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Research Paper

The Efficacy of Augmented Reality on Student Achievement and Perception among Teluk Intan Community College Student in Learning 3D Animation

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Abstract: This paper presents a research conducted in Teluk Intan Community College aimed to evaluate the effectiveness and usability of integrating the Augmented Reality (AR) technology as an aid for animation course in Teluk Intan Community College. The focus was to integrate AR tool as an aid for students in the task of 3D modelling. For this research, the intended outcome is to compare the effectiveness between using the AR tool and written tutorial. The AR tool which later be called as ARC-3DM (Augmented Reality Courseware for 3D Modelling) will be developed and be tested in the experiment. Quantitative approach and quasi-experimental design were used in the study. A total of 54 animation students are involved in the study. The students were divided into two groups: control and treatment. A pretest and posttest were conducted to both groups. System Usability Scale (SUS) Questionnaire were administered to treatment group after the posttest to evaluate usability. Statistical methods involved were descriptive analysis and the analysis of covariance (ANCOVA) with the pretest as the covariate at significant level of 0.05 was conducted to answer the hypothesis. The results indicate that the treatment group performed better than the control group in completing the task of 3D modelling. In terms of usability, the results showed that most of the students agreed on the usability in the ARC-3DM

Keywords: 3D Modelling, Animation Course, Augmented Reality, Effectiveness, Usability.

1. Introduction

Teluk Intan Community College is one of the public tertiary educational institutions in Malaysia which has been offering animation course at certificate level since it started its operation in the year of 2002. Since then until now, the teaching and learning process to learn 3D animation subject in classroom is still implementing the conventional way of written tutorial. In recent years, the introduction of Industrial Revolution (IR 4.0) has given a new impetus to educational transformation in Malaysia. In this era of Education 4.0, graduates are demanded to be highly competent, creative and with the ability to think critically. In order for community college graduates to level up their marketability and compete with other higher level of educational institutions, the education system in community college should be transformed and ready to accept and implement the current digital industrial technologies into their teaching and learning process.

For this study, the augmented reality (AR) technology will be integrated into the classroom for animation course in Teluk Intan Community College. The purpose is to compare and evaluate the significant of AR technology could give compare to the conventional method of written tutorial. This study is a way to breakthrough from the norms in community college education system as well as to provide insight and to promote the implementation of AR technology into the community college education system.

2. Related Work

2.1. Effectiveness and Usability Evaluation

The evaluation of a courseware involves measurement on the effectiveness and usability evaluation [1]. The effectiveness evaluation on the courseware will reflect the students' achievement once the student utilized the courseware. Furio et. al [2] studies the learning effectiveness and satisfaction of children using an iPhone game for learning the water cycle vs. the traditional classroom lesson. One group was administered with (AR) mini-games and another with non-AR mini-games. The result shows that the children found the iPhone AR game to be more satisfying than the classroom lessons. This suggests that this kind of technology does promote learning which can used to reinforce students' lessons. Gutierrez, Contero and Alcaniz [3] has conducted a study to evaluate the effectiveness of AR in improving spatial skills among students. They have presented an AR application called AR-Dehaes using didactics content of engineering graphic for the development of spatial skills. The results shown significant improvement in spatial skills among students which is reflected on the students' achievement in treatment group when using the AR compare to control group that used the conventional paper books which had not undergone any spatial skills training. According to Gutierrez et. al [3] Augmented reality is a cost-effective technology for providing students with attractive contents in respect to paper books, giving new life to classical pen and paper exercises.

The reason why Sezali et al. [4] used AR is using textbook in teaching and learning process causes students become bored and easily to fall asleep during class, while Zainal & Abdullah [5] using AR because AR can give fun aspect to the learner, which can also help learner to focus longer without distraction.

