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Evaluating students readiness, expectancy, acceptance and effectiveness of augmented reality based construction technology education

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ABSTRACT

Augmented reality (AR) has the potential to enhance the teaching and learning experience in construction technology which involves the learning of construction processes and understanding the construction elements. Augmented reality also provides the ability to change and improve the nature of education. This is due to the possibility of overlaying media onto the real world for content consumption using smartphones and tablets devices, which enables students to access information anywhere and anytime. However, before implementing a new approach to teaching, the state of whether the students are ready to use AR have to be identified. This also goes toward what the students expect when using AR in learning, how do they accept using AR and effectiveness of using AR in learning. Therefore, the purpose of this study is to (1) Identify the readiness of students on using AR in teaching; (2) Identifying what do the students expect when using AR in learning construction technology; (3) Identifying the student's acceptance of AR in learning; (4) The effectiveness of AR in construction technology learning. A quantitative method of analysis has been implemented measuring the mean score of objective 1-3 based on the student's responses to the questionnaire. On the other hand, the second phase of the study which is to determine whether using AR is effective in learning was done by comparing pre-test and post-test results. Results from the study show assuring indicators that students accept the usage of AR in construction technology education, the application also fulfils their expectations on what AR could aid in the learning process and for student's acceptance, the result shows that students accepted the usage of AR as a learning tool. Meanwhile, the results regarding AR effectiveness on construction technology displayed noticeable improvements regarding student's pre-test and post-test results with 68% of students display improvements in their scores.

1. Introduction

Mobile devices have been essential for people with the purpose of connecting and procuring information on the go. With the development and innovation made toward information and communication technologies, primarily toward mobile devices (mobile phone, tablets, etc.), the utilisation of technology in education has quickly been a norm in the last decade (Emiroğlu & Kurt, 2018). The utilisation of technology toward teaching and learning is best when combining the traditional elements of the classroom setting with the technological benefits of the technology (D'Souza et al, 2013, cited by Shirazi & Behzadan, 2014). However, Shirazi & Behzadan (2014) claims that students were still educated with the outdated method of teaching even with the advancements of technology currently present.

Therefore, with the adaptation of technology in teaching and learning, especially mobile devices, students can benefit from the availability of information and educational resources from their fingertips (Cadavieco, Goulão, & Costales, 2012; Herrington & Herrington, 2007; Ligi and Dr B. William Dharma Raja, 2017; McConatha, Praul, & Lynch, 2008).

This study aims to design, implement and assess the readiness, expectancy and acceptance of students toward a new technology-based pedagogical methodology based on augmented reality (AR) technology to support the prospect of a more engaging learning experience in construction technology courses for quantity surveying and construction degree programmes at Universiti Teknologi Malaysia.

2. Augmented reality in quantity surveying education

Augmented reality (AR) or mixed reality is defined as overlaying artificial or virtual effects onto the real world using computer-generated graphics or 3D models (Delello, 2014; Ismail, Bandi, & Maaz, 2018). Researcher Milgram et al. (1995) has explained that AR is a mixed reality that adds graphic elements to the real world as shown in figure 1.

Augmented reality is different to virtual reality which creates a virtual environment for the users. AR can aid users to better grasp the knowledge and functionality that had been delivered through the content with the help of computer-generated visualisation (Emiroğlu & Kurt, 2018).

With the current technological advancements, AR technology has come to the point that anyone can access it anywhere. This is due to

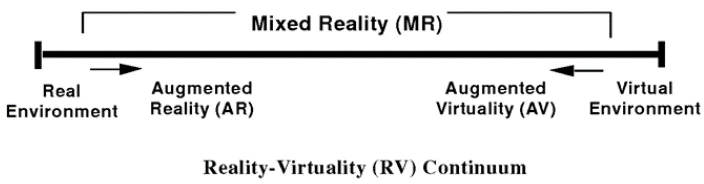

Figure 1 *Augmented reality: A class of displays on the reality-virtuality continuum (Milgram et al., 1995)*

the existence of smartphones. Nowadays, smartphones are so advance that it is considered as a minicomputer that fits on the palm (Anshari et. al, 2017).

Furthermore, smartphones are also considered the best tools to adopt AR technologies because of its onboard global positioning system (GPS) sensors, internet access, display panel and a camera. Hence, AR will be integrated into an application so that it can be accessed through a smartphone (Bower et. al, 2014; Mekni & Lemieux, 2014; Shirazi & Behzadan, 2014).

