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Augmented Reality Application: an Approaches to Enhance Students Motivation in Learning PC Assembly

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Abstract: One of the new technologies that has begun to spark high interest among educators in the context of pedagogy is Augmented Reality (AR) technology. This paper examines the effect of the use of AR application on student motivation based on 4 dimensions in the ARCS Model, namely attention, relevance, confidence, and satisfaction. This study uses an experimental study with a one-group pre-post design type. This research examines the differences in students learning motivation before and after using AR applications in learning introduction to computer system course. A total of 41 respondents who used the AR application answered the pre and post questionnaires. The results show that the use of AR application has successfully increased student motivation by 20.10 %. Percentage values for each ARCS dimension and difference tests showed significant values. Based on these results, it can be concluded that the use of technology such AR applications in classroom has affected the enthusiasm and motivation of student. Therefore, an educator has to form a teaching style in teaching millennial student who raised with technology at their fingertips by integrating technology in education to providing better teaching and learning opportunities, especially to the next generation.

Keywords: Augmented reality application, student motivation, personal computer assembly

1. Introduction

Since 2016, the world has experienced a technological shift through a revolution known as the Industrial Revolution 4.0 (IR 4.0). Klaus Schwab through his book "The Fourth Industrial Revolution" stated that the presence of IR 4.0 is marked by the emergence of technologies such as supercomputers, smart robots, vehicles without drivers, the development of neurotechnology that makes humans better optimize brain function (Schwab, 2017). Unbeknownst to them, everyday affairs of human life are now based on IR 4.0 technology which can be felt in its role in various sectors, including education. These changes have greatly changed the lifestyle, way of working and communicating to the universal human being. It is stated IR 4.0 was introduced for the transformation of digitization and automation technology in the global world landscape (Oesterreich & Teuteberg, 2016). In education field, the IR 4.0 revolution has seen a very significant change from traditional learning to technology-based learning (Hussin, 2018). The integration of IR 4.0 technology in education has changed the form of information delivery, the way one obtains information and the way one learns.

Furthermore, with the development of the use of mobile technology, social media as the main medium of communication as well as wireless networks have renewed reforms to support learning activities. Citing a report from the international community of the New Media Consortium (NMC) in the Horizon report 2020 report (Brown et al., 2020), stated that higher education's exploration of Augmented Reality (AR) in learning has exhibited very wide diversity and had a significant impact. While in the latest Horizon report 2021, blended learning and hybrid learning have also had a positive impact in addressing educational challenges in the face of pandemic pressures (Pelletier et al., 2021). Thus, looking at the role and advantages of this AR technology, the use of AR in education became an important topic in the study (Sirakaya & Alsancak Sirakaya, 2018).

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The use of AR has become increasingly accessible as it no longer requires special equipment and is increasingly easy to use in mobile devices such as smartphones. According to the report Department of Statistic Malaysia (DoSM) (Jabatan Perangkaan Malaysia, 2021), mobile phone and laptop access showed an increase from 77.6% to 98.6%. In the face of the challenges of the millennial era and the millennial generation, educators will always be looking for new and better approaches to make delivery more effective. This coincides with the current tendency of students to be more oriented towards pedagogy and cybergog approaches (Ismail et al., 2019). AR technology is seen as an innovative and effective teaching medium and can attract students. The integration of this technology in learning also has the potential to help educators to enrich teaching materials to make them more meaningful. Numerous studies have reported on the positive impact of AR in the world of education in terms of motivation, engagement, achievement, learning attitudes, interactions as in the literature review by Bacca Acosta et al. (2014). However, studies on the impact of the use of AR applications in education are still lacking and there is still room to study the potential of AR in increasing student motivation and improving academic achievement. As such, this study is a continuation of previous studies conducted globally that looked specifically at the impact of AR application use on student motivation with experimental from Polytechnic Muadzam Shah (PMS). The purpose of this study was to measure the motivation of students who enrolled in Introduction to Computer System courses in PMS before and after using the AR PC assembly application. To achieve the purpose of the study, the researcher will obtain answers based on the following research questions:

a) Are there any differences in motivation between the two teaching methods used?
b) What is the difference in student motivation before and after using AR Application?
c) How motivated are students to use AR Applications in the learning process?

