AREDApps: Integrating Mobile Augmented Reality in Orthographic Projection Teaching and Learning

Marlissa Omar, Dayana Farzeeha Ali, Ahmad Nabil Md. Nasir, Mohd Shahrizal Sunar

ABSTRACT---Engineering drawing course is one of the compulsory curricula in almost all engineering faculty. This course helps familiarize students with the must possess skills for engineers known as engineering drawing skills and visualization skill. However, there are some limitations to the previous teaching and learning methods which does not include an emphasis on the development of students' visualization skills and concept understanding. Instead, it leads the students to incorporate the trial and error method while solving the task that requires visualization. This paper introduces Augmented Reality Engineering Drawing Apps (AREDApps) as a new approach in the teaching and learning of orthographic projection, which is one of the important but critical topics in engineering drawing syllabus. A total of 30 respondents has participated in this study, which requires them to use AREDApps during teaching and learning session. The results of the evaluation that has been conducted among the respondents indicate a favorable agreement on the constructs studied in this paper. These findings show that AREDApps have great potential for the revolution of teaching and learning in the classrooms.

Index Terms: Mobile Augmented Reality, Orthographic Projection, Teaching and Learning, Engineering Drawing

I. INTRODUCTION

The fourth industrial revolution or also known as industrial revolution 4.0 were defined as the application of cyber-physical systems to the industrial production systems. This revolution generally implemented the use of internet technologies into industry. Recently, it has become a top priority for various research centers and universities [1]. In today's society, education plays an important role to help a country in realizing their vision as well as promoting their economic growth. Among all fields, engineering field are one of the important fields to ensure the growth of a country. Recently, radical changes have occurred within engineering field especially involving technologies specialties [2]. Based on that, technologies have been predicted to transform engineering education in the next 50 years [3]. This is due to the rapid development of technologies in the recent years that witnesses many new inventions in technology devices and information technology. Furthermore, engineering education has been facing numerous challenges where various researcher claimed that there should be a reform in terms of its curricula and teaching methods.

There have been various efforts done by authorities to redesign engineering drawing curricula for undergraduate engineering students where contents addressing visualization skills were included in the curricula [4]. Emphasis on visualization skills are important because this course requires students to deal with the construction of 2-dimensional and 3-dimensional geometry and the creation of multi-view and pictorial representations.With rapid advancement of technologies today, various researches have been conducted to identify the possibilities of implementing technologies in various fields and that includes education field.

Nowadays, augmented reality technology has been used in almost all field due to its possibility to bridge the gap that exists between physical world and digital world [5].There are many other potential benefits that have been identified from implementing augmented reality especially in education.However, augmented reality has huge potential to support the improvements of students' visualization skills or spatial abilities as well as promotes problem solving skills by allowing the students to view, touch and manipulates the objects or design [6].Other than augmented reality, there are many technologies that have been identified and used in educational setting which supports students' learning and skills enhancement compared to the conventional methods. Thus, it is crucial for current researcher to continuously search for the best technology-based teaching method and approaches to match the current trends today.

II. LITERATURE REVIEW

In the literature review section, the researcher discusses issues in learning Engineering Drawing, Augmented Reality (AR) in Education, and ADDIE Model. The previous researches related to this study is elaborated to provide insight for the readers.

Issues in Learning Engineering Drawing

Engineering drawing is the first course offered to students in engineering faculties in order to provide the basics of engineering education. Engineering drawing used to be taught using chalk and board, as well as model blocks back

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in the days. Nowadays, the development of technology has introduced the use of computer-aided software in the teaching of engineering drawing in higher institutions [7]. However, research has shown that the use of computer-aided software is not enough in helping students to develop their spatial understanding which can help in polishing their drawing skills [8]. Students were still having difficulties learning engineering drawing especially when it comes to understanding and mastering the concepts of engineering drawing [9].

Table. 1 Difficulties in Engineering Drawing Course [10]

Statement/ Indicator	Agree		Disagree		Mean	SD
	F	%	F	%		
Understanding sectional drawing	33	83	7	17	*1.95	0.85
Lack of understanding of sectional drawing principles	31	77	9	23	2.40	0.73
Have drawing models	21	53	19	47	3.38	0.74
Familiar with EGD line-types	26	65	14	35	1.70	0.72
Relevant previous topics of sectional drawing	20	50	20	50	2.88	0.69
Have EGD background	5	12	35	88	3.40	0.50
Lack of knowledge on 2D/3D sectional drawing	24	60	16	40	1.65	0.83

Apart from difficulties of understanding the concepts, students also usually faced difficulties due to the lack of visualization skills [11]. Difficulties during teaching and learning might be caused by failure of adapting suitable approaches used during lesson. Even in the 21st century, there are still educators who used conventional approach to teach students [12]. Learning three-dimensional concepts through sketching which is the most common method used in engineering drawing classroom is one form or passive learning which might end up generating a heavy cognitive load among students during learning process [13]. Thus, it is important to identify the suitable approach in teaching and learning to maximize the learning experience.