AR has been utilised in the various field from education, training, entertainment and simulations. The use of AR in education has gained momentum from the Z generation as it is easily accessible by mobile devices which is available to most Z generation students. AR's ability in visualisation helps to enhance student's creativity and understanding of the course (Hughes et. al, 2005; Pan et. al, 2006). Besides, many researchers concluded that AR's interactive simulations are more effective for cognitive learning (Dünser et. al., 2012; Georgilakis, Orfanos, & Hatziargyriou, 2014; Lee, 2012) Due to the rising popularity of mobile learning in the last decade, AR application for education has drastically increased in numbers and is mainly used with mobile devices (Emiroğlu & Kurt, 2018).

Quantity surveyors play an important part in the construction industry. Generally, quantity surveyor is a professional who is involved in a team comprising the client, architect, engineers, and contractors which combined the skills in drafting and interpretation of contract documents and to safeguard the ongoing progress of a construction project (Nnadi & Alintah, 2016; Shafie et al. 2014). Quantity surveyors serve as one of the team advisors toward the construction project. In the construction industry, the main source of information exchange is largely made through construction drawings, which until this day is in the form of 2D drawings. However, there are challenges in integrating or understanding 2D drawings into a 3D object which involves understanding the vertical and horizontal elements of the drawings (Suk et.al, 2017).

Therefore, construction technology courses are important for students, as the course teaches students how to understand and visualise what are the construction process involved on site. However, the attempt is insufficient as construction technology courses often utilise the outdated method of teaching and learning, same as other quantity surveying courses (Hasan & Rashid, K., 2005; Lee, 2009; Shirazi & Behzadan, 2014, 2015; Zakaria, Munaaim, & Khan, 2006). With the implementation of AR in construction technology courses, students can better understand, visualise and integrate the 2D drawings.

Research conducted regarding AR integration into the construction field are infrequent. In a research by Shanbari, Blinn, & Issa, (2016) on teaching masonry and roof components for construction management students using AR based videos, the students have positively agreed that AR had aided them in visualising roof construction and its components. Shirazi & Behzadan, (2015) has integrated AR into the teaching of building design and assembly project on construction students and reported that AR content increased the performance of construction management students in term of understanding the concept of the subject.

3. Student's readiness, expectancy and acceptance

3.1 Student's readiness

Advances in mobile technology have open doors to numerous method of learning in informal learning by incorporating flexible and ubiquitous access to information. Nowadays, mobile learning plays a significant role as a supplement to aid in formal education (Cheon et. al, 2012). The mobile devices can also access applications that can be used as aids in learning. With the usage of mobile devices in education being a regular occurrence, it is wise to incorporate AR technology into mobile applications as current mobile devices have technologies that could benefit AR with its variety of sensors and camera that is already built in into smartphones (Sommerauer & Müller, 2014).

However, before implementing a new method or technology in learning, readiness is a critical factor in determining whether a technology would be successfully implemented or not. Although there is a plethora of online resources and information regarding construction technology, student's should have the propensity to embrace and use the technology as part of their learning process (Mahat et. al, 2012). Therefore, the readiness level for this study will be referring to the student's readiness in using this application which will focus on the student's preference and applicability in using AR with a mobile phone in the teaching and learning process.

3.2 Student's expectancy

Expectation is defined as the act or state of looking forward or anticipating. (Chen, 2011) in his study has explored regarding student's technological expectancy toward e-learning system which used the expectancy-value theory in order to predicate that a student's behavioural intention is due to their technological expectancy and educational compatibility.

Chen added that for learning expectancy, most students expect to gain a higher level of knowledge when applying the new method. Chen has identified four general technological expectancies which are performance expectancy, effort expectancy, social influence and facilitating conditions as the dominant construct toward technological expectancy. Performance expectancy refers to an individual believes that using the technology would improve performance.

On the other hand, effort expectancy is whether a product is easy to use (Moore & Benbasat, 1991). Therefore for student's expectancy, this study will focus on the four general technological expectancies in the questionnaire that will be distributed during the data collection

3.3 Student's acceptance

Acceptance is often related to the intention and behaviours of the potential users of the technology (Davis, 1989). The technology acceptance model (TAM) commonly used to perceive the ease of use and the usefulness of a technology that could influence people's behaviour toward accepting the technology. However, the original TAM has been superseded by TAM2 which added the perceived usefulness and usage in terms of social influences and cognitive instrumental processes (output quality, relevance, demonstrability and ease of use). Moreover, TAM2 can predict the direct influence of subjective norms on behavioural intentions. Then TAM2 was improved by introducing facilitating conditions that directly relates to the actual behaviour of adopters, not to the behavioural intentions.