The question of this study is supported by 4 main dimensions, namely attention, relevance, confidence and satisfaction. 3 research questions have been designed. The rest of this research paper is organized in 6 sections. Part one briefly introduces the introduction and review the relevant literature. Part two describes describe about the methodology of the study method implemented. Next the third section will describe the results of the study and then a discussion of the results of the analysis. The fourth section will present the conclusions of this study paper.

2. Literature Review

AR is generally a merger between a virtual object and a real object in the real world. The definition of AR is given a different definition from the perspective of researchers in the field of education and information technology. However, according to one of the most widely accepted definitions of AR is a technique where users combine virtual objects and real -time real -time worlds by displaying various multimedia formats such as graphics, 3D objects, video and so on (Ibanez & Delgado-kloos, 2018; Martín-gutiérrez et al., 2015; Billinghurst Mark et al., 2015) visualization of a diagram known as "Milgram Reality-Virtuality Continuum" as in Fig. 1 as stated by Milgram et al. (1995).

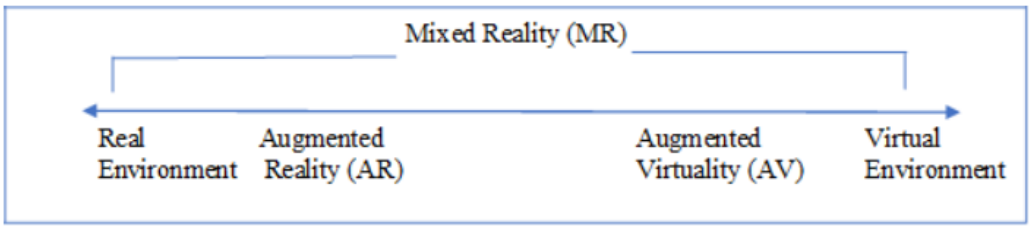

Fig. 1: Reality-virtuality continum

This continuum is a scale that consists of a real environment to a fully virtual environment. Milgram et al. (1995) states that interfaces can be classified by reference to the ratio of real content to how much content is generated by a computer, with Augmented Reality (AR) and Virtual Reality (VR). Based on this continuum, mixed reality can be defined as a situation where the real and virtual worlds are combined. It can be seen that AR is located close to the real environment as seen through Fig. 1. This shows that the AR system has the following three characteristics as stated by Azuma one of the pioneers in the field of AR (Azuma et al., 2001):

a) Combine real-world and virtual objects in a real-world environment
b) Align real and virtual objects
c) Carried out interactively and in real time

Based on the characteristics mentioned, it can be concluded that AR is a situation where it combines virtual and real environments, which allow interaction with virtual objects in a real-world environment. In line with the development of technology, AR can now be used with mobile devices such as smartphones or tablets. The use of this device makes it easy to carry anywhere and even easy to operate. For example, the Pokémon Go application that can be used with a smartphone. AR can be implemented to many types of devices, but the use of mobile devices is becoming the choice of students and users now (Craig, 2013). The use of this device is seen to be able to support the principle of education that

can be accessed at anytime and anywhere. Looking at the advantages of this device, as well as the increase in the use of smart phones, the integration of AR in education is seen to be growing and feasible.

Mobile technology has contributed positively to education. Meanwhile, the use of Augmented Reality (AR) and Virtual Reality (VR) is considered an innovative teaching and learning medium that able to attract students (Radosavljevic et al., 2020). In fact, in recent years, much research has focused on the use of AR in education. Based on a review of the literature from 2012 to 2018, the increase in research on the use of AR in education is increasing (Garzón et al., 2019). According to the researchers, the most widely cited AR advantages are related to academic achievement and motivation. Motivation in the teaching and learning process is very important to ensure that students continue to be interested and enthusiastic to learn. In education, motivation is expressed as the drive or instinct of a student to engage in learning. Motivation is a need for students because it is an incentive for students to participate in teaching and learning activities. When students are motivated, they are able to receive and process the received knowledge better. This in turn improves the students' academic achievement. The Table 1, describes the study related to the impact of the use of AR technology on student motivation from 2013–2018.

