EXPERIENTIAL LEARNING IN GREEN BUILDING TECHNOLOGY USING AUGMENTED REALITY

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Abstract: Industry 4.0 hasn't yet done much to promote the use of Augmented Reality (AR) technology in Malaysian education. AR technology is more intriguing when the components are 3D-shaped, such as images or videos. The impact of the Covid-19 pandemic and online learning requires pedagogical adaptation in higher education in line with 21st-century learning skills and industrial revolution 4.0. Most students are still lacking a solid understanding of green building technology. The use of 2D drawings rather than 3D models when explaining to students the structure of buildings sometimes does not achieve the understanding. This project aims to develop AR game applications that will help learners in civil engineering better understand the information on green buildings. This AR application was created using the MAKAR application and designed contents by using Canva, Microsoft Powerpoint, SketchUp Pro 2020, and Revit 2020. The efficacy of the AR application was tested by 30 Polytechnic Ungku Omar Semester 5 students using a Google Form. In this study, the quantitative technique is used to analyse statistical data. The results suggest that the AR application game aids and enhances students' learning of the fundamentals of green building technology through gameplay. The AR applications are compiled with a short video, and evaluation features also generate a visual experience in the learning process that is dynamic and modularly comprehensive.

***Keywords**: Augmented Reality, Green Building Technology, Internet of Things, 21st Century Education*

1. Introduction

The usage of augmented reality (AR) and the internet of things (IoT) in education has been shown to boost student motivation in the teaching and learning process whether interactively or online (Cipresso et al. 2018). AR is now viable for use in higher education because of technological advancements and the availability of hardware and software (Ayer, Messner & Anumba 2016; Kravets, Midak & Kuzyshyn 2017). The Covid-19 epidemic necessitates the development of more innovative and effective virtual teaching approaches (Aziz et al. 2020; Wan Hassan et al. 2020). Furthermore, the implementation of AR as an education model is regarded to better address the demands of 21st-century higher education students (Cipresso et al. 2018; Milovanovic et al. 2017; Rafiq & Hashim 2018). AR in civil engineering education is also not widely used and should be explored as an interactive teaching tool with online student-centred learning (Farshid et al. 2018; Singh et al. 2015; Zhao, Zhang, & de Angelis

2019). As a result, the Augmented Reality Game for Green Building Technology (AReGB Games) application was built to impart green building technology information in virtual reality.

The objective of this innovative product is to create a game application for an early understanding of green building information using AR technology that examines the concept of green building technology, green building assessment tools, and green building elements with a virtual exploration of polytechnic students studying the DCC50232 Engineering in Society course under the topic of Environment and Sustainability in Civil Engineering, as well as evaluating the effectiveness of the game application.

Augmented reality (AR) is a technology that enables humans, computers, smartphones, and reality to connect by allowing digital and actual items to cohabit and giving civil engineering students an intuitive sense of experience in an animated world (Midak et al. 2019). According to (Ayer, Messner & Anumba 2016; Milovanovic et al. 2017), AR can also increase the quality of building-related instruction. To avoid confining AR to specific technologies, AR is described as a system that combines real and virtual; is interactive in real-time and 3-D (Farshid et al. 2018; Zhao, Zhang, & de Angelis 2019). This definition is meant to allow additional technologies, such as mobile technology, to be used in addition to the virtual 2-D overlay on top of the video at an interactive pace, as long as the overlay is not coupled with the video. This concept, however, includes monitor-based interfaces, monocular systems, head-mounted devices, and mobile devices (Kravets, Midak & Kuzyshyn 2017; Midak et al. 2019; Singh et al. 2015).

Green building is a related trend in attaining sustainability in the construction sector following the Sustainable Development Goal 2030 (SDG 2030). Green Buildings aim to improve the efficiency of the use of energy, water, and material resources while reducing the impact of buildings on human health and the environment over the life cycle of the building (Shafiei, Abadi & Osman 2017; Yen et al. 2016). This is accomplished through better design, construction, operation, maintenance, and seat removal. As a result, green buildings are intended to conserve energy and resources, recycle materials, and reduce harmful chemical emissions throughout their entire cycle (Zhao et al. 2019). Its compatibility with climate, tradition, culture, and environment may preserve and increase the quality of human existence while also preserving the capacity of the ecosystem on a local and global scale (Yen et al. 2016). It also uses resources efficiently, saves money on operations, increases productivity, and sends the proper message about being devoted, organised, and responsible for the future (Pandey 2018; Shafiei, Abadi & Osman 2017).