This new integration of TAM is called UTAUT which stands for a Unified Theory of Acceptance and Use of Technology. The addition is because people are generally motivated to use new technology if they are introduced to a particular technology, their intent to use new technology is usually not by themselves (Venkatesh & Davis, 2000). However, in 2008, Venkatesh, V., & Bala had proposed an extension on TAM, TAM2 and UTAUT which combines the model of the determinants of perceived ease of use . The determinants are computer self-efficacy, perception of external control, computer anxiety, computer playfulness, perceived enjoyment and objective usability into it.

TAM3 also consists of 17 constructs including various mediating and moderating relationships includes individual differences, system characteristics, social influences and facilitating conditions. For this study, the acceptance will be referring to the rate of student's acceptance to use AR technology in learning and continue using AR as part of their learning process. Therefore, in order to measure the rate of acceptance among students regarding AR technology, the use of TAM3 by Venkatesh, V., & Bala, (2008) will be used as the basis for the questionnaire.

4. Methodology

4.1 Research design

This study is held to address the 4 objectives of this study which is (1) Identify the readiness of students on using AR in teaching; (2) Identifying what do the students expect when using AR in learning construction technology; (3) Identifying the student's acceptance of AR in learning; (4) The effectiveness of AR in construction technology learning. This study will be conducting two types of test as a data collection method. The first and second phase of the study was conducted according to Table 1 below. The first phase is the questionnaires, which is intended to measure the student's readiness, expectancy and acceptance. However, the first three sections were conducted before the demonstration of the AR application to the students and the fourth and fifth sections were conducted when the students have been presented the AR application. The second phase of this study is conducted by implementing the pre-test, post-test method (Dimitrov & Rumrill Jr, 2003).

Table 1 *First and Second Phase Outline*

Phase	Descriptions	Execution
1st Phase	Section 1 (Basic Information)	Before AR Presentation
	Section 2 (Student's Readiness)	Before AR Presentation
	Section 3 (Student's Expectancy)	Before AR Presentation
	Section 4 (Student's Acceptance)	After AR Presentation
	Section 5 (Opinion & Recommendation)	After AR Presentation
2nd Phase	Pre-Test	Before AR Presentation
	Post-Test	After AR Presentation

4.2 Sample

41 first year Quantity Surveying undergraduates who enrolled in Construction Technology at Universiti Teknologi Malaysia, Skudai participated in the study. Construction Technology is the first course that exposes students to the construction design and methods in various building components such as substructures, super-structures and finishes with a low rise building.

The course learning objectives are 1) Understand the principle of design and method of construction of the related building components. 2) Describe the process of carrying out the work. 3) Sketch the plan, section, elevation and diagrams if necessary of all related building components. 4) Understand and describe the relevant construction materials. The students participated in this survey had no construction industry experience beforehand.

4.3 Instrument

For the first phase of the study, the instrument used for obtaining the data is by a questionnaire distributed to the students. The first section (basic information) of the questionnaire form is done to collect the data and identify the student's demographic. The questions solely ask the students regarding their age, gender, academic year and basic knowledge regarding AR and mobile learning.

The second section of the questionnaire is a closed format question which consists of 12 questions intended to measure the student's readiness toward mobile AR, the availability of mobile devices, access to the internet and the students' knowledge and experience in mobile AR. This format of questions has been used in the previous study (Abu-Al-Aish, Love, & Hunaiti, 2012; Lam et. al., 2011; Trifonova et. al., 2006; Yun & Murad, 2006).

The third section contains 12 statements of a five-point Likert scale (Boone & Boone, 2012) that is developed to evaluate the student's attitudes toward mobile AR. The Likert scale is used in similar studies regarding student's perception of the expectancy of mobile learning (Jacob & Issac, 2008; Kallaya, Prasong, & Kittima, 2009; Nassuora, 2012). The question has been modified to appear related to mobile AR. The scale ranged from 1- Strongly Disagree to 5- Strongly Agree.