Augmented Reality in Education

Augmented reality technology can be defined by three properties which are [14]:

i. The system must be a combination of real and virtual objects in real environment
ii. Aligned the real and virtual objects together simultaneously
iii. Runs interactively in real time

The advantages that this technology offered are the reason why people in the various field have come to see this technology as one of the emergent technologies recently.Other than education field, augmented reality also has been used in clothing, automobile and biomedical industry [15].The concept of this technology surpassed the needs of various areas, which provides a more exciting and productive environment compare how it used to be before this technology were introduced. The results from all these studies showed that the implementation of this technology could especially elevate students understanding of complicated concepts and improve visualization skills in various course and areas. Augmented reality is practical when it is used to explain a complex concept; a concept that cannot be explained using word alone [16].This is because, augmented reality can augment abstract information and present it in a more effective ways that enables learner to easily understand the complex concept. This is due to the ability of augmented reality to help reduce cognitive load during learning process [17].

III. AUGMENTED REALITY ENGINEERING DRAWING APPS (AREDAPPS)

Augmented Reality Engineering Drawing Apps (AREDApps) is developed specifically for the orthographic projection topic in Engineering Drawing course. AREDApps is developed using Unity3D, Vuforia, Android Studio and Java, where its primary users were Android users. This is due to the large population of university students who possess an android device instead of other types of devices.Development of AREDApps is mainly due to the lack of teaching and learning tools that can cater to the lack of conceptual understanding and visualization skills problems among students learning engineering drawing.

Marker

The marker used with AREDApps is a piece of A5-sized paper containing different patterns. Fig. 1 shows the picture of AREDApps marker. The marker is used as a target image for the apps which will trigger the virtual three-dimensional models when scanned via the app.

Fig. 1 AREDApps Marker

AREDApps Interface

AREDApps starts with Unity logo showing up on the whole screen. The main menu interfacecontainsfive buttons; Steps to Draw, 3D Objects, Video Tutorial, About Us and Exit as shown in Fig. 2.

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Fig. 2 Main Interface of AREDApps

When the 3D Objects button is pressed, an AR camera will show up in the screen. This camera will be used to scan the marker in order to trigger the virtual three-dimensional model in this app. In this interface, there are three button which is Back button to navigate the page to the main interface again, Rotate and Static button for controlling the movements of the three-dimensional model. Fig. 3 shows the AR camera in this app.

Fig. 3 AR Camera

Users can pick how they want to view the objects by actively manipulates the objects. Users can move the phone in order to see all the views, as well as click on Rotate button to make the virtual three-dimensional objects rotate by itself. Apart from the 3D Object button, there are also Video button that can activates the collection of tutorial videos showing the construction of orthographic projection. Instead of having the teacher to re-draw the construction drawing in front of the class, students can easily re-play the tutorial video anytime and anywhere. Fig. 4 shows the interface that shows the video.

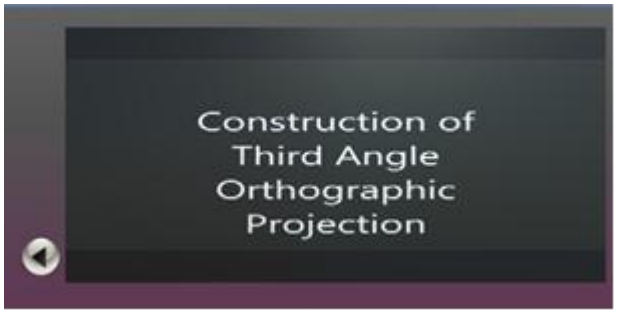

Fig. 4 Tutorial Video in AREDApps

The next button is the About Us button as shown in Fig 5 which shows the information related to AREDApps such as the developers, the software used, credits and the copy right information. The purpose of About Us button is to provide information to the users regarding the app developer and its copyright information to ensure no plagiarism of the app as shown in Fig. 6.

Fig. 6 About Us Interface

IV. METHODOLOGY

AREDApps is developed as an alternative to help increase students' understanding, enhance visualization skills and attract students' interests in engineering drawing classroom. Thus, this study is conducted to identify the perception of students in the use of AREDApps. The perception is categorized in terms of ease of use, concept understanding, visualization aid and intention of usage. This study involved a total of 30 first year engineering students enroll in Engineering Drawing course. All of the respondents is an android users and is familiar with the use of apps in their android device.

