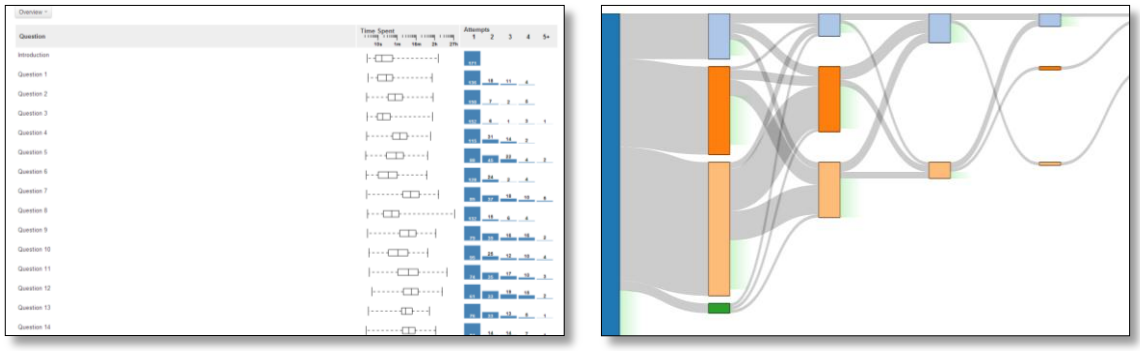

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Figure 2: (a) Adaptive e-tutorial authoring interface; (b) e-tutorial practice interface; (c) Analytics engine interface

Figure 2 shows screen shots of the adaptive e-tutorial. Figure 2(a) depicts the e-tutorial authoring environment. Figure 2(b) shows student views of the e-tutorial; when a correct answer is selected, a real-time encouraging comment is displayed, but if an incorrect answer is chosen, feedback with hints is displayed to enable the student to redo until he/she gets it right. The balanced real-time feedback can motivate students and retain their interest. Figure 2(c) shows the analytics engine where students' progress can be monitored, and areas that they need further explanations can be identified.

EFFICACY OF ADAPTIVE E-TUTORIAL FOR STUDENT LEARNING

Kember & McNaught (2007) characterised learning and teaching efficacy with eight attributes: student engagement, interactive mode of delivery, motivation to learn, flexible delivery, feedback, enhancing analytical & critical thinking, enabling independent & reflective learning, and helping students understand basic concepts well. The e-tutorial was launched prior to a class test. After students have practised it, an online questionnaire survey was conducted to assess how well the new strategy satisfied the eight attributes above. The questionnaire had three sections; section one gathered participants' details, section two collected data related to the efficacy of the adaptive e-tutorial approach, on a 5-point Likert scale, and section three received descriptive comments. All 90 students in the class were invited, but only 52 students responded, making a response rate of 58%. Figure 3 shows the distribution of responses to specific questions in the questionnaire.

Data Analysis and Discussions

The data were further analysed to compute mean ratings for the indicators. The following numerical points were allocated to the linguistic rating scales for compute mean ratings:

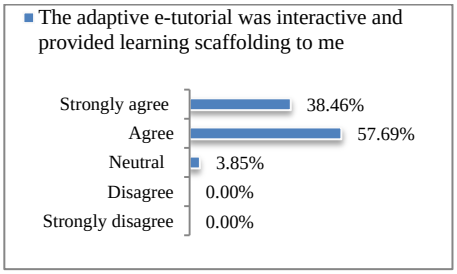
- Strongly agree (SA) = 5
- Agree (A) = 4
- Neutral (N) =3
- Disagree (DA) = 2
- Strongly disagree (SDA) = 1

Then, the following formula was used to compute mean ratings:

$$Mean\ Rating = [(Fraction\ of\ responses\ for\ SA\ \times 5) + (Fraction\ of\ responses\ for\ A\ \times 4) + (Fraction\ of\ responses\ for\ N\ \times 3) + (Fraction\ of\ responses\ for\ DA\ \times 2) + (Fraction\ of\ responses\ for\ SDA\ \times 1)$$

Table 1 shows the mean ratings for the indicators and the values explain the strength of consensus by the survey participants. The indicators are rearranged in the table in the descending order of mean ratings. It was

evident from responses given by the participants that the combined power of flexibility, real-time feedback and interactivity that were built in the adaptive e-tutorial allowed students to enthusiastically engage in independent, yet reflective learning. This resulted in a good learning experience for them.