The fourth section is focused on the student's attitude and acceptance and they will have to classify the practicality of mobile AR toward teaching and learning construction technology. The set of question will also be in the form of Likert scale where the scale ranged from 1-Strongly Disagree to 5- Strongly Agree. The approach of this study is adapted from Corbeil & Valdes-Corbeil, (2007) and Trifonova et al., (2006).

The second phase of this study will determine the effectiveness of mobile AR in education. The research design of a single group, pre-test and post-test was employed to determine whether AR images can help enhance the students understanding of construction technology. The students have been taught in class regarding pad foundations prior the test. However, they did not know that there will be a quiz at the demonstration. The students were asked to list out the components, materials and explain and sketch the construction process of a pad foundation. The students were given 15 minutes to answer the following questions:

1. List out the components of a pad foundation
2. List out the materials needed to construct a pad foundation
3. Explain and sketch in detail the process of constructing a pad foundation

Before the second test, students have presented the AR modules which include the 3D models, 3D animation video of the construction process and on-site scenario of constructing the foundations. The students were also given AR markers on foundations which can be accessed and overlaid as 3D models on the marker using their mobile phone. The marker was taken from the Building Construction Handbook by Chudley & Greeno (2006).

The list of foundations was 1) Isolated Pad, 2) Combined Pad. 3) Piling, 4) Raft Foundation, 5) Strip Foundation, 6) Cantilever Foundation. The 3D models were created using Sketch-up 2017 and imported to the AR application (ENTiTi) as an FBX file format and then can be viewed from the ENTiTi application. The application can be obtained from Google Playstore and Apple Appstore. After the presentation of AR modules as shown in Figure 3, students were asked to re-take the quiz in 15 minutes and submit their answers when the 15 minutes is over.

Finally, the two test were graded and compared the mean scores of the pre-test and post-test. This comparison is made to analyse whether AR could enhance the students understanding and visualisation of construction technology.

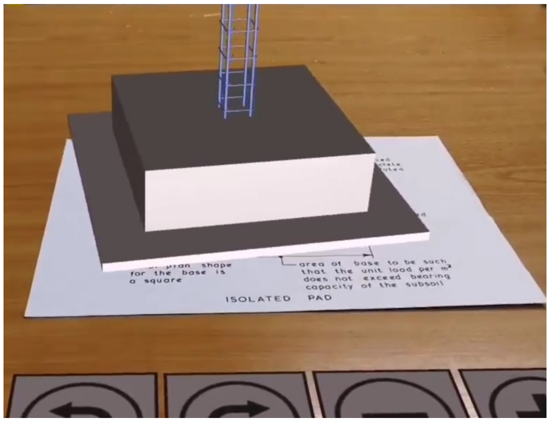

Figure 2 *Sample of the 3D model overlayed onto the marker*

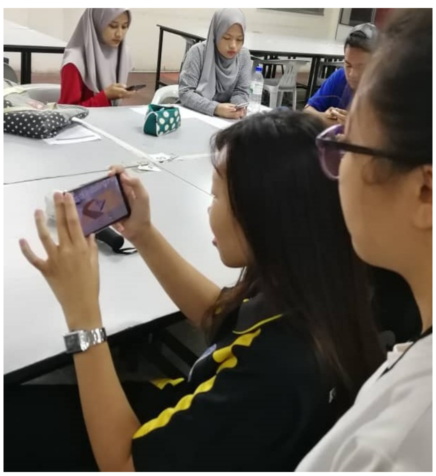

Figure 3 *Student's using AR application during demonstration*

4.4 Data analysis

The first phase of the study was done by using the quantitative data obtained and analysed using the Statistical Package for the Social Sciences (SPSS) software. Similar to this, the second phase of the study also done by inserting the data into the SPSS software.

5. Results

The results were separated into two phases, phase 1 is the questionnaire that has been distributed to the students and phase 2 is the pre-test and post-test which the students will have to answer the same questions before and after the presentation. From the analysis, it will highlight the student's readiness, expectancy, acceptance and effectiveness of the mobile AR application.

5.1 Student's readiness questions (SRQ)

Based on the data collected with the questionnaire, the student's readiness level is above average. This is shown in Table 2, the total mean score is 3.82 out of 5. Majority of the students are equipped and have the required tools to use mobile AR as shown in the results of SRQ1 until SRQ 10. Most students answered that they have smartphones that can connect to the internet and have a monthly internet subscription on their phones. This indicates that students are ready and the applicability of using mobile devices for learning purposes is present.