According to Fernandez, Insfran and Abrahao [6] a usability evaluation method is a procedure which composed of a set of well-defined activities for collecting usage data related to end-user interaction with a product or application and how the specific properties of the product contribute to achieving a degree of usability. Brooke [7] has presented System Usability Scale (SUS) questionnaire to measure usability in 3 domains in the aspects of effectiveness, efficiency, and overall ease of use. Study by Peres, Pham and Phillips [8] has proven that SUS scores are predictive of usability testing scores and discover that the SUS questionnaire to have more credibility for expedited usability studies. The SUS questionnaire also was shown to be reliable across numerous sample sizes compared to other usability scales such as the Questionnaire for User Interface Satisfaction (QUIS) and Computer System Usability Questionnaire (CSUQ) [9].

2.2. Research Background

The aim of this research is to evaluate the effectiveness and usability of integrating Augmented Reality (AR) tool as an aid for animation students in the task of 3D modelling in Teluk Intan Community College. The goal is to enhance students' cognitive and spatial skills by enabling students to learn in an interactive learning environment using AR technology. The framework for this research is divided into three stages as illustrated in Figure 1.

According to Figure 1, Stage 1 is the preliminary analysis. In this stage, the analysis is based on reading and analysis on previous studies related to integration of computer based technologies such as courseware and AR in the field of teaching and learning process. Stage 2 will involve the development process of the ARC-3DM as the AR tool by implementing the ADDIE model. It involves the analysis, design, development, implementation and formative evaluation. The data gathered from the analysis is used to design and construct the content of AR using the existing platform MAKAR. The final stage will be the stage 3 which involves conducting the research and evaluation in terms of effectiveness and usability. The effectiveness of the ARC-3DM will be evaluated using the pretest and posttest and the usability of ARC-3DM will be evaluated using the System Usability Scale (SUS) questionnaire.

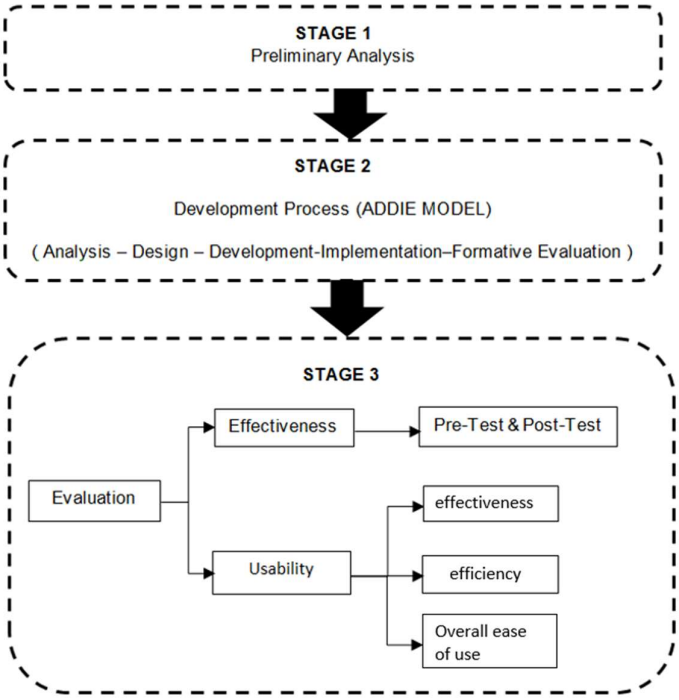

Figure 1. Research Framework of the Study

3. ARC-3DM

3.1. The Overview of ARC-3DM

The AR tool (aka ARC-3DM) for this study was developed based on the topic of 3D modelling. In animation course, 3D modelling is a skill that is very important in the production of 3D animation project. Therefore, animation students in Teluk Intan Community College are expected to have high competency level in 3D modelling skill. In Teluk Intan Community College, 3D modelling is one of the animation subjects which are taught in the first semester. However, the 3D modelling skill is needed in all four semesters of the animation course.

In this study, the AR tool will be designed and constructed using the existing platform MAKAR for educational purpose by implementing marker-based AR with multimedia elements. The AR system runs entirely on smartphone and the platforms to be used are Android and Macintosh. In this AR tool, there are four main components:

1. A camera to capture target information,
2. Marker which is the target information,
3. Smartphone to store and process information when the captured image is the target information (marker), and
4. Digital content is the content that will be displayed on the screen when the camera is able to track the marker.

