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Conventional Approach vs Augmented Reality Textbook on Learning Performance: A Study in Science Learning among Secondary School Students

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Abstract

Malaysia is moving towards becoming a developed nation by 2020. As such, the need for adequate human resources in science related fields is one of the requirements to achieve a developed nation status. Unfortunately, there is a downward trend in the number of students pursuing the science stream at the secondary school level. This paper introduces an enhanced science textbook using Augmented Reality (eSTAR) that is intended to motivate students to be interested in science. The eSTAR was implemented to provide a supplement to the conventional science teaching and learning methods in the secondary schools. A learning performance study with a control group was conducted to investigate the effectiveness of the eSTAR for science learning among a sample of 140 Form Two secondary school students. The results indicate that the learning performance of the students in both groups had a significant difference in mean scores between the pre-test and post-test. Students using the eSTAR have a better score in the post-test and eventually resulted in a better learning performance compared to those who were exposed to the conventional science learning. Overall, the results show that the students benefited from the use of the conventional and eSTAR learning approaches.

Key words: Augmented Reality Textbook, Science Learning, Learning Performance Study.

1. INTRODUCTION

Augmented Reality (AR) is a platform that generates a coalition of real world and virtual world environment scenes produced by the computer that augments the scenes with additional information materials such as text, images, audio, video and graphics based on the real world perception (Diegmann et al, 2015; Solak and Cakir, 2015; Radu, 2014; Yuen et al, 2011). The word "augment" refers to an action that escalates something in order to make it more substantial. Based on Azuma (1997), three things that must be considered while developing the AR based projects are; the combination of real and virtual world, interactivity in real time and registered in 3D. Researchers have suggested that the AR technology is suitable to be implemented in teaching and learning (Solak and Cakir, 2015; Radu, 2014; Di Serio et al, 2013; Dalgarno and Lee, 2010; Dunleavy et al., 2009) and also been tested in a real classroom environment (Cuendet et al, 2013; Lee, 2012; Kerawalla et al, 2006). AR has made a positive impact among the students in term of performing an effective in-class assessment (Solak and Cakir, 2015; Lee, 2012). Apart from that, AR successfully combined the education and entertainment activities together, which motivate the students to perform well (Solak and Cakir, 2015; Lee, 2012).

The government has introduced the 60:40 (60 percent for science and 40 percent for arts) education policy for the purpose of producing a balance number of students studying in science and technology over the arts. As Malaysia is moving towards becoming a developed nation by 2020, more human resources in science and technology related fields are required. Unfortunately, over a few decade, the statistics indicated a downwards trend in science and technology related professions and careers among the younger generations (Osman et al, 2006). The interest among form two students in

science learning has been declining by approximately 17% from the year 2003 to 2011(Sung, 2013).

The achievement and progress in science learning in schools are very prominent and must be given more priority (Wellcome, 2015). In Malaysia, science is one of the core subjects in primary and secondary schools. As such, this makes science as an important subject to excel in (Aziz et al, 2011; Talib et al, 2009). There is plenty of research that has been conducted to identify the root of the existing problem in science teaching and learning in Malaysia (Sung, 2013; Phang et al, 2012; Aziz et al, 2011; Osman et al, 2006; Norjihan et al, 2006). The teaching and learning processes take place in the class where the teacher teaches their students using "chalk and talk" technique, whiteboard, slide or video presentations which can be categorized as obsolete methods of teaching (Huda Wahida, 2013; Tan et al, 2008; Norjihan et al, 2006). The importance of new and improved techniques and technologies has over the past few years led to the use of new technologies as learning tools due to the technologies have become a significant part of an individual's life. Unfortunately, science learning in the classroom is contrary to the teaching methods proposed by the researchers. Apart from that, implementing technology in the learning environment helps the teachers to present their material in a new way and also in presenting complex subject matters effectively (Preston et al, 2015; Arnone et al, 2011; Klopfer et al, 2009). By the way, using technology such as computer, internet and other e-learning materials for learning would not be a problem for learners since they have already spent countless hours immersing in the popular technologies and social media such as Facebook, Twitter, My Space, Skype and Yahoo Messenger (Arnone et al, 2011; Allyn, 2011; Pasaréti et al, 2011; Klopfer et al, 2009; Norjihan et al, 2006). Even though, AR technology is not new to the technology world, but still it is at the infancy level due to certain limitations. In fact, only few studies have been conducted in enhancing the learning process, especially in science learning (Arunachalam, 2014; Azer et al, 2013). Unfortunately, none of them studied on the students' learning performance. So far, they only provided the perceptual results which have the tendency to change at any time. In order to fill in the research gap, we have conducted an experiment among form II students of a secondary school in Perak to determine the effects of using the enhanced science textbook using AR on learning performance.