Table 1: Study of the impact of the use of AR on student motivation in higher education (2019 -2022)

Author	Sample	Method	Results
Chin et al. (2019)	Year 2 student enrolled in a Liberal Art course at Aletheia University, Taiwan. Total N= 63 participant	The sample was divided into 2 groups, namely the control group which used the traditional method which is the book while the treatment group studied using AR application that has been developed with the same course content	The results of the study found that students who learned using AR applications were more motivated and had better learning performance than students who learned using traditional methods. Confidence was the highest motivating factor among students based on the ARCS model
Chang et al. (2020)	Consists of N = 100 students who study interior design courses in layout plan	Consists of 2 groups, the control group that uses the traditional method of sketches. The treatment group used an AR app that used an animated 3D mode	The results clearly showed that the treatment group that utilized AR application as a learning aid showed higher learning effectiveness as the control group
Low et al. (2022)	50 undergraduates studying chemical engineering courses	The data collection method was through 16 questionnaire questions Instructional Materials Motivation Survey (IMMS)	The results showed that 82% of the respondents found that AR application was more helpful than conventional methods. 92 % of respondents agreed that AR can be used as an additional source to existing resources
Simoglou & Roditakis (2022)	The study involved 45 consumers in Greece, aged 20 to 60 years. Sample consists of: 2 are high school graduates, 22 university students, 9 hold Masters and 2 hold doctoral degrees	The sample was divided into 4 age levels. Each age group was given training for 2 hours using the AR Ingres game application and respondents were given 1 hour to use the Ingres application. The study used the ARCS model to measure the level of motivation of the respondents	The results show that the use of the Ingres AR application has improved all the factors in the ARCS model especially attention and satisfaction. The authors concluded that this study had a positive impact on the respondents in terms of user engagement, feedback and user behavior
Ebrahimi (2022)	120 students who took English as a Foreign Language courses (EFL)	The study sample was divided into two groups, and both used a mobile app to learn English. The control group used the Language app while the treatment group used the Ling AR app group. Focus group method has been implemented to obtain data	The findings of this study suggest that AR can improve student learning. Nevertheless, there are some challenges that need to be considered accordingly

3. Methodology

This study uses a quantitative approach that is an experimental study with a pre-post design type of one group. The effect on student motivation was measured by comparing students' learning motivation before and after using the AR application by using a questionnaire. The duration of the implementation of this study is for 2 weeks where the first week students will learn using traditional methods (M1) that is reference books and worksheets. After that, the questionnaire was adapted from (Keller, 2010) which is Instructional Materials Motivation Survey (IMMS) has been used to measure student's motivation. The following week, students learned the same topic but with a different method, which is using the AR application method (M2), which is the AR PC assembly. The same questionnaire questions were used again to measure students' motivation levels.

3.1 Respondents

Respondents for this study consisted of 1st year students of the Diploma in digital technology at Polytechnic Muadzam Shah (PMS), who registered for the DFC10033 Introduction to Computer System (ICS) Course. The sample of this study was selected by using purposive sampling technique, that is, the researcher sets the information and characteristics on the sample based on the knowledge and purpose of the study in selecting the sample (Etikan et al., 2016). The characteristic is a group of students who learn PC assembly course. The sample size of this study is 41 students consisting of 23 males and 18 females. The study also showed that all the respondents had their own smart phones equipped with internet connection.

Most of the respondents use smart phones with Android operating system (92.5 %) while 7.5 % use smart phones with iOS operating system. The results show that 7.5% of respondents have a good level of knowledge about AR, 7.5% of respondents have a moderate level, 42.5% of respondents have a weak level of knowledge and very weak. Meanwhile, 42.5% of respondents have no knowledge of AR technology. Fig. 2 shows the distribution of respondents' level of knowledge on AR technology.