In contrast, the mean score of SRQ 11 and SRQ 12 which asked the students whether they have heard of AR is particularly low with the mean of 2.49 for SRQ 11 and 2.63 for SRQ 12. The mean score displays that the students may need guidance and instructions in order to use the AR application. Overall, the total mean for student's readiness is 3.82 which is good and shows that the students are ready to use mobile AR in learning.

Table 2 *Mean score of student's readiness*

Question	Mean	Std. Deviation
SRQ 1 - I have access to a smartphone	4.81	0.39
SRQ 2 - I have internet access on my smartphones	4.74	0.49
SRQ 3 - I usually surf the web using my smartphones	4.67	0.57
SRQ 4 - I depend on the university's Wi-Fi to access the internet	3.79	1.15
SRQ 5 - I have internet access when I'm outside the university	4.70	0.56
SRQ 6 - I subscribe to a personal internet plan on my smartphone	4.65	0.53
SRQ 7 - I have no problem with using the internet for learning purposes	4.30	0.94
SRQ 8 - I use smartphones as an aid to learning	4.51	0.63
SRQ 9 - My smartphone is very useful when I'm study-ing	4.40	0.66
SRQ 10 - Learning using smartphones in learning is in my interest	3.98	1.01
SRQ 11 - I have knowledge regarding AR	2.49	1.08
SRQ 12 - I have heard of learning using AR	2.63	1.02
Total Mean Score	3.82	

5.2 Student's expectancy questions (SEQ)

For the student's expectancy of using mobile AR, the questions focus on what do the students expect when using mobile AR after the briefing that had been done explaining AR and the potential of AR in learning. Based on the findings, it can be seen that the students are sceptical as shown by the total mean score of 3.71 out of 5.

Based on Table 3, the mean score of SEQ3 which ask the students "I am capable of using AR in learning" is the lowest with the mean score of only 3.21 out of 5. This shows that the students are doubting the benefits of mobile AR in education from the briefing. However, this is prior to the demonstration and activity that uses mobile AR in teaching and learning.

5.3 Student's acceptance questions (SAQ)

This set of questions addresses the behaviour of the students regarding accepting the usage of mobile AR. Based on table 4, the total mean score is 4.09, which makes it the highest score from all section of the questionnaire. This shows that the student already acknowledges and are attracted to mobile AR. The highest mean score from the set of question is SAQ 13 "group work will be more interesting when using AR" which means that AR will attract students in using the application for students as the medium to help them learn.

5.4 Effectiveness of mobile augmented reality

The graded scores from both pre-test and post-test were divided throughout both tests according to the student's name to identify the changes in the student's scores. The equation as shown as Equation 1 was used to identify the percentage of the number of students with

Table 3 *Mean score of student's expectancy*

Question	Mean	Std. Deviation
SEQ 1 - Learning using AR will be beneficial	3.67	0.68
SEQ 2 - I would like to learn construction technology using AR	4.02	0.64
SEQ 3 - I am capable of using AR in learning	3.21	0.94
SEQ 4 - Training is needed to understand how to use AR in learning	3.77	1.09
SEQ 5 - Learning using Mobile Augmented Reality will be interesting	3.79	0.83
SEQ 6 - I can understand better when learning using AR	3.60	0.73
SEQ 7 - Learning using AR will improve the interactive level between peers and lecturers	3.41	0.79
SEQ 8 - The curricular will be improved when using AR in Learning	3.53	0.86
SEQ 9 - I can visualise better when learning using AR	3.70	0.85
SEQ 10 - I can learn independently using AR	3.53	0.85
SEQ 11 - I can learn with my classmate using AR	3.86	0.71
SEQ 12 - The classroom activity will be more active with AR	3.88	0.85
SEQ 13 – I will be more excited to learn using AR	4.23	0.68
Total Mean Score	3.71	