This experiment was driven by the hypothesis that students can learn better from the enhanced science textbook compared to the conventional science textbook. The theoretical foundation for this hypothesis is based on Cognitive Theory of Multimedia Learning (CTML) and inherently implements the sub-principles formulated in the CTML namely, multimedia principle, the spatial cognitive principle, the temporal contiguity principle, the coherence principle, the modality principle, the redundancy principle and the individual differences principle. The statistical results obtained provided the strongest evidence for the hypothesis.

2. THEORETICAL BACKGROUND

Mayer's Cognitive Theory of Multimedia Learning defines that multimedia learning occurs through constructing the mental representation using texts and images. This is so since, the human mind is limited in the amount of information that it can process (Mayer, 2003). Basically, the human brain does not interpret words, pictures and auditory information in a mutually exclusive fashion, but these elements are selected and organized dynamically to produce a logical model of the MM presentation (Mayer, 2001). Thus, presenting the information through verbal (written text or audio) or pictorial (animation or pictures) produces a productive learning process (Mayer, 2003). The CTML is utilized to explain the human behaviour by understanding their thought processes (Mayer, 2002). The cooperation between the MM elements in a learning process might improve the learners' long-term memory in storing information and knowledge. According to Mayer (2001), the MM principles emphasize that learners learn better from words and pictures than from words alone. So, they can easily build a

connection between the models when words and pictures are both presented together. The MM technology is a combination of various media. Thus, the CTML theory and principles that have been discussed above are related to the MM learning and play vital roles in a learning material. So, the students can present a better outcome and feedback in a learning process.

3. DESIGN AND DEVELOPMENT OF eSTAR

The main interest of this study is to propose a conceptual model for the design and development of the enhanced science textbook using augments reality (eSTAR). The conceptual model was constructed by incorporating the motivational theories and MM principles. Several prominent models, theories and principles were utilized namely; the ARCS (Attention, Relevance, Confident and Satisfaction), the Cognitive Theory of Multimedia Learning (CTML), the Intrinsic Motivation Theory and Multimedia Learning Principles.

The eSTAR was developed as a standalone application based on the eSTAR conceptual model. The software that has been used during the development phase include; Adobe Flash CS5, Adobe Photoshop CS5, Camtasia Studio 7.0, Autodesk 3DS Max 2010 and BuildAR 2.0. The eSTAR application is specifically developed for form two secondary school students since the contents are mainly focussed for form two science only. The contents of the eSTAR application are based on the form two science textbook and also from several other learning materials suggested by the content experts (teachers). Figure 1 shows some snapshots of the contents that have been embedded into the eSTAR application which can be retrieved through the use of various AR quick response markers.

