

# EXAMINING THE USE BEHAVIOUR OF AUGMENTED REALITY TECHNOLOGY THROUGH MARLCARDIO: ADAPTING THE UTAUT MODEL

Nur Nabihah Mohd Nizar<sup>1</sup>, Mohd Khairezan Rahmat<sup>2</sup>, Siti Zuraida Maaruf<sup>3</sup>, Siti Maftuhah Damio<sup>4</sup>

Faculty of Education, University Teknologi MARA<sup>1234</sup>  
[nurnabihahnizar91@gmail.com](mailto:nurnabihahnizar91@gmail.com)

Received: 18 November 2019

Accepted: 16 December 2019

Published: 26 December 2019

## ABSTRACT

Augmented reality (AR) is one type of learning process that can be applied through mobile learning known as mobile augmented reality. AR offers an innovative learning space through an active interaction of superimposing digital contents into the real context to enhance learning experiences. Previous studies have found that AR in education is able to lead students to achieve higher levels of engagement in the learning process. In contrast, the potential of AR in education has not been explored intensively. Therefore, this article is to look into factors that might influence pre-service teachers use behaviour of Mobile Augmented Reality Learning Cardiovascular (MARLCardio). A self-designed MARLCardio app has been used as an experimental instrument in collecting data. The influencing factors towards use behaviour of MARLCardio are performance expectancy, effort expectancy, social influence and facilitating conditions. This study is a part of an on-going research. In this study, a total of 75 respondents used MARLCardio app before answering a survey questionnaire. The respondents were pre-service teachers at one public university in Malaysia. All data from the questionnaire were analysed using multiple regression analysis. As a result of this investigation, findings showed that effort expectancy is the dominant factor in determining the use behaviour of MARLCardio. Interestingly, performance expectancy did not show any significant relationship.

**KEYWORDS:** *Augmented Reality, Mobile Augmented Reality, UTAUT Model, Technology Adoption Model, Use Behaviour*

## INTRODUCTION

The advance of digital technology has now made major changes to the world. The birth of varieties of digital technology has also developed and evolved. This scenario has provided potential to varieties of learning approaches related with technology usage (i.e : e-learning, massive online open course) where students can gain knowledge widely through the internet. Additionally, with rapid technological developments, students began to gaze at another learning opportunity by using mobile devices (Issham et al., 2016) called mobile learning. As mentioned by Usal & Sirin (2015), mobile learning can be described as the use of mobile or smart phone and internet in the teaching and learning process. The acceptance of mobile learning usage is relatively high as it allows students to acquire learning resources anytime and anywhere by the informal use of mobile devices via the internet. This idea is also in accordance to the 'Malaysia Education Blueprint 2015-2025' that emphasized for Higher Education

Institutions to enhance leverage the use of technology to a more personalized learning (Ministry of Education Malaysia, 2015).

Recent researchers (Chung et al., 2017; Hanafi et al., 2016; Mohd Lazim & Abd Rahman, 2015; Yilmaz, 2016 and Wojciechowski & Cellary, 2013) have started exploring the benefits of augmented reality (AR) which can be applied in mobile learning, called Mobile Augmented Reality. Mobile augmented reality refers to the use of mobile devices in accessing AR technology. AR offers an innovative learning space through an active interaction of superimposing digital contents into the real context to enhance learning experiences (Azuma, 1997). Initially, AR has been widely exposed to the gaming and entertainment industry. Now, the great potentials of AR have been discovered in education (Lee et al., 2018; C.Santos et al., 2014; Wojciechowski & Cellary, 2013 and Serio et al., 2013). Basically, the idea of AR been developed in 1950s, but people started to discover the potential of AR in education after about 51 years, in 2009 (Yuen et al., 2011). Within the period, the potential of AR in education remains underexplored (Serio et al., 2013) and even if it is explored, it is still at an infancy stage. This is happening in Malaysia (Mat-jizat et al., 2016) even though it is the future in education. Given these statements, are we going to wait for another 51 years to see the uptake of AR to be implemented?

These ideas are additionally related with the design principles in Industry 4.0. One of the principles is interconnection where it promotes people to connect via the Internet of Things (IoT). In addition, Industry 4.0 technology also promotes the scenario where assistance systems can help to support humans by visualizing information comprehensively. In this scenario, AR technology is represented as an assistance system where is it helping people to get a better understanding on elusive topics in a simpler explanation. Moreover, it is also part of IoT where a user can access some of the public AR technology through the internet. Lu (2017) agreed that by facilitating information and knowledge, IoT improves the efficiency and effectiveness of knowledge development.