After identifying the marker, the system loads the corresponding text, video and image. The interactive learning environment provided by ARC-3DM enables the students to enhance spatial skill by visualizing the 3D object in three dimensional and anticipating the steps in modelling the 3D object. ARC-3DM is developed using the existing platform MAKAR and the content is developed using authoring applications like Autodesk MAYA 3D, Adobe Photoshop and Adobe Premiere Pro.

3.2. ARC-3DM Mechanism

In this study, the ARC-3DM is consisted of a module called 3D Modelling.

There are six markers used in the ARC-3DM which are labelled as TI or target image.

The markers used are divided into two types:

1. The first type of marker is the black and white graphic which act as the QR code.
2. The second marker is the student's 3D model displayed on the screen monitor of viewport in Autodesk MAYA 3D application.

There are two QR codes used in this study:

1. The first QR code (TI 1) will display the end product of 3D model in three dimensional.
2. The second QR code (TI 2) will display the video of step 1 to model the 3D object.

The student is required to follow the step 1 until finish. In order to proceed to step 2 (aka third marker) which is the TI 3, the students are required to scan using smartphone the 3D model which completed previously in the viewport of Autodesk MAYA.

The AR tool is expected to augment the 3D model which displayed on the screen monitor if the student manages to meet the quality expected as in step 1 video. The process will be repeated the same until it reach the last target image which is TI 6.

Figure 2 illustrates the visual interface of ARC-3DM in the scanning and augmented phases.

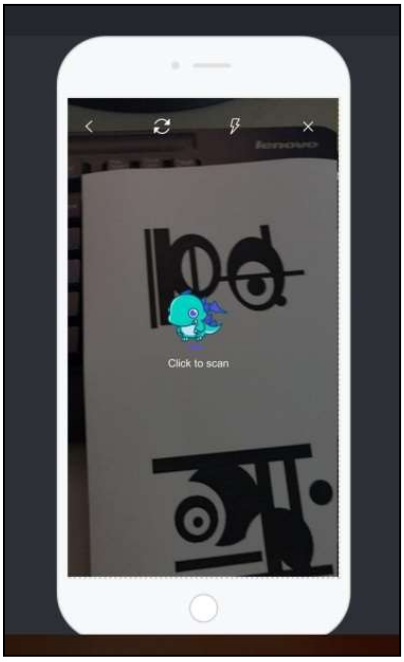

Figure 2. ARC-3DM Interfaces above Presents the Snapshot of an Active Camera View for the Phase of Scanning QR Codes

Figure 3. The Second Snapshot Shows the Augmented Phase of QR Code Which Displays the End Product of 3D Model in Three Dimensional Views

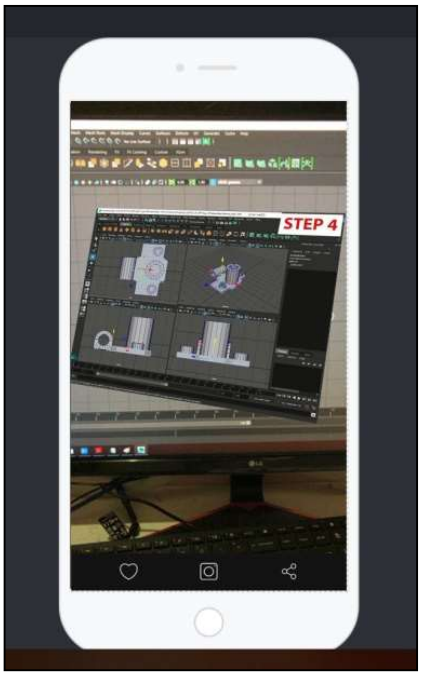

Figure 4. The Third Snapshot Shows the Augmented Phase of 3D Model in Autodesk MAYA Viewport Which Displays the Next Step Video

3.3. Values of ARC-3DM

The values of ARC-3DM are:

- ARC-3DM can be used to set a benchmark on the task of 3D modelling. The progress of 3D model is pre-evaluated in each step before it can proceed since the marker can only be augmented if the student's 3D model quality is exactly like the target image (TI) stored in the system of ARC-3DM.
- ARC-3DM allows students to utilize the data without suffering from the real consequences of human errors. Student can be adventurous and able to take risks and opportunities. This can help student to develop more on new knowledge and heighten their skills [10].
- ARC-3DM is easily accessible due to it runs on smartphone and doesn't require high storage because the data is stored in online clouds. However, students need to have access to internet to install the platform application MAKAR and the ARC-3DM module online through predetermine account.