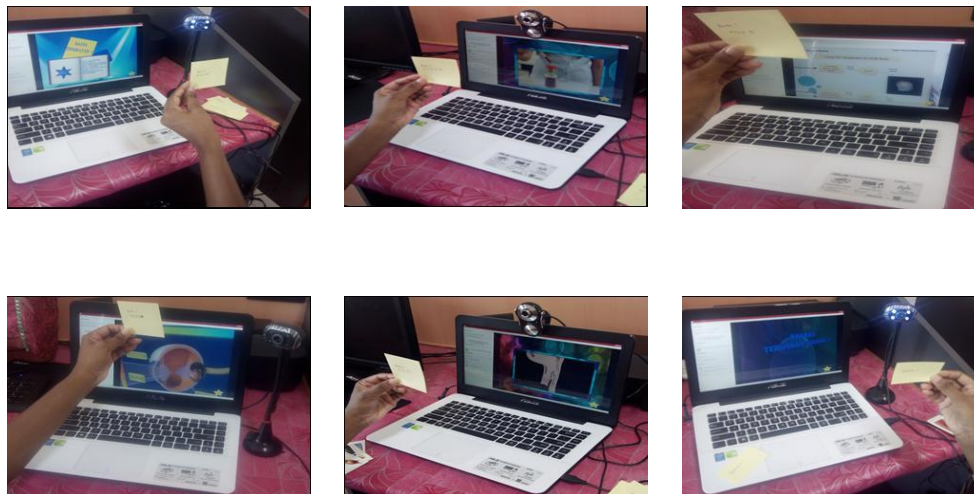


Figure1. Sample of snapshots of the eSTAR contents

4. DESIGN FOR LEARNING PERFORMANCE

Previous studies have proven that the use of the AR-based technology for teaching and learning in various domains which include science, medicine, engineering and arts (Chiang et al, 2014; Wu et al, 2012; Bakar et al, 2011; Dunleavy et al, 2011; Squire, 2010). Moreover, majority of the studies are of qualitative in nature (discussion, observation and interview) and focused on the constraint and affordances of AR for teaching and learning (Sommerauer and Müller, 2014). Until now, only few quantitative studies that have been conducted to measure the effect of AR on the learning

performance. This study compared two educational methods for learning science among form two students in order to identify the effectiveness between both methods. The methods are; i) conventional method where students learn about science using the provided science textbook and ii) *estar* application where students learn about science using the provided science textbook and the *estar* application.

4.1. Participants

The data for this study were collected from a sample of 140 Form Two students of a secondary school in Kuala Kangsar, Perak. The students were given a consent form to be filled by their parents. However, since some of the students did not return the form, only 140 students were able to take part in the study. The students were grouped into two whereby each group consists of 70 students. The groups were labelled as control group and experimental group. Students in the experimental and control groups differed only in the learning modes used for science learning. Students in both groups have almost equal academic achievements as testified by the teachers. All the participated students had basic computer skills. All the students in the experimental group have laptop or notebook at home.

4.2. Procedures

The control group students learn science through the conventional learning method by using the science textbook that is provided to the students. Meanwhile, the experimental group students learn science through the use of the same science textbook and *estar* application. The pre-test was conducted to assess the background knowledge of the students in both groups; they have to answer a set of 20 multiples choice questions and were allocated 20 minutes to answer those questions. The questions were based on chapter one (The World through Our Senses) and chapter two (Nutrition) from the existing science textbook provided by the Ministry of Education Malaysia. The selected questions were proposed by the content expert (teachers) who have more than five years of experience in teaching the science subject. After the pre-test, the developed *eSTAR* application was distributed among the experimental group and they were instructed to use the application for their in and out of the class science learning. Meanwhile, the control group students proceeded with their in and out of the class science learning based on the conventional method. After one week, students in both group had to undergo the post-test whereby they had to answer the same 20 multiple questions within 20 minutes as in the pre-test. The following section discusses on learning performance results.

5. RESULTS

To assess the learning performance of both groups, paired-sample and independent-sample t-tests were applied. Tables 1 and 2 show the learning performance of the control and experimental groups based on paired-sample t-test results. Pre-test scores of both groups represent students' prior knowledge in science which has been acquired from various other resources such as magazines, TV documentaries, internet and others. The post-test scores of the control group represent the learning performance of students through the use of the conventional science textbook. While for the experimental group, the post-test scores represent the learning performance of the students through the intervention of the AR science textbook (*eSTAR*).

Table 1. Results of learning performance for the control group

Evaluation type	Mean	Number of respondents	Std. dev.	Std. Error Mean
Pre-test	8.31	70	2.523	.302
Post-test	12.57	70	2.171	.259

Table 2. Results of learning performance for the experimental group

Evaluation type	Mean	Number of respondents	Std. dev.	Std. Error Mean
Pre-test	9.66	70	3.106	.371
Post-test	14.20	70	3.574	.427

Table 3 presents the results of the paired-sample t-test for pre-test and post-test of the control group. The mean scores of the control group's pre-test and post-test increased from 8.31 to 12.57 and the significance value is 0.00, which is significant at 0.05 and 0.01. This indicates that the students in the control group were interested in science and also have the motivation to continue to perform better than the previous test.