In Malaysia, there are limited published articles reviewing AR in Education (Mat-jizat et al., 2016; Lazim & Abd Rahman, 2015 and Abd Majid & Kamarudin Husain, 2014). In addition, there are also limited published AR applications that can be accessed for learning purposes. AR is exciting as it can enhance a user's impression. Users can have an interaction between the real and virtual world. The information obtained from the virtual objects helps a user to comprehend more real-world tasks. For that reason, there have been some attempts to use AR for training and educational purposes. For instance, Mohd Lazim & Abd Rahman (2015) explores the visual usage in AR while Allen (2016) extended the potential of AR in museum space. In addition, Estapa & Nadolny (2015) found out that learning through AR improves students' achievement and motivation in learning Mathematics. In other point of views, Mat-jizat et al., (2016) explored the use of AR to initiate active learning process as well as to promote innovative and creative thinking.

In addition to the lack of information on AR in education, especially in the local context of Malaysia, there is also inadequate information on the contributing factor that might influence a student's decision to use AR in the learning process. It is an important issue to address in order to ensure AR can be widely used for education purposes. Therefore, the present study attempts to convey a clearer picture on the influencing factors towards pre-service teachers' decisions to use AR. The discussion in past studies and the lack of information on the integration of AR in Malaysia have provided a clear rationale, as well as to reinforce the grounds to conduct the present study.

## Augmented Reality in Education

Augmented reality (AR) can be seen as one type of the learning process that can be applied through mobile learning. The rapid changes of technologies have suggested that the teaching and learning processes should run parallel with the advancement of technology and its peripherals. AR has always been associated with Virtual Reality (VR), since it was where AR started to evolve. VR provides experience to the users to totally immerse themselves with the synthetic world, which would exceed the boundaries of physical reality environments. On the other hand, AR focuses on the combination of real-virtual environment. In getting better understanding of this concept, Milgram et al. (1994) have viewed themselves in a scale ranging between the real environment and virtual environment, called Reality-Virtuality (RV) continuum (Figure 1).

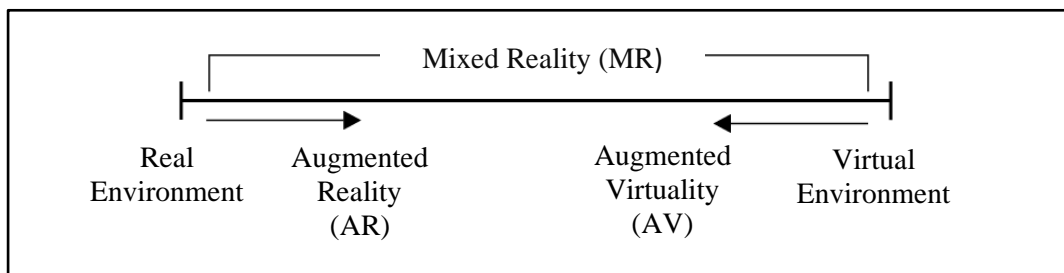


Figure 1. Reality-Virtuality (RV) Continuum

Generally, the AR application can be divided into two types of systems, which are location based, and image-based systems (Shang & Wu, 2017). The location-based system is determined by the Global Positioning System (GPS) based on the location of mobile devices. This system enables users to walk around and gather information surrounding them by detecting the mobile devices' camera to a pointed point. Conversely, an image-based AR is focused on image recognition technique. This technique is used in order to determine the position of physical objects in order to get virtual information. By pointing on the trigger image through mobile device capture, virtual information pops out to the screen after being generated by the AR software. Interestingly, the content of virtual information can be presented in various elements such as video, 3D model (Wojciechowski & Cellary, 2013), texts, audio and images (Mohd Lazim & Abd Rahman, 2015). However, the selection of elements in AR usually depends on the purpose in the student's learning process.