3.4. Objectives of the Study

The objectives in this study are:

- To design and develop the AR tool (ARC-3DM).
- To evaluate and discuss the effectiveness of using the AR tool (ARC-3DM) on students' achievement compare to the conventional method in learning the topic of 3D modelling.

4. Evaluation

Fifty four animation students (N=54) from second and third semesters in Teluk Intan Community College have participated in this evaluation study. The evaluation of ARC-3DM involved two types of testing: effectiveness and usability.

The quasi-experimental design was deployed to measure the effectiveness of ARC-3DM. The study involves two groups: treatment and control groups. Students in the control group are using the conventional method of written tutorial while students in the treatment group use the ARC-3DM that utilized the AR technology as learning instrument.

A pretest and posttest have been conducted to both groups. The posttest was conducted one month after the pretest. The System Usability Scale (SUS) Questionnaire was administered to students in treatment group after the posttest to evaluate usability and to provide insight on the students' perception and reaction to the ARC-3DM.

The results of these tests are compared to measure the students' achievement.

Table 1. Sample Number for Evaluation

Type of Group	Number of Students
Treatment	27
Control	27
Total	54

5. Result and Discussion

The findings from the evaluation were analyzed and presented in 2 parts:

1. Effectiveness of ARC-3DM, and
2. Usability of ARC-3DM as a whole.

5.1. Effectiveness of ARC-3DM

To test the research hypothesis, analysis of covariance (ANCOVA) will be tested at significant level of 0.05. ANCOVA was chosen because it has greater experimental control and a noise-reducing experimental design by adjusting the pretest as the covariate.

- Null hypothesis (H_0): There will be no significant difference in the means of students'

achievement between the treatment group and the control group after using the ARC-3DM compare to the conventional method when the pretest is adjusted.

Table 2 shows the result of ANCOVA for H_0. The result in Table 2 shows that, $F(1,51) = 133.91$, with the value of $p=0.00$, $p<0.05$ therefore rejected the H_0. The result indicate that there is statistically significant difference in the means of students' achievement between the treatment group and the control group after using the ARC-3DM compare to the conventional method when the pretest is adjusted.

Table 2. ANCOVA for H_0: **Tests of Between-Subject Effects**

Tests of Between-Subjects Effects

Dependent Variable: POSTTEST

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	16388.260[a]	2	8194.130	276.268	.000	.915
Intercept	415.190	1	415.190	13.998	.000	.215
PRETEST	13350.760	1	13350.760	450.125	.000	.898
GROUP	3971.892	1	3971.892	133.914	.000	.724
Error	1512.666	51	29.660			
Total	225725.000	54				
Corrected Total	17900.926	53				

a. R Squared = .915 (Adjusted R Squared = .912)

b. Computed using alpha = .05

From the Estimated Marginal Means result in Table 3, there is a slightly lower mean value in the group of Control (estimated mean score=53.48) and slightly higher value in Treatment (estimated mean score= 70.69). This will be the mean scores if the covariate Pretest with the value=53.06 is held constant across groups.

Table 3. ANCOVA for H_0: **Estimated marginal means of Posttest between groups**

GROUP

Dependent Variable: POSTTEST

			95% Confidence Interval	
GROUP	Mean	Std. Error	Lower Bound	Upper Bound
Treatment	70.690[a]	1.052	68.577	72.803
Control	53.484[a]	1.051	51.372	55.595

a. Covariates appearing in the model are evaluated at the following values: PRETEST = 53.0556.

