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The Effect of Augmented Reality Application toward Student's Learning Performance in PC Assembly

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ABSTRACT

Assembly is a process of combine two or more component together through particular sequence and operation. Now, lab instruction was utilizing as main tools to guide computer assembly in computer hardware course. However, this lab instruction contains too much text and it makes student takes time to visual the process and interpret the step. Numerous study has reported Augmented Reality (AR) has a great impact in improving student learning as well as assist in assembly task by means as visualization tool. This study aimed to investigate the effect of AR application on student learning performance in term of pc assembly knowledge. To meet the purpose, a marker-based AR application, AR PC Assembly was developed to provide a visualization in 3D on pc assembly. A quasi-experimental pre-test and post-test control group design was used as a research design. The participants were 68 first-year diploma students, where they were allotted to either an experimental or a control group. The control group learned the theoretical and perform the assembly task about personal computer assembly through textbooks while students in the experimental group used AR PC Assembly application for the same purpose. The experimental result reveal that using AR application can enhance the learning performance of the students. From the result of analysis, post-test score in experimental group was higher 20 % compared to control group. Considering these result, it can conclude that AR application is an effective and beneficial tool to be applied in education.

Key words : augmented reality, PC Assembly, Multimedia, Mixed Reality.

1. INTRODUCTION

Assembly is a process of combine two or more component together through particular sequence and operation. Assembly manual or instruction that include set of instruction, list of component or assembly drawing are commonly used to guide the task required and facilitate the assembly process [1]. However, these assembly instructions may contain unimportant information about assembly that can result in misinterpretation, especially for novice user who has no or limited experience. Furthermore, the number of error in assembly process can increase. Thus, this will caused work takes longer time to complete [2]. Due to the proliferation in computer technologies, particularly in the development of computer visualization and simulation, the use of Augmented Reality (AR) application become more prevalent [3][4]. AR is powerful and type of interactive technology that combine virtual and real world and engages people with digital content [5] which can used to solve problem stated above. AR enables user to support the assembly task at hand in a real-world environment and at the same time visually receiving computer-generated information.

The number of studies on AR has progressively increased because most of the studies reported the positive effect of AR application in primary, secondary and higher education, that can be found in the studies performed by [6]. However, the studies of AR impact in field of assembly task, particularly in personal computer (pc) assembly are still a few. Therefore, this study seeks to develop an AR application in learning pc assembly via mobile devices and examine the effect of AR application on student's learning performance. Certainly, the ability to visualize and interact with an environment that has been augmented with virtual object can result extensive impact on the way current assembly processes are accomplished, and produce solutions to the assembly problems of the future.

2. RELATED WORK

2.1 3D Assembly Manual

Presently, 3D assembly manual has been utilized as the main visualization means to guide assembly in many sector including in education. Student perform the practical session

such as assembly task or laboratory activities by using 3D manual instruction. This manual contain text and graphic (image) that represent the process on how to complete the task. According to [1], the manual is used to facilitate the assembly task. However, this instructional manual contains unnecessary information or unclear figure. This might confuse the user where user need to focus on the important information in order to complete the task. As a result, this has impact the time to complete the work to become longer. Similarly, a study conducted by [7], supported the argument where in their study, they seeks to compare on different instruction presentation format that would be the most effective to learn procedures. The experiment compared three instructional format which is
video and audio instruction, video with instruction and image with written instruction. The data analysis focus on the time to complete the task, the time spent to consult with the instruction and the time spent to carry the task. The first finding stated that animation is more effective than still images when involve psychomotor knowledge. This finding is in line with the study[8] where it demonstrate that instructional animation can foster the motor skill to student.

As the world is now heading to the Industrial Revolution 4.0 (IR 4.0), where a comprehensive transformation by merging the digital technology and internet convention applied to the industry, an advance information and technique to communicate with the information is important. Hence, many industries now days are seeking for another way in formed technical documentation where the manual paper is remaining.

2.2 AR Visualizations

AR is an integrationof computer generated images into a real world, where it enhanced the real world by projecting the virtual additional information. AR is a technology that can achieved a goal in satisfying user's perception. AR technology has been seen as effective tool in visualizing and conveying abstract concept and present 3D information. Thus. AR become a compelling environment in engaging spatial issue.

Many successful application has been developing where the AR technology has been applied as visualizations tool. For example, research conducted by [9], developed Social Augmented Learning (SAL) application that can be used in vocational and on job training environment. The SAL was help the user to visualize the modern industry machine than can increase the training quality. According to them, with the help of AR, the learning and acquiring complex process has created new way of collaborative and interactive learning possible because AR enhance the visualizations concept.

2.3 AR in Education

The influence of using AR technology in education has been resulted in positive impact toward learning and learner's attitude [5]. Table 1 shows the use of AR in education field.