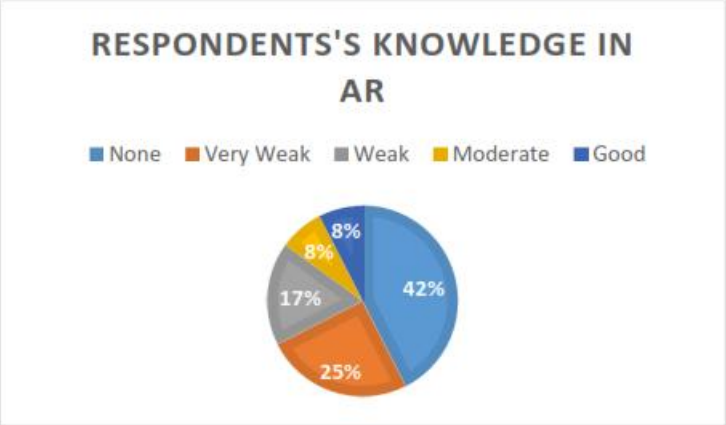

Fig. 2: Respondents' knowledge level of AR technology

3.2 Instruments

This study uses a questionnaire as an instrument for data collection tools that is the Instructional Materials Motivation Survey (IMMS). The questionnaire consisted of 36 questions in the form of a 5 Likert scale. Motivation measurement is based on the ARCS learning motivation model by Keller (2010), namely attention, relevance, confidence and satisfaction. This questionnaire was chosen because of the effectiveness of its use by previous researchers who studied the impact of AR technology on student motivation (Astuti et al., 2019; Hanafi et al., 2017; Budiman et al., 2017).

There are 10 questions are items in reverse for example items 2, 4, 6 and 8 on the confidence dimension) in the MMS instrument. In this inverse score, the lower the scale given by the respondent, the higher the value of the respondent's motivation. The score value for this inverted item has been manually reversed. This questionnaire has been translated into Malay to avoid confusion and misunderstanding among students.

The Cronbach alpha test was conducted using IBM SPSS to measure the reliability of each dimension in the ARCS model and the overall reliability. The alpha values of each dimension in the ARCS model are shown in Table 2. The overall Cronbach alpha values of the scale were 0.925 (36 items) and the Cronbach alpha values obtained for each ARCS dimension all exceeded the value of 0.7. This alpha value indicates an excellent and usable instrument.

Table 2: Cronbach alpha value

ARCS dimension	Cronbach alpha value	Total item
Confidence	0.895	9
Attention	0.821	12
Satisfaction	0.866	6
Relevance	0.848	9
Overall value	0.925	36

3.3 AR PC Assembly Application

To ensure that this study can meet the research questions, marker -based applications using AR technology have been developed. In this application, a book containing step -by -step instructions for installing a pc with an image as a marker. The software required in this development consists of Unity, Vuforia Android SDK, Blender (3D modelling software) while the software needed to run the application is the Android platform. Fig. 3 shows the AR PC Assembly book acting as a marker.

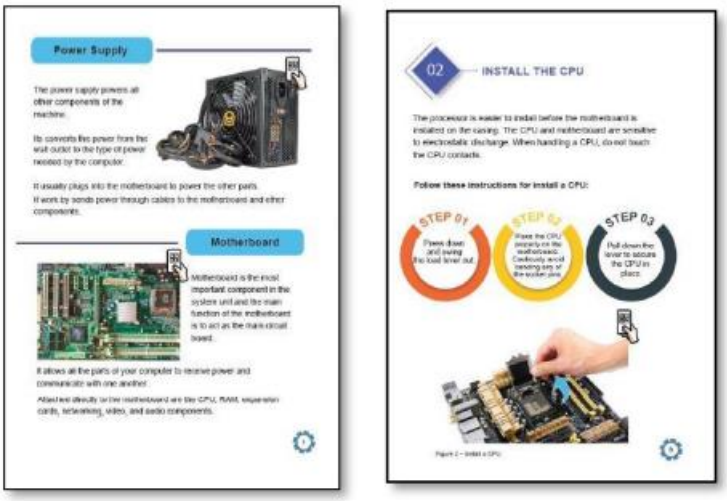

Fig. 3: Screenshot of AR PC assembly book (marker)

This app contains 4 main menus. Fig. 4 shows the main menu display which is Introduction which introduces the basic components in computer installation in 3 D, PC Assembly menu which displays 8 videos in 3D on how to install components into a computer, the third menu Help consists of computer installation tips and application usage procedures and menus the fourth is About which provides information to the application developer.

Fig. 4: Main menu display on the AR PC assembly application

4. Results

Research Question 1: Are There Any Differences in Motivation Between the Two Teaching Methods used?

The minimum and maximum score values of the IMMS instrument were 36 and 180 because the feedback scale was in the range of 1 to 5. The results showed that the total score for M1 was from 68 to 120, while the score for M2 was from 103 to 137. From the results of these results, it shows that students are more motivated when taught and learn by using AR applications in personal computer assembly courses.