## RESEARCH MODEL

There are various technology acceptance models that have been developed to explain and predict technology use, with the most commonly used being the Technology Acceptance Model (TAM; Davis, 1989), Theory of Reasoned Action (TRA; Fishbein and Ajzen, 1975), and Theory of Planned Behaviour (TPB; Ajzen, 1991). Each model suggests various variables in determining the use of proposed technology. This study, on the other hand is to adapt another model: the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) to develop a research model. The UTAUT model is extensively used in recent technology acceptance studies (i.e. Guest et al., 2018; Bharati and Srikanth, 2018; Madigan et al., 2017 and Madigan et al., 2016)

UTAUT come out with a concrete model explaining the use behaviour of technology. Based on UTAUT model, performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC) are the major predictors towards use behaviour (UB) of proposed technology. Although PE, EE, SI in UTAUT model did not show a direct relationship towards use behaviour, past studies (Mou et al., 2016; Lin et al., 2014; Teo, 2014) have proven that there are direct significant relationships without passing through behaviour intention variable. Apart from that, behaviour intention is more suitable to predict the intention of users to use the proposed technology, which means that users have yet to use the proposed technology. In contrast, this study allows the participants to use a newly developed technology, known as Mobile Augmented Reality Learning Cardiovascular (MARLCardio) before data collection process. To sum up, the behavioural intention is not compellingly relevant to be part of the variables in predicting the UB of MARLCardio. Thus, the proposed research model for examining the factors that might influence pre-service teachers' decision in using MARLCardio is presented in Figure 2.

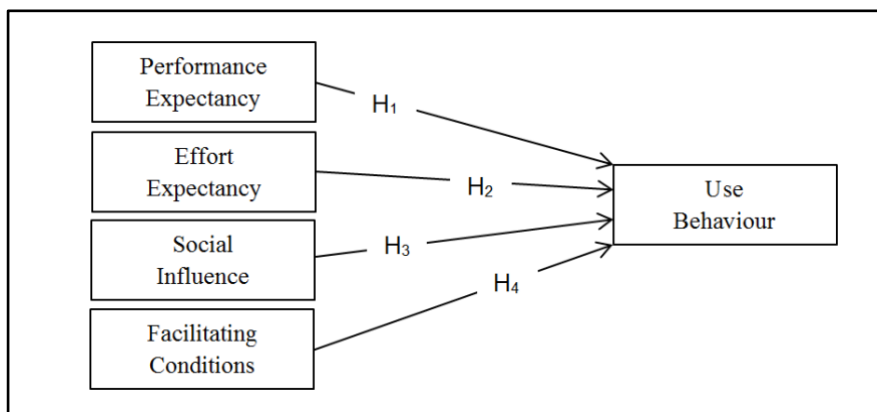


Figure 2. Proposed research model in determining use behaviour of MARLCardio

### Performance expectancy (PE) and Use behaviour (UB)

The importance of PE towards the use of technology has not only been proven in UTAUT model, but also in Technology Adoption Model (TAM; Davis, 1989) and Decomposed Theory of Planned Behaviour (DPTB; Taylor & Todd, 1995) under the construct of perceived usefulness. PE can be defined as the degree to which an individual believes that using proposed technology will help him or her to improve their performance under certain circumstances (Venkatesh et al., 2012). For the purpose of this study, PE is defined as the degree to which a higher institution student believes that using MARLCardio will help to improve their performance in learning process. Past studies' findings reported that PE always had positive impacts in determining the UB of proposed technology in different contexts of study (Bharati et al., 2018; Guest et al., 2018; Paulo et al., 2018; Madigan et al., 2017; Jaya et al., 2017; Madigan et al., 2016 and Abdullah & Ward., 2016). In online services contexts of study, Lin et al. (2014) and Mou et al. (2016) found that perceived usefulness is one of the strong indicators in predicting the use of online services. Thus, the hypothesis in this study is formulated as:

H1: The pre-service teachers' PE has a significant influence towards the UB of MARLCardio.

## **Effort expectancy (EE) and Use behaviour (UB)**

EE is represented as perceived ease of use in TAM (Davis, 1989) and Technology Acceptance Model 2 (TAM2; Venkatesh & Davis, 2000) through the different name of constructs. EE can be defined as the degree of an individual's belief that he or she will be free of effort while using the proposed technology (Davis, 1989). Thus, EE in this current study is defined as the extent of higher institution students that believe that they will be free of effort when using MARLCardio. Previous research findings provide confirmatory evidence that there is a relationship between EE and UB (Bharati et al., 2018; Guest et al., 2018; Jaya et al., 2017; Abdullah & Ward, 2016 and Madigan et al., 2016). The relationship between the two variables has also been proven in a study by Shang & Wu (2017) and Lin et al. (2015). Their study concluded that the perceived ease of use is the main predictor towards the user's satisfaction in using mobile application services. All these findings indicate that when a person feels the proposed technology as easy to use and can give benefits, the percentage to use the proposed technology is usually higher. Nonetheless, studies by Paulo et al. (2018), Madigan et al. (2017) and Maillet et al. (2015) showed no positive significant relationship between EE and UB of the proposed technology. Given these inconsistent research findings, this present study is to carry further investigation on the issue with the following hypothesis:

H<sub>2</sub>: The pre-service teachers' EE has a significant influence towards the UB of MARLCardio.