Table 4 *Mean score of student's acceptance*

Question	Mean	Std. Deviation
SAQ 1 - I am eager to try new technology	4.19	0.76
SAQ 2 - The learning objectives of construction technology will be achieved better with AR	4.05	0.87
SAQ 3 - The usage of AR will improve productivity in learning construction technology	4.02	0.77
SAQ 4 - The usage of AR will improve the understanding of construction technology	3.98	0.80
SAQ 5 - Learning using AR is flexible in a learning session	4.02	0.89
SAQ 6 - Learning using AR is beneficial for the course	4.07	0.91
SAQ 7 - AR can help students visualise construction elements better	4.35	0.75
SAQ 8 - Students can understand sequential construction process better using AR	4.14	0.83
SAQ 9 - Learning using AR will help me visualise the process better	4.16	0.75
SAQ 10 - I am comfortable in using AR in learning construction technology	3.81	0.93
SAQ 11 - I will encourage my classmate to use AR to learn Construction Technology	3.91	0.89
SAQ 12 - Classroom activity will be more active	4.14	0.71
SAQ 13 – Group work will be more interesting when using AR	4.37	0.76
Total Mean Score	4.09	

increased scores, unchanged scores and decreased scores. From the graded test on table 5 below, it shows that sixty-eight percent of the students had an increase in scores with the aid of a 3D model in AR and some students could explain the construction process more thoroughly after using AR application in the second attempt. Twenty-nine percent of the students have their scores remains the same and unchanged. Only one student had a decrease in scores after using the AR application. The results show that there was significant evidence that student's understanding of construction technology was improved, as shown in the post-test.

Equation 1 Percentage calculation

$$p(\%) = \frac{n}{t}$$

p= percentage

n= number of students (Increase, unchanged, decrease)

t= total

Table 5 *Phase 2 Test Results*

Pre-test & Post-Test Results	Number of Students	Percentage (%)
Increase	30	68.29
Unchanged	12	29.27
Decrease	1	2.44

Table 6 *Phase 2 t-test Results*

	Post-test	Pre-Test
Mean	15.5610	12.9268
Observation	43	43
Correlation	0.677	
Hypothesised Mean Difference	0	
df	40	
t Stat	6.143	
P(T<=t) two-tailed	0.000 (2.9709E-7)	
Effect size (*d*)	0.155	

However, in order to find out whether the results are statistically significant, a t-test has been conducted to the test results. The paired samples *t-test* represent the student's performance comparison during the pre-test and post-test. As shown in table 6, the mean of the post-test is 15.56 and the pre-test is 12.93, this shows that the difference between the mean is 2.63. The results of the paired t-test on the two attempts show that the results that the students' performance after introduced to the concept of AR is significantly increased. The difference, although statistically significant, is small when using Cohen's (1988) guidelines.

6. Discussion

The first phase of the test shows that students are ready to use AR as a tool to aid in teaching and learning construction technology. Although some students had troubles in using the application at the beginning, the student's stated that they are more focused and active in the class session. Based on the questionnaire, the application demonstrated to the student's had are sceptical regarding the application. It can be seen by the total mean score shown in the student's expectancy. Although students were sceptical and have set average expectations on the application, the ubiquitous aspect of the application attracts students in learning and students actively participate in class when using AR as a learning tool. However, based on the expectancy questions, it can be seen that students expect that AR as a learning tool is troublesome. In contrast, the results for student's acceptance toward the AR application is high with the total mean score of 4.02 which is the highest among the three objectives. This shows that the students can accept the use of AR and teaching and are excited to learn when using AR.

Based on the results of the second phase, it shows that students could understand and visualise more with the help of 3D models projected by the AR application. Construction technology is defined as the study of method and equipment used to construct structures. Therefore, the understanding of construction technology could be considered achieved when the students could understand the construction process of a building element and each component and materials needed to construct a building. This confirms that AR images enhance the students understanding of the foundations and its construction process.

The results suggest that AR technology could enhance the understanding of construction technology courses for quantity surveying students. Although it is difficult to visualise the construction process and the structure of the foundation, the students can illustrate and visualise it using AR technology. Moreover, with the implementation of AR in the syllabus, students who do not have the extensive field experience can understand and interpret the construction process and components of the construction elements. Even though site visits at construction sites could enhance the students understanding, it is hard to conduct site visits that are tailored to the course outline.

With the integration of AR application in the student's syllabus, students can access the 3D image overlaid on the marker easily with the AR application. Nevertheless, to apply AR in the student's entire syllabus, it requires a lot of resources as this type of AR requires 3D modelling and animation videos. Different contents need to be developed to aid the students according to the course outline to develop the continuity of applying AR to the whole syllabus. More research efforts have to be conducted to simplify the integration of AR and the content.

Understanding and visualising construction elements is important for quantity surveying students to better prepare them for the industry. Therefore, with the implementation of AR in the teaching and learning process of quantity surveying students, the construction technology course can be enhanced.

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