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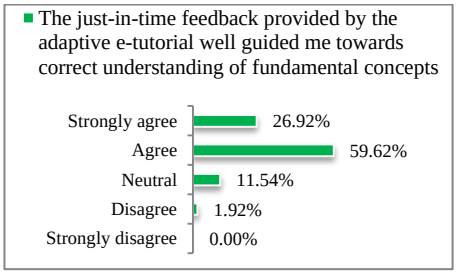

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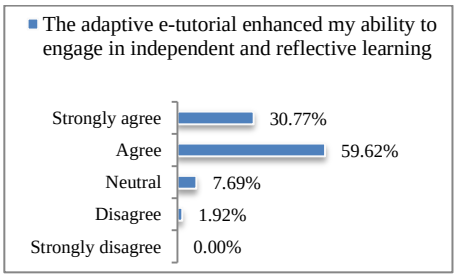

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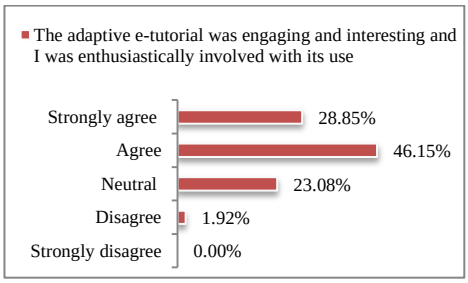

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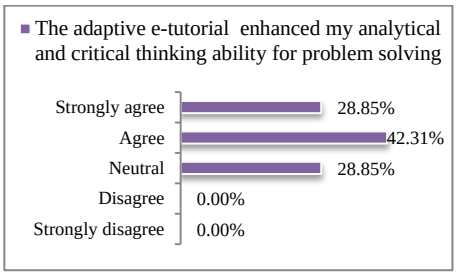

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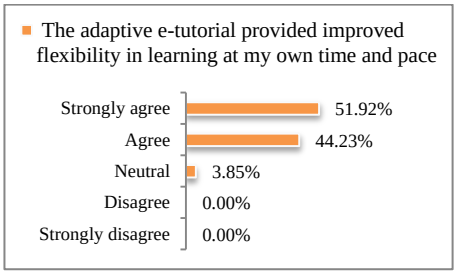

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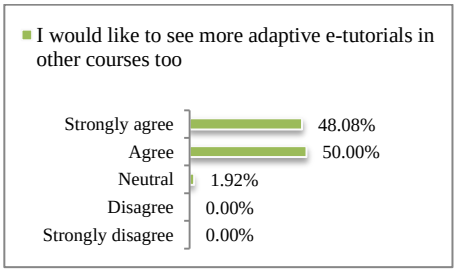

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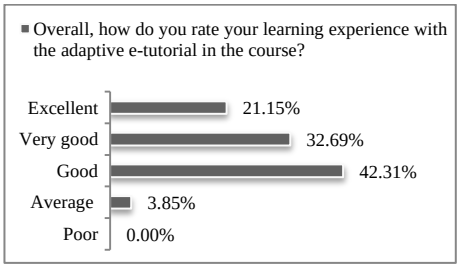

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Figure 3: Survey responses

Table 1: Summary of data analysis

Description of effectiveness indicator	Mean rating	Standard deviation
About adaptive e-tutorial:		
1. The adaptive e-tutorial provided improved *flexibility* in learning at my own time and pace.	4.48	0.58
2. The adaptive e-tutorial was *interactive* and provided learning scaffolding to me.	4.35	0.56
3. The adaptive e-tutorial enhanced my ability to engage in *independent and reflective learning*.	4.19	0.66
4. The *just-in-time feedback* provided by the adaptive e-tutorial well guided me towards correct understanding of fundamental concepts.	4.12	0.68
5. The adaptive e-tutorial was *engaging and interesting* and I was *enthusiastically involved* with its use.	4.02	0.78
6. The adaptive e-tutorial enhanced my *analytical and critical thinking ability* for problem solving.	4.00	0.77
About student learning experience:		
1. Overall, how do you rate your learning experience with the adaptive e-tutorial in the course?	3.71	0.78
2. I would like to see more adaptive e-tutorials in other courses too.	4.46	0.54

The level of flexibility offered by the adaptive e-learning strategy was highly appreciated by the survey participants, which is apparent in the quantitative mean rating of 4.48 in Table 1. In qualitative feedback given to the question "what are the best features of this approach to university learning?, 48% of the comments was related to flexibility in learning. Some direct quotes of the participants are as follows:

> *You can work at your own pace and anytime you want, also it provides good experience for students*
>
> *You are able to learn within your own pace. Some may not be able to attend lectures due to work commitments, and I find this approach solved many of these problems.*
>
> *The e-tutorial allowed me to learn the concepts in my own time when I was free*
>
> *It allows learning to be done at a time that suits me*

Flexibility in time and place seems to be a highly desired attribute of university learning for most students as they work while studying.