Table 3. Paired-sample t-test of control group

Learning Evaluation	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Dev.	Std. Error Mean
				Lower	Upper			
Pre-test Post-test	-4.257	1.924	.230	-4.716	-3.798	18.514	69	.000

Table 4 presents the results of the paired-sample t-test for pre-test and post-test of the experimental group. The mean scores of the experimental group's pre-test and post-test increased from 9.66 to 14.20 and the significance value is 0.00, which is significant at 0.05 and 0.01. The paired-sample t-test confirms that there is a significant difference in the learning performance mean scores for the experimental group. In other words, learning science through the use of the eSTAR application resulted in better learning performance.

Table 4. Paired-sample t-test of experimental group

Learning Evaluation	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Dev.	Std. Error Mean
				Lower	Upper			
Pre-test and Post-test	-4.543	3.479	.416	-5.373	-3.713	10.924	69	.000

Additionally, this study also examines whether the learning performance of the experimental group is superior to that of the control group based on independent-sample t-test results. Table 5 compares the learning performance of the control group and the experimental group based on the independent-sample t-test results. Results show that pre-test mean scores for both groups differ significantly. Next, this study assesses whether the difference in post-test scores for both groups is significant based on independent-sample t-test results. Results reveal that post-test scores for both groups

differ significantly in motivating students to perform well after both methods of intervention in science learning.

Table 5. Comparing results of learning performance between control and experimental groups

Group	Pre-test mean (std.)	t	Sig. (two-tailed test)	Post-test mean (std.)	t	Sig. (two-tailed test)
Control	8.31	27.576	0.00	12.57	48.453	0.00
Experimental	9.66	26.011	0.00	14.20	33.245	0.00

5.1 Null Hypothesis Testing

5.1.1 Testing Hypothesis $_{01}$

Hypothesis $_{01}$: There is no significant difference in the students' learning performance between the pre-test and post-test mean scores of the control group.

Table 1 presents the result of the paired-sample t-test for pre-test and post-test of the control group in which the significance value is 0.00. Thus, the null hypothesis is rejected. Therefore, there is a significant difference in the students' learning performance between the pre-test and post-test mean scores of the control group.

5.1.2 Testing Hypothesis $_{02}$

Hypothesis $_{02}$: There is no significance difference in the students' learning performance between the pre-test and post-test mean scores of the experimental group.

Table 2 presents the result of the paired-sample t-test for pre-test and post-test of the experimental group in which the significance value is 0.000. Thus, the null hypothesis is rejected. Therefore, there is a significance difference in the students' learning performance between the pre-test and post-test mean scores of the experimental group.

5.DISCUSSION AND CONCLUSIONS

Since the perceptual evaluation has the potential to change in the future, hence, the learning performance study was conducted to observe the students' performance level before and after the intervention by implementing the pre-test and post-test. In order to control other external intervention such as internet sources and videos, this study has been designed to have a control group. Thus, an experimental design with a control group was formed. The experimental design consists of a control group and an experimental group. The students in the experimental group were allowed to access the learning content from the AR enhanced textbook (eSTAR), while the students in the control group had the conventional method of learning. Furthermore, the Paired Samples t-Tests depicted the significant level for all the collected data. Besides that, the results show that there is an increase in the correct answers for the questions and have significant difference after the intervention of the AR science textbook and also the conventional science textbook.

The target of this evaluation is to scrutinize the knowledge learnt after the intervention of the AR enhanced textbook in learning science subject. Overall, the learning performance of students in both groups had a significant difference in mean scores between the pre-test and post-test. The difference in mean scores for the experimental group is 4.54 while for the control group is 4.26. These indicate that the experimental group has a higher difference in mean scores. The analytical results indicate that both methods of learning are able to increase the learning performance of the students. However, through the use of the eSTAR application, the students from the experimental group have a better score in the post-test and eventually resulted in a better learning performance compared to those who were exposed to the conventional science learning. However, the eSTAR application is not aimed to replace the current education system. It is merely a supplementary learning approach that can be used to encourage and motivate students so that they are aware of the importance to excel in the fields of science not just for their own sake but also for the sake of the nation.

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