2. Materials and Methods

2.1 AReGB Game Display

Tablets or ordinary smartphones may be used to practise AR, with the device's screen acting as a realistic interface to exhibit, operate with interactive buttons, and play videos, and 3D models. Using a MAKAR application, as seen in figure 1, the AreGB gaming application will generate an augmented reality that displays the application's content, as shown in figure 2. With the aid of a visual display, the game has three key parts: START, QUESTION, and FINISH.

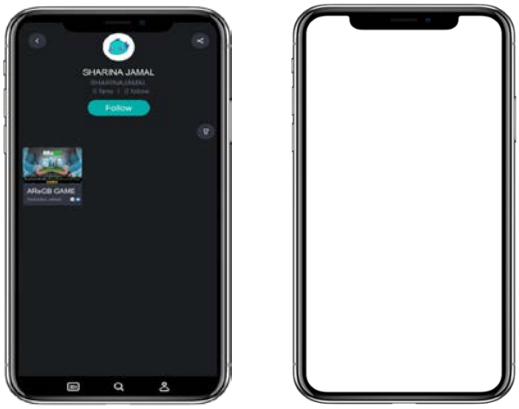

Figure 1. The interface of the MAKAR Application

Figure 2. AReGB Games Content

2.2 Method of Game Production

The AReGB game was created by utilising graphics tools to create the basic model of green buildings and then creating infographics with Ms PowerPoint and Canva.

2.2.1. Software for Designing Green Building Models

The green building sample design was created using two software packages, Revit 2020 and SketchUp Pro 2020. This 3D design of a green building focuses on the fundamental features of a green building as well as a portrayal of the shape of a green building that may be used in the most recent construction planning that stresses green aspects, as seen in figures 3 and 4.

Figure 3. Building a 3D model in Revit 2020.

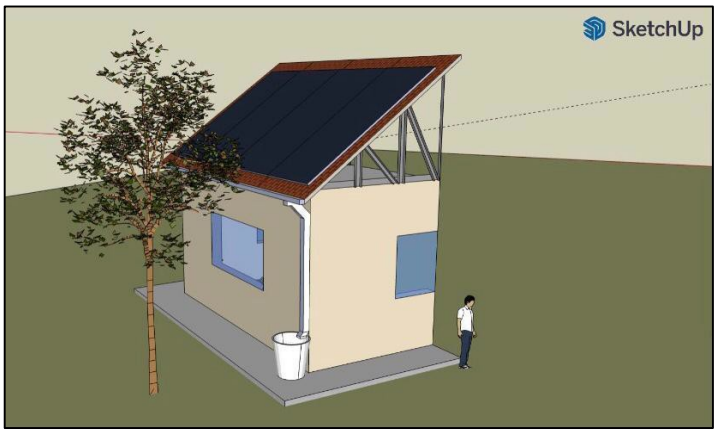

Figure 4. Building a 3D model in SketchUp Pro 2020

2.2.2 Creation of Green Building Technology Question Infographics

This green building technology information infographic was created using Microsoft PowerPoint and Canva, as seen in figures 5 and 6. All of this material is gathered in preparation, and the reliability of the source is ensured for citation, and it fits the standards of the syllabus DCC50232, topic Environment and Sustainability in Civil Engineering.

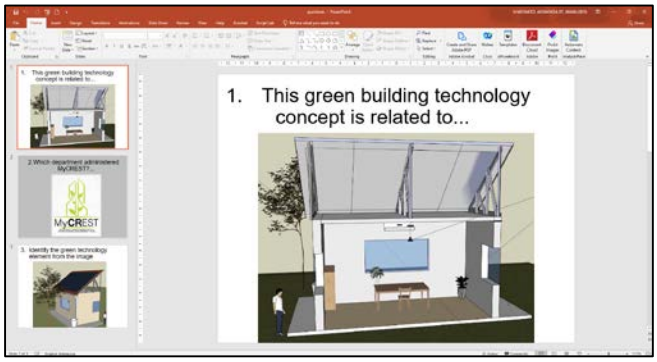

Figure 5. Creating graphical questions in PowerPoint

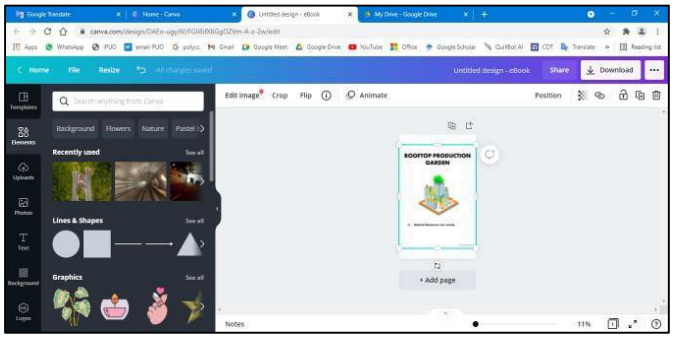

Figure 6. Creating graphical questions in Canva

2.2.3 Developing a Green Building Technology AR Game

The augmented reality game of this green building was created with the open source program MAKAR. The infographic material of questions and 3D videos of green building technology produced was uploaded to this programme and then organised and modified according to the learning outcomes to be reached for the DCC50232 course, as seen in pictures 7 and 8 below.