Table 1 indicated that there are numerous field where AR technology has been applied and provide a new shape in delivering the content and conveying the lesson as well. Most of the result demonstrated the positive feedback from the participants in the experiment. Clearly, the application of AR in education can influence student learning performance and learning outcome. However, only a few studies have been conducted in assessing practical skill such as assembly, maintenance and laboratory [16].

Table 1: Use of AR in Education Field

Author	Field	Result
[10]	Engineering	Provide an interesting classroom and increase motivational to student.
[11]	Mathematics	Achievement test show that learning mathematic using AR has increased as well as their motivation toward learning.
[12]	Science Lab	AR application significantly enhance the laboratory skill and build a positive attitude toward physic laboratory.
[13]	Electrical	Result from analysis, show majority express they agree the AR application has provided an easy way to acquire knowledge in lesson (70%).
[14]	Landscape	The pre and post-test show some improvement but lower score. However, researcher state the AR application help to create better understanding in learning the concept compared to 2D.
[15]	Chemistry	The result shows the AR application improved learning objective because of student can view and understand better the molecular module with the help of AR technology.

2.4 AR in Assembly or Maintenance Task

A study from [17] shown that people tend to have a difficulty in learning assembly skill without supervision from the expert. This process requires various form of visual guidance. Likewise, in assemble a personal computer, it requires a clear visualization in order to ease the assembly process. Assembly

manual or lab instruction generally used in the classroom to facilitate the learning process on assembly the pc.

However, user has to keep alternate between assembly task and content when using these tool [18]. Thus, this has caused user tends to do error or mistake and makes a longer time to complete the task. AR can provide a meaningful view of represent model through visualization[19]. As an alternative of following the guidelines used in the assembly from lab instruction, users can view the task concurrently on the actual image with the support of AR [20]. Table 2 summarize the AR application used in assembly or maintenance

Table 2: The use of AR in Assembly and Maintenance

Author	Assembly	Result
[1]	Assembly	Implement Animated AR to assemble LEGO model by using AR marker –based type. The result indicate the use of animated AR has decrease the time of assembly and reduce number of error.
[21]	Maintenance	To develop tool that increase cognitive process for the technician during aircraft training
[22]	Assembly	Using AR system for virtual training in assembly gully trap. Develop the real image in 3D modelling and convert into AR system to create AR instruction. The time to assemble the gully trap become shorten compared using traditional method.
[23]	Maintenance	Mobile application namely Paint-cAR, for using in learning of paint repairing in TVET. The analysis from IMMS instrument show using the application has foster student motivation in learning
[24]	Assembly	Develop an AR application to guide mechanical process Adapting AR Glasses. AR Operation increase efficiency because it performs better than traditional and enhanced the customers understanding

3. METHODOLOGY

3.1 Participant

In this study, a quasi-experimental non-equivalent pre-test–post-test control group design was adopted to compare the student learning performances of those who exposed to augmented reality applications teaching method with those who had experienced traditional teaching method, in the acquisition of theoretical knowledge. First year student of Diploma Digital Technology at one of the Polytechnic, in Department of Information Technology and Communication was chosen as sample. There are two classes (Section A and B) of first-year students in the department where randomly, Section A was allocated to the control group, and Section B was allocated to the experimental group. In total, 68 samples aged 18-20 contributed in this study.

3.2 Instruments

To evaluate the theoretical knowledge, the development of the pre-test and post-test was performed as an instrument to get the numerical data to measure the difference of learning outcomes. The main textbook was used as a reference to construct the questions in both test. For validation purpose, the tests have been verified and validated by two subject matters expert. Both group responded to the same pre-test and post-test in different form of instruction.

To ensure this study can meet the research question, a marker-based application using AR technology has been developed. In this application, a book that contain an instruction step by step to assemble a pc with an image as a marker. Software needed in this development consist of Unity, Vuforia Android SDK, Blender (3D modelling software) while software needed to run the application is Android platform. Figure 1 show the screenshot of AR PC Application with explanation. The Application consist of 4 main menus as shown in Figure 1. The Assembly menu consist sub-menu as shown in Fig 2. Figure 2 show the sub menus when the button PC assembly is pressed. There are six sub menus include: motherboard, CPU, heat sink, memory card, internal drive, power supply and cable. Figure 3 show the images when user played the button. User need scan on the marker, and the assembly video will be played. User can press play and pause button while the video is playing. Help menu consist of 2 sub menu which is pc assembly tips that give the do and don'ts when assemling the pc. Meanwhile user guide, provide user the manual on how to use the apps. Finally, About menu contain info about the developer

Figure. 1: Main Menu

Figure.2: Submenu for Assembly

Figure. 3: Screenshot video in 3D

3.3 Procedures

During the research implementation, student in both group were provided with the theoretical concept and they have a hands on activity on assemble a pc. Firstly, before the student began their pre-test, each of the student filled out one page of demographic survey about themselves. Next, student in both group carry out pre-test to test the prior knowledge about pc assembly. They were given 30 minutes to complete the 20 multiple choice questions.