Due to the small sample size of respondents (N = 41), determining the distribution of variables is important for selecting an appropriate statistical method. Therefore, the Shapiro-Wilk test of normality was used to examine the data distribution of student motivation differences when using two methods M1 and M2 and the test result was (W (41) =

0.969, p-value = 0.311). Since the p-value > 0.05, then the study data are normally distributed. Based on these results and also the results of the study on the Q-Q plot as in Fig. 5, the researcher chose to perform a parametric test for analysis purposes.

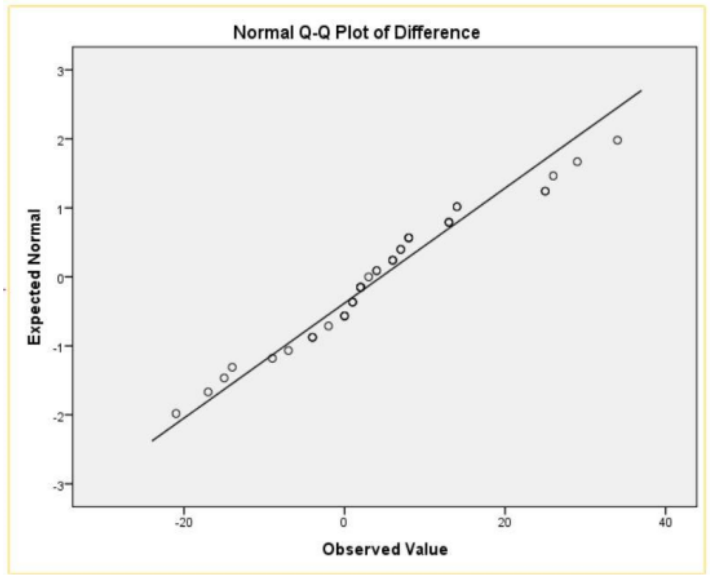

Fig. 5: Normal distribution of Q-Q plot

Paired-sample t -test was conducted to compare students' motivation scores. The results showed that the M2 score was higher (mean = 120.1, standard deviation = 8.06) compared to the M1 score (mean = 102.2, standard deviation = 9.91, t (40) = 9.28, p = 0.000). The findings of the study found that the level of significance is at p = 0.000, which is a significant level is smaller than p <0.05, meaning there is a significant relationship between the differences in student motivation scores. Thus, it can be concluded that there is a significant difference in the level of motivation of students using M1 and M2.

Research Question 2: What Are the Differences in Student Motivation Before and After Using AR Application?

The mean values for each dimension in the ARCS were assessed to see a comparison of students ’motivation before and after using the AR Application. Table 3 shows descriptive statistics for 4 dimensions that measure the level of motivation. For all four dimensions, the mean score value obtained by M2 is higher than M1 where the mean score value of the dimension for M1 is below 3.5. The highest difference between the mean scores was produced by the satisfaction dimension (M2 = 3.77, M1 = 2.60 which is 1.17) and the attention dimension where (M2 = 3.43, M1 = 2.82 which is 0.5). The difference in the lowest mean score value resulted from the Relevance dimension (M2 = 3.23, M1 = 3.07 difference of 0.16).

Table 3: Mean values of 4 dimensions of ARCS model

	M1	M2	Percentage increase
Confidence	2.89	3.42	15.49
Attention	2.82	3.43	21.63
Satisfaction	2.61	3.77	45.00
Relevance	3.07	3.37	9.31
Overall	2.84	3.37	20.10

Overall, it can be seen that the mean value obtained by M2 is 20.10 % higher than the value obtained by M1. Fig. 6 shows the comparison of mean values obtained by M1 and M2.