## **Social influence (SI) to and Use behaviour (UB)**

Social Influence is one of the constructs in UTAUT, which will also bring the same meaning with, the subjective norm construct in Theory of Planned Behaviour (TPB; Ajzen, 1991), DTPB (Taylor & Todd, 1995), TRA (Fishbein, 1975) and TAM2 (Venkatesh & Davis, 2000). Venkatesh et al. (2003) defined SI as "the person's perceptions that group of people who are important to him think he should or should not perform the behaviour in question". Taylor & Todd (1995) stressed that peers and superiors are the groups that are closely related to SI. Hence, in this study, SI is defined and used as the extent to which a pre-service teacher perceives pressure from peers and superiors in his or her environment to use MARLCardio. A number of previous studies discovered the positive and negative relationship between social influences (SI) and use behaviour of the proposed technology (Madigan et al., 2017 and Madigan et al., 2016). Drawing on the UTAUT model, a study by Jaya et al. (2017), Maillet et al. (2015) and Hamari & Koivisto (2015) indicated that influences among friends or colleagues give a positive impact in a person's decision to use a proposed technology. In meta-analysis findings, Abdullah & Ward (2016) showed 27 out of 32 studies that confirmed the relationship of SI in determining the use of technology. On the other hand, a recent study conducted by Bharati & Srikanth (2018) and Paulo et al. (2018) on the use of mobile learning did not find a positive relationship between both variables. Feedback from their respondents gave evidence that an individual's perception will not influence other person's decision in use of technology. Given these justifications, the present study hypothesized that:

H<sub>3</sub>: The pre-service teachers' SI has a significant influence towards the UB of MARLCardio.

## **Facilitating condition (FC) and Use behaviour (UB)**

Facilitating conditions which is based on the idea of UTAUT (Venkatesh et al., 2012) was derived from previous construct, namely the perceived behavioural control in DTPB (Taylor & Todd, 1995) and TPB (Ajzen, 1991). FC is defined as being the perceived level of an

individual towards the technical infrastructure needed to support the existed technology (Venkatesh et al., 2012). With regards to this study, the individual’s FC is defined as the pre-service teachers perceived level towards the mobile devices-assistance to support the use behaviour of MARLCardio. A study by Lin et al. (2014) extended the TRA model to perceive the use of mobile commerce services. Their study suggested perceived risk (PR) as one of the essential factors towards the use of mobile commerce services when the findings showed a positive impact between the variables. A study by Shang & Wu (2017) also confirmed that perceived value (PV) has a strong influence towards the customer’s satisfaction in using mobile shopping with  $\beta$  value = 0.997. The PR and PV in both studies bring the same meaning to the FC factor. In addition, other past studies also had confirmed the significant relationship between both variables (Guest et al., 2018; Paulo et al., 2018 and Madigan et al.,2017). In spite of this, a research by Bharati & Srikanth, 2018; Madigan et al., 2016; Maillet et al. (2015) reported that FC did not show any positive relationship towards the use of Electronic Patient Record (EPR). Given the inconsistency in research findings, further investigation needs to be conducted. Therefore, this present study will test the following hypothesis:  
H4: The pre-service teacher’s FC has a significant influence towards the UB of MARLCardio.

## APPLICATION DESIGN

This section briefly explains about MARLCardio, an experimental instrument used in this study. The rationale of selecting content is also articulated.

### MARLCardio

In this study, MARLCardio was developed based on the Augmented Reality Environment Model (AREM; Wojciechowski, 2012) . This model enables individuals to design and create learning scenes for augmented reality environments. MARLCardio comes in two versions of AR-objects which are MARLCardio booklet and MARLCardio application. MARLCardio booklet is an AR-object in the form of a physical object or a real object. Basically, it is an interactive booklet since users can interact with it by using an app which is called MARLCardio application. Users can explore the AR content in MARLCardio booklet by scanning the marker image in the booklet using MARLCardio application. Figure 3 provides an AR installation for MARLCardio for better understanding.