Figure 7. AReGB game interface development.

Figure 8. MAKAR content display creation

2.2.4 Instrument and sample development

The AReGB games efficacy was evaluated among 30 Ungku Omar Polytechnic (PUO) students who took the DCC50232 course in session 1 2021/2022. Then, with the purposive sampling approach, a sample population of 30 fifth-semester students from two classes of Diploma in Civil Engineering (DKA) as indicated (Hair et al 2006; Cohen, Manion, & Morrison 2011) is adequate. This innovation is validated using a two-part questionnaire instrument, I and II. Part I includes demographic data. Part II includes three items relevant to students' understanding of green building technology and augmented reality in the form of before and post questions, as shown in figure 9.

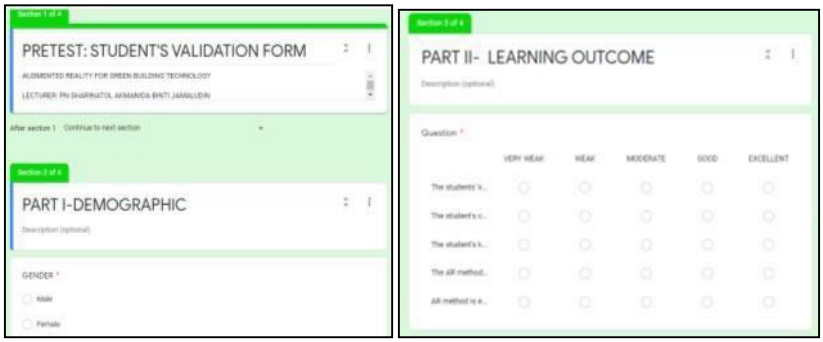

Figure 9. Questionnaire instrument

Alpha Cronchbach is an instrument's reliability index whose value is approved if it surpasses 0.70. Questionnaire development employs a Likert scale, as indicated in Table 1.

Table 1. Likert Scale.

Title 1	Score
Strongly Agree	5
Agree	4
Moderate	3
Disagree	2
Strongly Disagree	1

The questionnaire data was gathered and analysed using Microsoft Excel software for the interpretation of mean score values (as shown in Table 2) and standard deviation values. This means the score level is established by referring to the study by Pallant (2020).

Table 2. Mean Score Level.

Level	Mean Score
High	3.34 - 5.00
Moderate	1.67 – 3.33
Low	1.00 – 1.66

3. Results

The results of this innovative research will be discussed in terms of the efficacy of the AReGB gaming application. Alpha Cronbach's dependability is rated based on the classification index's reliability, which is 0.90-1.00 very high, 0.70-0.89 high, 0.30-0.69 medium, and 0.00-0.30 low, according to Babbie (2010). The analysis findings suggest that Alpha Cronbach's is more than 0.90, as shown in Table 3.

Table 3. Alpha Cronbach's Reliability Value.

Variables	Items	Alpha Cronbach's Value
Learning outcomes	5	0.93

3.1 Student Demographics

As indicated in Table 4, a total of 30 respondents from the two courses of semester 5 completed the questionnaire to measure student comprehension of green building technology and the usage of augmented reality. Overall, 53% of male students responded to the questionnaire, while female students answered up to 47%.

Table 4. Frequency of Student Response to Learning Results.

Course	DKA5A		DKA5B	
Gender	**M**	**F**	**M**	**F**
Frequencies	8	7	8	7
Percentage (%)	53	47	53	47
Total	15 (100%)		15 (100%)	

3.2 Pre and Post Test

A questionnaire was also used to analyse students' perceptions before and after the AReGB game, with pre and post-assessments based on mean interpretation values and standard deviations, as shown in Tables 5 and 6 for the DKA 5A class and Tables 7 and 8 for the DKA 5B class.