Next process is where theoretical concept was provided by the lecturer in the classroom where computer assembly course was implemented. After the theory class, each subject performs the
assembly task based on the assigned approach. During the four-week of research study, the control group students performed their lab in pc assembly using the traditional instructional methods and under the observation of the lecturer. On the other hand, the experimental group performed the pc assembly lab using augmented reality application namely AR PC Assembly under supervision of the same lecturer. Student are required to install the application into their devices and used the application to perform the lab. A few students who are iOS user, share devices of other student in the class. This treatment process utilized in 2 weeks (4 contact hour).

Upon completion the treatment process, each subject is required to answer the post-test to measure the theoretical knowledge and to see the different from the pre-test. The implementation process was completed in 4 weeks (8 contact hour).

4. DATA ANALYSIS AND RESULT

4.1 Pre-test and Post-test result of Experimental Group

Table 3 present the result of the t-test in mean for experimental group. The null hypothesis indicating that the pre-test scores and post-test scores were equal for the experimental group (AR group) could be rejected, with $t(33) = 9.954$, $p < .001$. In summary, this result shows that post-test scores were higher than pre-test scores in experimental (AR) group. Taken together, these results suggest that AR application does have a positive effect on student learning outcome.

Table 3: T-Test Means for Experimental Group

	t	df	Sig. (1-tailed)	Mean Difference
test	9.954	33	.000	19.706

Table 4 shows improvement in student achievement for control group and experimental group. From the table, it was found that the mean increment scores for the control group and experimental group were 14.85 and 24.71, respectively. These results indicate that the mean increase in student achievement scores for the experimental group is higher than control group student.

Table 4: Increment Score for Both Group

Type of group		Pre-test Score	Post-test Score	Increment Score
Control	Mean	54.85	69.74	14.85
	N	34	34	34
	Std. Deviation	13.789	11.609	7.928
	Minimum	30	50	
	Maximum	80	90	
Experimental	Mean	58.38	83.09	24.71
	N	34	34	11.543
	Std. Deviation	14.287	12.734	
	Minimum	35	55	
	Maximum	80	100	
Total	Mean	56.62	69.71	19.78
	N	68	68	68
	Std. Deviation	14.048	13.845	11.01
	Minimum	30	50	
	Maximum	80	100	

4.2 Pre-test and Post-test comparison between both groups

To initialize the analysis, the first step is to compare the pre-test and post-test score of the traditional instructional and AR instructional group. Figure 4 provides the scores for both test (pre and post-test) for each student in the control group, while Figure 5 displays the scores for the AR instruction group. Figure 6 illustrates a comparison of the means to gain a deeper understanding into which of the two groups may have obtained more score.

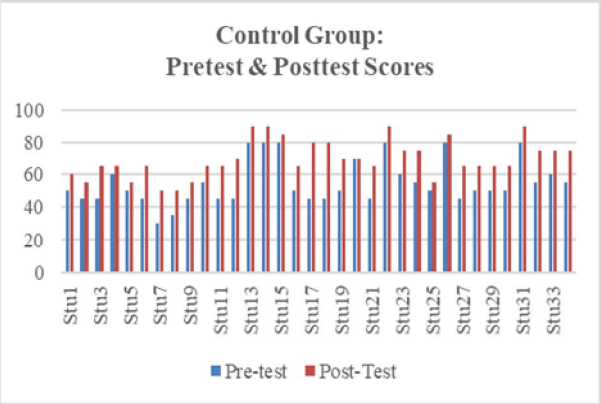


Figure .4: Pre-test and post-test scores for individually student in the control group

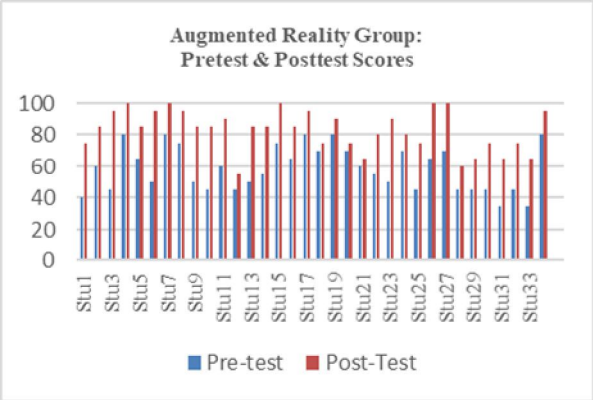
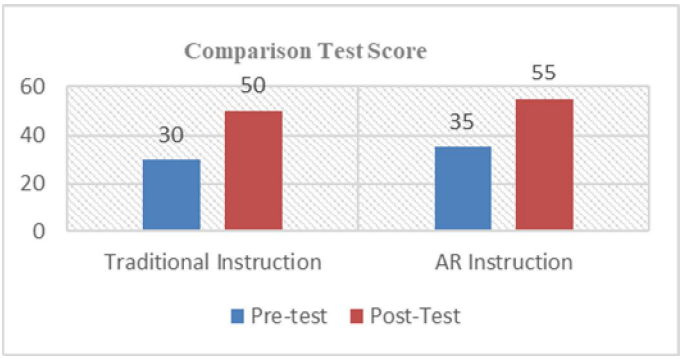