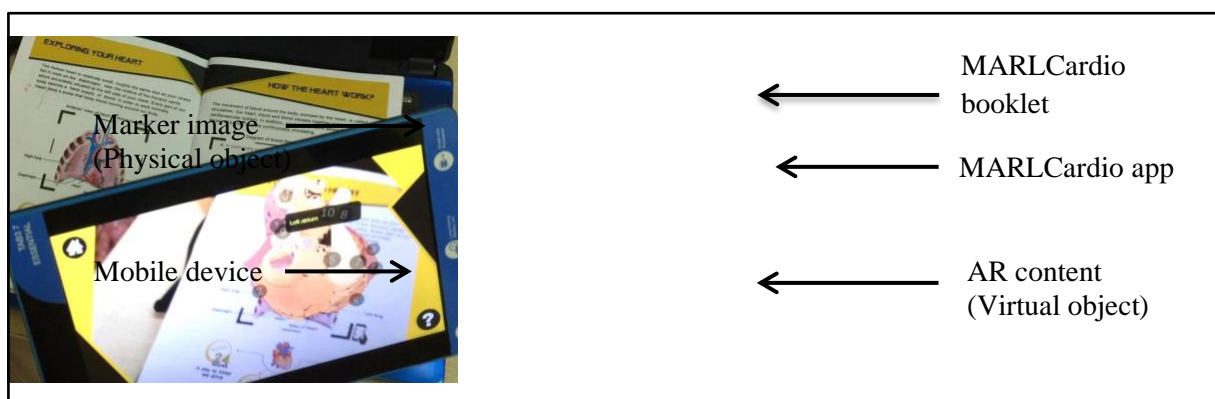


Figure 3. AR installation – MARLCardio with marker image and AR content

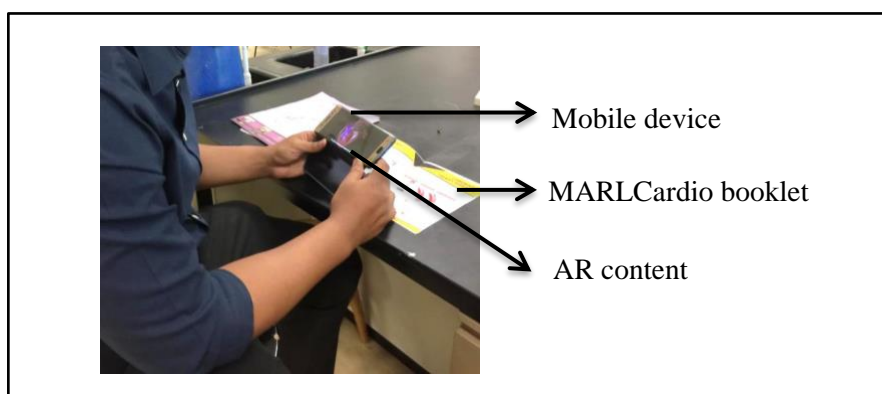
The design of MARLCardio's booklet and the development of MARLCardio's app were prepared by researchers. The development of AR – content in MARLCardio application involved an intensive process. It is due to the variety of features that should be included and completed. The MARLCardio app offered AR-content in five multimedia features which are 3D model, 3D video, 2D video, texts and images. All the features were designed and developed in different software's based on its necessity.

## Content of MARLCardio

Cardiovascular disease and its risk factors are the topics covered in MARLCardio. The selection of topics were based on the facts that Malaysian statistics in burden of disease shows that ischemic heart disease holds the highest ranking since 2000 consistently (Ministry of Health Malaysia Strategic Plan, 2016). The burden of this disease contributes to the higher causes of death. Moreover, Ministry of Health Malaysia released the fact that a disease of the circulatory system is the number one ranked cause of death in the government as well as private hospitals. Therefore, various actions and plans were carried out by the Malaysian government in their attempt to reduce health risks. One of the plans is to provide an early warning to society. An early warning about health risks can help to create awareness as well as educate the society to maintain their health. Due to these reasons, this study takes an initiative in highlighting this issue as part of the content in MARLCardio.

## METHODOLOGY

The present paper aims to evaluate the contributing factors that might influence pre-service teacher's use behaviour of MARLCardio. The study involved 75 respondents of the pre-service teachers with different fields of study in one public university. Each participant was given a chance to access the AR content provided in the MARLCardio booklet. The participants were asked to download the MARLCardio app to assist them in exploring the AR content. Participants used their own mobile devices in exploring MARLCardio. The participants browsed the content in th eMARLCardio booklet and started scanning AR image using the MARLCardio app when they want to know more on a certain topic (Figure 4).