Based on the results shown, the students in treatment group have achieved more through ARC-3DM compared to the students in control group who were taught using conventional method. The results are consistent with the findings by Furio et. al [2] and Gutierrez et. al [3] which shows positive impact of integrating AR technology into the learning environment compare to conventional method of learning.

5.2. Usability of ARC-3DM

The usability of ARC-3DM evaluation was done using the System Usability Scale (SUS) Questionnaire which develop by John Brooke in 1986.

The students rate the questionnaire using the 5 points Likert Scale (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree).

The calculation for SUS score was based on the method of calculation by Brooke (1986).

The findings are presented in Figure 3.

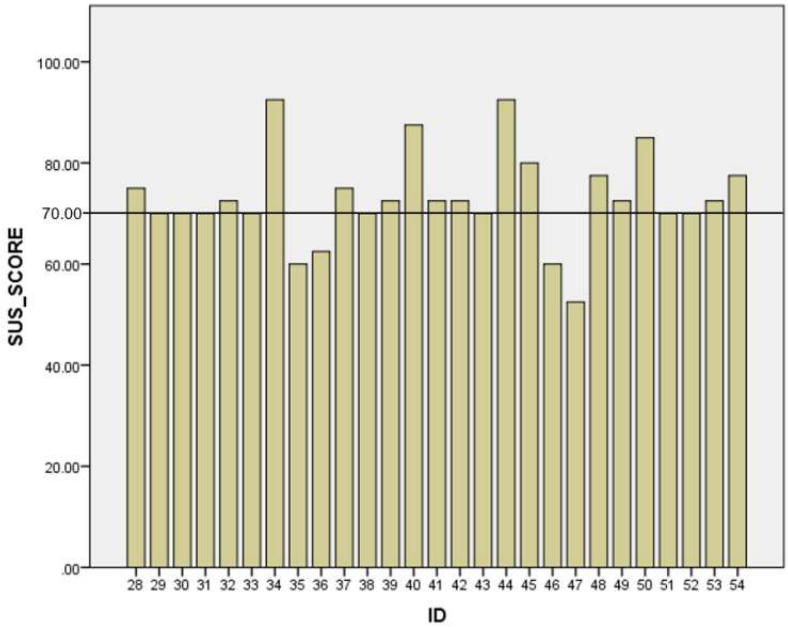

Figure 3. Graph of SUS Score for Each Student

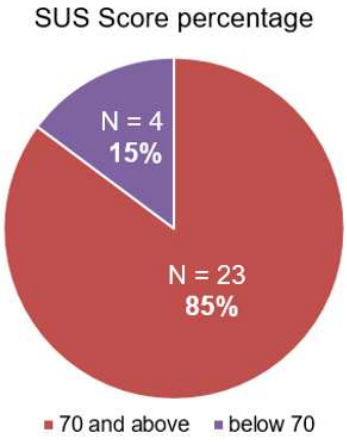

Figure 4. Pie Chart of SUS Score Percentage

SUS score will be able to explain the usability performance in the aspects of effectiveness, efficiency and overall ease of use as a whole. Each responses yield a score on a scale of 0 – 100. The higher the score, the higher usability performance would be. The average SUS score is 68. The score of 68 will put the usability performance at 50th percentile.

Results in Figure 3 shows that there are no student that receive average score of 68. The closest score to the average value that the students received would be 70. Therefore, we can assume that the students who received score 70 and above can be considered high achievers.

According to result in Figure 4, 85% students (N=23) are high achiever with SUS score 70 and above while 15% students (N=4) are low achievers with SUS score below than 70. Overall, the usability of the ARC-3DM is considered acceptable to the students. The findings indicate that most students are satisfied with the efficiency of the ARC-3DM.

6. Conclusion

This paper has described an evaluation on the effectiveness and usability of ARC-3DM. The quasi experiment has been deployed for the effectiveness evaluation. The usability evaluation has been conducted based on effectiveness, efficiency and overall ease of use as a whole. The result of the effectiveness and usability of ARC-3DM has received a positive feedback. This feedback will be used to further improve the ARC-3DM.

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