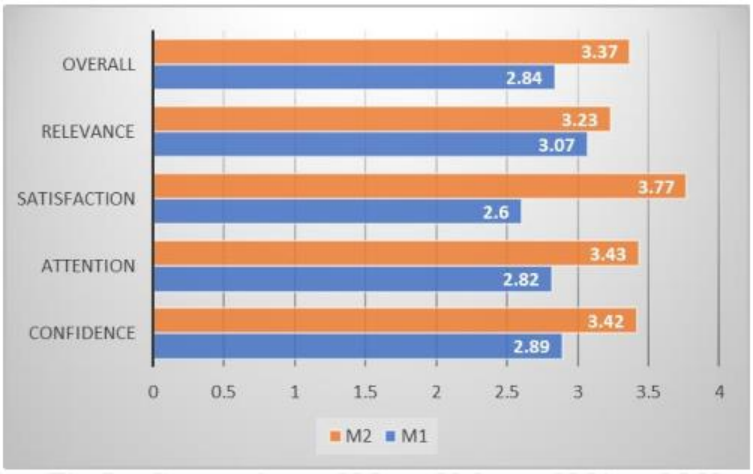

Fig. 6: Comparison of mean values of M1 and M2

Table 4 shows the results of the paired t-test against each ARCS dimension. The results showed that the mean difference between the two methods M1 and M2 was significant for each dimension namely confidence (t (40) = 3.10, p = 0.003), attention (t (40) = 10.84, p = 0.000), satisfaction t (40) = 7.14, p = 0.000) and correlation t (40) = 3.37, p = 0.02). The increase in the mean value for the dimensions of confidence, attention, satisfaction and relevance was significant with a p value <0.05. In conclusion, the K2 method that is the use of AR application successfully increases student motivation.

Table 4: ARCS dimensional paired t-test results

	N	Mean	Standard deviation	dk	t	p
Confidence	41	0.197	0.40	40	3.10	0.003
Attention	41	0.621	0.36	40	10.84	0.000
Satisfaction	41	1.15	1.03	40	7.14	0.000
Relevance	71	0.398	0.75	40	3.37	0.02

Research Question 3: How Motivated Are Students to Use AR Applications in the Learning Process?

Student motivation was analyzed from 4 ARCS dimensions namely confidence, attention, satisfaction and relevance. Refer Table 5, it can be seen that the dimension of attention (mean = 3.43) and the dimension of satisfaction (mean = 3.77) is the highest dimension of the mean value obtained.

While the lowest dimension is shown by the confidence dimension (mean = 3.05). Table 5 shows the mean values or each item in the attention dimension. The total mean was 3.43 and the highest mean value was at item 2 (mean = 4.78), while the lowest mean value was at items 8 and 11 (mean = 3.91).

Table 5: Mean values for the attentional dimension

No.	Item	Mean
1	There is something interesting at the beginning of this AR PC App that caught my attention	4.70
2	The materials of this AR PC application are eye-catching	**4.78**
3	The writing quality helped grab my attention	4.68
4	This lesson was so abstract that it was hard to keep my attention on it (-)	4.0
5	This lesson page appears dry and uninteresting (-)	4.1
6	The way the information is laid out on the page helps keep my attention	4.56
7	This lesson has something that piqued my curiosity	4.60
8	The amount of repetition in this lesson makes me sometimes bored (-)	**3.91**
9	I learned some surprising or unexpected things	4.73
10	The variety of reading passages, exercises, illustrations, etc., helps keep my attention on the lesson	4.75
11	Writing style is boring (-)	**3.91**
12	There are so many words on each page it's frustrating (-)	3.93

Based on the data, the students were very satisfied on item 2 which is the marker book and this AR application attracted their attention. In addition, students think that the amount of repetition and writing force is acceptable (mean = 3.91) but there is still room for improvement. Whereas, in the satisfaction dimension, the total mean was 3.77, and the highest mean value was at item 3 (mean = 3.92) and the lowest mean value was at item 4 (mean = 3.19). Table 6 shows the mean values of each item in the satisfaction dimension.

Table 6: Mean values for satisfaction dimensions

No.	Item	Mean
1	Completing the exercises in this lesson gives me a satisfying feeling of accomplishment	3.90
2	I really like learning through this PC AR application so much that I want to know more about this topic	3.82
3	I really enjoy using this PC AR App	**3.92**
4	Words of feedback after a workout, or other comments in this AR app, help me feel appreciated for my efforts	3.19
5	It's great to be able to successfully complete my lessons with AR PC	3.87
6	It is a pleasure to learn by using a well-designed AR app	3.90

Next, Table 7 shows the mean value of the relevance item which is the lowest rated dimension of motivation. That is, the overall mean value is 3.37. It can be seen that none of the items got a value greater than 4. However, the students agreed that there were pictures or examples when using this AR application and the students thought this application was useful to them (item 2 and item 9).