Table 5. Pre-test value for DKA 5A related to green technology and AReGB game

ID	Variables (Pre)	Mean	Standard Deviation	Interpretation
A1	The students' knowledge about green building information	2.86	0.36	Moderate
A2	The student's comprehension level of green buildings.	2.79	0.58	Moderate
A3	The student's knowledge level of Augmented Reality (AR)	2.43	0.65	Moderate
A4	The AR game method is effective in attracting students to learning.	3.43	0.85	High
A5	AR method is effective in attracting students to learning.	3.43	0.76	High

The pre-test before utilising the AReGB game reveals a modest interpretation value among DKA 5A students since the student's understanding of green building technology and augmented reality is not yet thorough. Variable P4 and P5 get the high result because some of the students understood the function of AR.

Table 6. Post-test value for DKA 5A related to green technology and AReGB game

ID	Variables (Pre)	Mean	Standard Deviation	Interpretation
PA1	The students' knowledge about green building information	4.43	0.65	High
PA2	The student's comprehension level of green buildings.	4.43	0.65	High
PA3	The student's knowledge level of Augmented Reality (AR)	4.36	0.63	High
PA4	The AR game method is effective in attracting students to learning.	4.64	0.50	High
PA5	AR method is effective in attracting students to learning.	4.71	0.47	High

In comparison to Table 5, student success improves when they experience augmented reality on their smartphones. According to the previous interpretation, this AReGB game boosts the motivation and inventiveness of students' learning about green technology and augmented reality.

Table 7. Pre-test value for DKA 5B related to green technology and AReGB game

ID	Variables (Pre)	Mean	Standard Deviation	Interpretation
B1	The students' knowledge about green building information	2.86	0.36	Moderate
B2	The student's comprehension level of green buildings.	2.79	0.58	Moderate
B3	The student's knowledge level of Augmented Reality (AR)	2.43	0.65	Moderate
B4	The AR game method is effective in attracting students to learning.	3.14	0.82	Moderate
B5	AR method is effective in attracting students to learning.	3.21	0.82	Moderate

Table 7 displays the results of the DKA 5B pre-test. Overall, a moderate interpretation value was achieved since students' knowledge and comprehension of green building technology and augmented reality still need to be enhanced.

Table 8. Post-test value for DKA 5B related to green technology and AReGB game

ID	Variables (Pre)	Mean	Standard Deviation	Interpretation
PB1	The students' knowledge about green building information	4.57	0.51	High
PB2	The student's comprehension level of green buildings.	4.64	0.50	High

PB3	The student's knowledge level of Augmented Reality (AR)	4.43	0.51	High
PB4	The AR game method is effective in attracting students to learning.	4.64	0.50	High
PB5	AR method is effective in attracting students to learning.	4.43	0.51	High

Table 8 displays the post-test for the DKA 5B class, which also has a high interpretation value. It was discovered that students can better grasp and evaluate green building technologies when relativity is used. Overall, this AReGB game is highly successful and valuable in boosting students' knowledge online with augmented reality.

4. Discussion

The findings of this study are discussed in light of the study's two objectives: i) developing green building technology augmented reality game applications (AReGB Games), and ii) acknowledging the effectiveness of the AReGB game among Ungku Omar Polytechnic students enrolled in Engineering in Society course. Based on the data, all students explore augmented reality as a mobile learning access tool. In addition, based on the findings of the study, students gain experience and abilities in using augmented reality through their smart devices. This AReGB gaming application is meant to boost students' skills in studying green technology themes in the Engineering in Society course. In addition to student use, this program may be utilised as a teaching tool for lecturers for Engineering in Society course teaching activities.

Nowadays, the teaching and learning process is not restricted to the lecture halls, but mobile technology aids the learning process as a teaching aid to students (Rafiq& Hashim 2018). As a result, the invention of this augmented reality application game may maximally utilise the aspects of active learning and self-learning of the students.

5. Conclusion

This research addresses the design and development of green building technology augmented reality (AR) game apps (AReGB Games) and learning activities centered on 21st-century teaching and learning. The AReGB game combines fundamental questions on green building technologies to give ordinary polytechnic students a first AR-based learning experience. By introducing augmented reality to the field of civil engineering study, this invention provides a significant contribution to the student community. This innovation's output can pique polytechnic students' interest in green building technology by merging AR experiences and strategic learning, as well as a fundamental framework to facilitate learning in the field. AReGB game innovation not only adds a new application category for mobile AR, but also provides a reference for various technological, logistical, and design issues based on the experience of designing, producing, and assessing AReGB games. This application enables the interchange of context between traditional and virtual learning methods for green building technologies. Finally, polytechnic students were able to utilise the AReGB gaming program intuitively and complete all exercises with ease, and they were enthusiastic about AR technology.

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