Figure.5: Pre-test and post-test scores for individually student in the experimental instruction group

		t	df	Sig (2 tailed)	Mean Diff
Post-test Score	Equal variance assumed	-4.529	66	.000	-13.382
	Equal variance not assume	-4.529	65.917	.000	-13.382



Closer inspection of the figures shows that the post-test score for experimental group (augmented reality student) is increase over and above the control group (traditional instruction). However, to determine if there were a significant difference in students' learning achievement between AR group and traditional group, a statistical analysis of achievement in post-test mean scores was conducted. An Independent T-test was carried out on post-test score to compare the groups score over the two test. Table 5 summarize the result of the test.

Table 5: T-Test Result of Post-test Score between Control and Experimental Group

The result of the t-test analysis is summarized in Table 5. it can be seen that there was a significant effect of a mean gain score of the experimental and control group in post-test. the t-test confirmed the null hypothesis which indicated that there is no statistically significant within groups (control and experimental) in the gaining of the pc assembly theoretical knowledge. the test of between - groups effects found $t(66) = -4.529$, $p < 0.01$. taken together, these results suggest that there was a statistically significant difference in students' theoretical achievement between those students in ar application group and those in traditional instruction, where it can be indicated that AR have a positive impact in assisting student in experimental group to learn better in pc assembly task.

5. DISCUSSION

The current study found that experimental group who utilized AR application was more successful compared to control group who received the lesson using traditional method. The result of t-test indicates there is increasing score from pre-test to post-test in experimental group. This result was parallel with the result obtained which score in experimental group was significantly higher than control group. This can determine that AR can be better instructional media used to assemble a pc. This finding was important as it contribute to support the AR as viable method in assembly task. From the statistical test that execute, all null hypothesis has been rejected, thus this show that AR application is an effective tool in increasing achievement. Certainly, many studies has

shown the effect of using AR that can increase the learning outcome [25] . From the results of their experiment, it was demonstrated that the use of MDAS in teaching has contributed to student achievement and students' skill performance. Analysis result has found that the MDAS tool has improving the cognitive and performance factor compared to the traditional method.

This result are in line with the study conducted by [26]. In their study, it reported that the adoption of AR simulation can engage the student more rigorously in the inquiry process. Thus, it results in student learn using AR simulation can perform better compared to student learn using traditional 2D simulation. Similarly, study execute by [27] explore the effects of individual differences on learning earth science phenomena. The results show that the overall learning achievement is significant for AR instruction compared to the traditional learning. It can be stated that learning through AR could reduce the number of head, eye and body movement that student need to go through to read the instruction, thus reduced the number of error made. This is because student do not have to memories the instruction, performed the assembly task, look back at the instructional to recheck and confirmed the step. By using AR application, student has better visualizations on how to perform the step and they can perform it without need to take a longer time to understand the instruction. Therefore, the time to complete the task can be reduced as well as the error.**5.**

6. CONCLUSION

The present study was designed to determine the effectiveness of using AR in facilitating effective pc assembly as part of the computer course subject. A prototype application called AR PC Assembly was successfully developed and used as learning tool in this study. This study compared two learning methodologies: traditional instructional where the student need to learn assembly manually and augmented reality environment where they learned through AR application as instructional media in learning pc assembly. The results of this investigation show that the use of AR can increase the student achievement in theoretical knowledge in assembly. In addition, AR has been found to be better instructional media compared to traditional manual as student in experimental group attain more scores in assembly test. The implications from this study can be substantiated that AR PC Assembly Application can be used as a competent tool in learning pc assembly and tool that most student like to learn with. AR presents clear advantages compared to traditional method means of visualizing instructional in assembly process. Realistic and dynamic characteristic in visualization setting become one of the factor to increase motivation to learn. Taken together, these findings suggest a role for AR in promoting education. This study was examined the impact of using AR in learning pc assembly with group collaboration. Future studies also could investigate the implementation of AR with consideration to the individual outcomes without group collaboration.

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