Active engagements and interactions are two important requisites for deep learning that leads to quality learning outcomes. However, these are difficult in large classes. Scholars of learning and teaching suggest encouraging peer discussions to get students engaged and interested in learning. However, this approach may not be entirely practical in courses that involve mathematical/financial calculations. An alternative mode for calculation based subjects is in-class questions, which can promote active learning and interactions when students' answers are elicited. Students'

answers may be elicited either by written submissions or by selecting students from a class to give verbal answers. With written responses, feedback is delayed to a future class and the likelihood of interaction is reduced. Selecting students from the class for responses is intimidating to them; even confident and knowledgeable students maybe reluctant to display their responses in a large class, particularly if concepts are relatively new or students are uncertain of their grasp of the concept. The adaptive e-tutorial provided an outside-of-class interaction opportunity; students were asked to give answers to multiple choice questions, which needed complex mathematical calculations, and real-time feedback was given from the courseware for both correct and incorrect answers, making it a live and interactive learning. This approach neither delayed feedback nor was it intimidating to students. The high proportion of qualitative comments (46%) received from the survey participants in favour of feedback and interactivity provided further evidence for it. Some of the direct quotes are as follows:

> *It is very interactive and stimulating. The responses for wrong answers helped me understand the problem*
>
> *A good compliment to the theory learnt from class and more practice which is great way to improve our understanding*
>
> *The wrong answers given by me are explained but not given away; this helped me learn for myself*
>
> *The fact that hints are given if your answer is incorrect is helpful. Also, the practice questions themselves are helpful, especially given that you can do them in your own time*
>
> *The adaptive e-tutorial aids with study and helps solve problems that you are not familiar with as a student, which would encourage better class results*

The final question in the questionnaire asked how this approach maybe improved to further enhance student learning. Students' comments were in the line of requesting for more of this kind. A strong desire to see the approach be implemented in other courses too was sensed. This resonated with the high mean rating of 4.46 on the 5-point Likert scale for the question "I would like to see more adaptive e-tutorials in other courses too". Some of the qualitative comments on this were:

> *Need more of this exercise*
>
> *More feedback*
>
> *More questions in the tutorial to reinforce learning a bit more*
>
> *It should be implemented into more subjects to allow greater learning away from university*
>
> *All lecturers and subjects should adopt and use this system of teaching*

The mean rating for the overall learning experience of students scored the lowest value (3.78) although other attributes that characterise student learning experience scored values of above 4.00. This is largely attributed to technical problems students faced. Because this was the first launch in the author's faculty, significant technical difficulties were encountered in making the system easily accessible by students. It also took a long time to resolve the problem, which resulted in students having only a few weeks to use the e-tutorial. Regardless, the overall student satisfaction is close to "very good" in a 5-point scale that has a continuum of poor, average, good, very good and excellent. The concern students had over the technical problems was evident in students' qualitative comments to the final question "how may this approach be improved to further enhance student learning". These were:

> *This site could have been easier to access and view lessons.*
>
> *I could not log onto the site without going into blackboard and resetting my password which was very time consuming.*
>
> *Server was very much delayed; sometimes repeated the question and would not let me return.*
>
> *Make it easier to connect to. It took me a while to access the e-tutorial as I kept having technical difficulties.*
>
> *It needs to be made easier to access. I know of at least one other student who was unable to access the e-tutorial, and it took me a long time to figure out how exactly I was to access it.*

CONCLUSIONS

Lecturers need to design and implement courses that would enable students to develop such graduate attributes as creativity, problem solving skills, professional skills, communication skills, teamwork and lifelong learning skills. These attributes can be acquired when student-centred active learning strategies, interactive learning environments, feedback on student progress and motivating learning tasks are contained in a course delivery plan. However, large classes pose challenges to this, yet large classes are a norm in universities nowadays due to increasing student numbers and shortages of resources. Alternative pedagogical models are therefore sought to address the challenges. The adaptive eLearning model was implemented in a relatively large class in Construction Management degree program, in that, an adaptive e-tutorial was introduced as a supplementary learning resource. From the students' perspective, the novel pedagogical approach harnessed student learning by providing improved flexibility, interactivity, motivation, real-time feedback and reflective learning, which are often difficult to achieve in large classes. Furthermore, the students liked to see more adaptive eLearning resources in other courses too. It can be concluded based on this that students can have a good learning experience with adaptive eLearning tasks. From the lecturer's perspective, the implementation of

adaptive eLearning resources may require more efforts than regular eLearning materials or other conventional learning tasks. The technical soundness of the platform used to author adaptive eLearning tasks also influences both the lecturer's and students' experiences. It may also be necessary to convince students about the potential benefits of engaging in the learning task. However, all these extra efforts will be rewarded pedagogically.

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