Table 7: Mean values for relevance dimensions

No.	Item	Mean
1	It is clear to me how the content of this AR application relates to what I already know	3.68
2	There are stories, pictures or examples that show me how these AR apps can be important to some people	**3.78**
3	Successfully completing this course is important to me	3.75
4	The content of this AR application is related to my interests	3.68
5	There are explanations or examples of how people use knowledge in these lessons	3.48
6	The content and writing style in this AR application conveys the impression that the content is worth knowing	3.68
7	This AR app is not relevant to my needs because I already know most of them (-)	3.65
8	I can relate the content of this AR application to things I've seen, done, or thought about in my own life	3.39
9	The content of this AR application will be useful to me	**3.78**

5. Discussion

Based on test results, it shows students are motivated when the use of AR technology is integrated with learning and teaching. The satisfaction dimension (mean value = 3.77) and the attention dimension (mean value = 3.43) were the dimensions that received the highest values compare to dimensions. Satisfaction is one of the factors where students will be rewarded from the learning experience. Satisfaction can come in the form of a sense of accomplishment, praise and pleasure. In this study, students are exposed and given the opportunity and guided to use the AR PC assembly application by interacting with hardware and books (markers). This is what the Loorbach researcher said that in ensuring that students are satisfied with learning, students should be given the opportunity to use new skills (Loorbach et al., 2015). The percentage increase in the satisfaction dimension indicated that students were more satisfied using the AR application than using the worksheet. This improvement also indicates that students have more fun using AR applications while studying computer installation courses. Students have a satisfactory sense of achievement when using the AR application (refer to the mean of item 1). As a result of the observations in the study session, the researchers found that students enjoyed learning with new methods through AR applications. This sense of achievement provides an experience that allows them to perform and understand topics better.

The dimension of attention can be acquired through perceptual stimulation or curiosity. Perceptual stimuli are obtained through renewals, surprises or surprises and unexpected things which attract attention (Lin et al., 2014). Attention can be obtained through a variety of methods including elements of humor, diversity, participation, conflict and examples related to the real world (Loorbach et al., 2015). From the study data, the increase in mean value of 21.63% is significant and shows that the AR PC assembly application is better in attracting students' attention than worksheets. This percentage also indicates that the perceptual stimulus of students increases and this makes students' interest also

increase. Therefore, students will willingly spend time and attention during the learning session. From these results, it can be suggested that education that utilizes the use of AR technology can help teachers in getting and attracting students' attention.

The confidence dimension involves the establishment of positive expectations in achieving success among students. Give confidence to students by the way students can master the topic of learning and control their learning. This situation can increase student motivation. The increased percentage after using the AR PC assemble application shows that students are confident in learning the computer assembly course. The findings of the study for the relevance dimension showed an improvement, but it had the lowest mean value among the dimensions (mean value = 3.37). However, these improvements indicate that students felt the AR PC assembly application was relevant and relevant to their personal experiences and needs. Subsequently students will be able to apply the skills in the future.

The results of this study are equivalent to studies conducted by previous researchers who concluded that the use of AR application technology can increase student motivation (Anuar Salwa, 2021; Chen, 2019; Erbas & Demirer, 2019). In addition, the results of research through observation, students were found to show an increase in interest and attention to the learning session. Students generally state that learning to use this AR PC assembly application enhances their visual acuity on how to properly assemble computer components. This coincides with a study conducted by Di Serio et al. (2013) which stated that students are more motivated to interact when studying in an AR environment. In addition to increasing motivation, studies by some researchers linked that high motivation among students will have an impact on learning achievement. Similarly, research by Sáez-López et al. (2020) which stated that the improvement in students' learning performance was related to students' motivation and confidence in feeling the experience of using AR technology.

6. Conclusion

The results of the study provide an overview of students 'motivation before and after using AR applications. The findings of the study found that the AR application of AR PC Assembly has positively and significantly motivated students to study computer installation course at Polytechnic Muadzam Shah, Pahang. Motivation of students is at a moderate level with a mean value between 2.61-3.07 when studying with traditional materials such as books and worksheets. However, the mean value on each dimension increased as students learned using AR applications (mean 3.37-3.77). Through the strength of AR which lies in added value through the provision of interactivity, and graphic stacks, students are seen to have more fun learning coupled with books that act as markers on the application. Statistical tests conducted show that the AR PC Assembly Application has a significant relationship to the four dimensions of motivation based on the ARCS model. In conclusion, this study as an added value to the existing studies that have proven that the integration of AR technology has successfully increased the motivation of students in various courses. The use of 4.0 technologies in education is seen as a good effort in providing better teaching and learning opportunities, especially to the next generation.

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