A set of questionnaires was used to conduct the evaluation process. The constructs measured in the instrument is ease of use, concept understanding, visualization aid and intention of usage. Before the evaluation, students were given a briefing to enable them to familiarize themselves with the app. Then, the evaluation took place after all respondents has already used AREDApps by handing out the questionnaire to each of them.

V. RESULTS

When developing something, it is crucial to get the users evaluation in order to identify the users' perception towards the product. Evaluation is done for AREDApps to obtain what users think about using AREDApps in teaching and learning. The evaluation is done among 30 respondents

consisting of first year engineering students enrolled in the Engineering Drawing course. The analysis involved in this study is descriptive statistics. SPSS version 2.0 was used in order to perform descriptive statistics to obtain the results. Table 3 shows the evaluation result obtained in this study.

Table. 3 Evaluation Result

Construct and Items	Mean	Standard Deviation
1. Ease of Use	**4.15**	
AREDApps content delivery is simple, concise and orderly which is easy to follow	3.97	.490
AREDApps is easy to use and user friendly	4.20	.551
I do not face mobile phone problem in exploring AREDApps	4.23	.626
Using AREDApps ease my learning process	4.20	.407
2. Concept Understanding	**4.05**	
AREDApps helps me to relate the content of this topic with the real world	3.90	.712
Usage of animation/graphic/3D model in AREDApps is more helpful to me compared to explanation lecture method alone in understanding the content of this topic	4.23	.626
By learning through AREDApps, i can reduce my study period compared to learning through printed notes	4.23	.568
AREDApps helps me to learn the concept of first angle and third angle orthographic projection	3.90	.548
AREDApps helps me to learn the construction theory of third angle orthographic projection	4.10	.481
AREDApps helps me to understand the dimensioning concept in orthographic projection	3.97	.490
3. Visualization Aid	**4.41**	
AREDApps help me in getting better picture (realistic) towards the content of this topic.	4.10	.403
AREDApps helps me to visualize the view of given object more easily	4.63	.490
AREDApps helps me to visualize side views of each object more easily	4.50	.509
4. Intention of Usage	**4.21**	
I feel good about using AREDApps	3.93	.450
I am glad if other subject also has similar apps	4.30	.466
Usage of AREDApps increase my interest towards this topic	4.47	.507
I prefer learning through AREDApps compared to 3D computer-aided animation	4.20	.847
I prefer learning through this learning kit compared to model blocks	4.13	.571

The results of the descriptive statistics analysis were then referred based on the criteria of analysis by numerical scales as shown in Table. 3 [18].

Table. 3 Criteria of Analysis by Numerical Scale [18]

Category	Numerical Scale
Strongly Disagree	1 – 1.99
Disagree	2.0 – 2.99
Agree	3.0 – 3.99
Strongly Agree	4.0 – 5.00

The descriptive analysis findings indicate that the mean score for ease of use is 4.15 (Strongly Agree), concept understanding is 4.05 (Strongly Agree), visualization aid is 4.41 (Strongly Agree) and intention of usage is 4.21 (Strongly Agree). Based on table 3, visualization aid shows the highest mean scores of 4.41 while concept understanding shows the lowest mean scores of 4.05. However, overall results indicate that all users strongly agree on all the constructs which shows a positive agreement on the evaluation of AREDApps.

Visualization aid received the highest mean scores because by allowing students to experience a situation or environment involving space and objects in space, visualization skills can be developed [19].Multimedia elements such as animation have a great effect towards students' motivation, and knowledge transfer. This is because multimedia learning allows students to construct their own mental model through experimenting with the learning environment [20].

VI. CONCLUSION

This study has identified the potential of introducing the use of Mobile Augmented Reality in the teaching and learning of orthographic projection among engineering students. The use of this technology has been seen as promising teaching and learning tools to increase students interests as well as brought a positive impact on their learning outcomes. This approach, which utilized a Mobile Augmented Reality technology, was chosen due to the promising potential of this technology usage among the 21st-century citizen. AREDApps can provide students with a flexible learning experience as well as promotes self-directed learning. Its ease of use helps students to learn more quickly and effectively, and the novelty of this technology increases students interests towards learning itself. This study provides an evaluation of the use of AREDApps among respondents in order to show their perceptions and acceptance of the use of MAR in teaching and learning. It can be seen from the results which indicate that respondents positively agreed that AREDApps could fulfil all the constructs, which include ease of use, concept understanding, visualization aid and intention of usage. It is hoped that these findings will encourage more researcher to further integrate MAR in teaching and learning to improve the quality of education and enhance students' understandings.

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