*Figure 4.* Interaction of participant with AR content.

In the data collection process, this study deployed a quantitative methodology in the form of a survey questionnaire. After exploring MARLCardio, participants were asked to answer a questionnaire in order to determine the contributing factors that might influence pre-service teacher's use behaviour of MARLCardio. The decision to choose the questionnaire is due to the fact that it can facilitate the data collection process within a short period of time.

There are 7 items in each variable that have been adapted from UTAUT and TAM in addressing the influencing factors towards the use behaviour of MALRCardio. These items utilized four-point likert scale ranging from “Strongly Disagree” (1) to “Strongly Agree”(4). In analysing the data, the study employed multiple regression analysis to address all hypotheses.

## FINDINGS

This section addresses the reliability of items for each construct in the questionnaire. In addition, the finding of the research hypotheses has also been reported to determine the dominant factor in determining the UB of MARLCardio.

### Reliability of Items

The cronbach’s alpha is the most common form of internal consistency reliability coefficient and it is primarily used for questionnaires constructed items (Singh, Ghani & Hoon, 2009). It has been suggested by White et al. (2012) that the value of alpha 0.5 is acceptable while scores more than 0.7 are indicated as great reliability. Reliability statistics output in Table 1 provide confirmatory evidence that these constructs have high reliability since the value is greater than 0.70.

Table 1  
*Cronbach’s alpha value for each construct*

Construct	Number of items	Cronbach’s alpha
Performance Expectancy	7	0.915
Effort Expectancy	7	0.880
Social Influence	7	0.900
Facilitating Condition	7	0.821
Use Behaviour	7	0.900

### Multiple Regression Analysis

To verify hypotheses H<sub>1</sub>, H<sub>2</sub>, H<sub>3</sub>, and H<sub>4</sub>, researchers examined the relationships between pairs of the appropriate constructs defined in the research model using multiple regression analysis. The result of multiple regression analysis is presented in Table 2.

Table 2  
*Coefficients of Multiple Regressions*

Dependent Variable	Predictors	R <sub>2</sub>	p	β
Use Behaviour (UB)	Performance expectancy (PE)	0.625	0.077	.165
	Effort expectancy (EE)		0.000	.392
	Social influence (SI)		0.025	.208
	Facilitating condition (FC)		0.030	.213

As a result of multiple regression analysis, it revealed a regression model of UB based on EE, SI and FC (R<sub>2</sub> = 0.625). The results of the regression analysis supported the H<sub>2</sub>, H<sub>3</sub>, and H<sub>4</sub> hypotheses. The multiple regression coefficients caused the exclusion of PE due to the p



value that is higher than the significant level ( $p = 0.77$ ). Thus, the  $H_1$  hypothesis was not supported. Based on the results, three variables which were EE, SI and FC had positive impacts on UB. To compare these three variables, EE ( $\beta = 0.392$ ) has extra impact to use behaviour due to the  $\beta$  value that is higher than SI ( $\beta = 0.208$ ) and FC ( $\beta = 0.213$ ). Figure 5 shows this research model results.

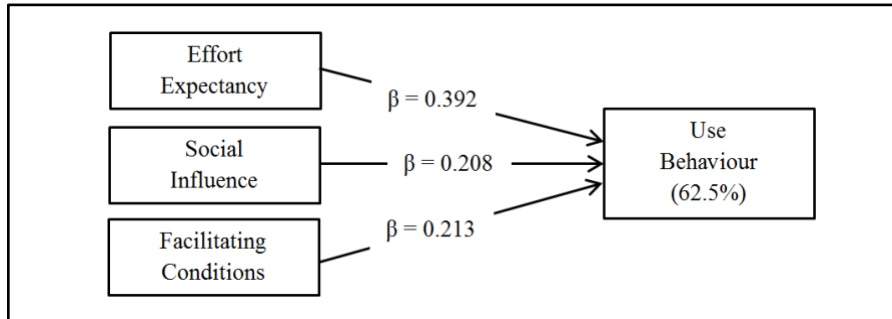


Figure 5. Research model in determining use behaviour of MARLCardio.

## DISCUSSIONS

The present study analyses the influencing factors towards the use behaviour of AR by using the MARLCardio app as an experiment instrument. To achieve this main objective, UTAUT model was adopted based on the necessity of this study. The results reported in this study provided evidence that the UTAUT model is a valuable framework in increasing our understanding of pre-service teachers use behaviour of augmented reality through MARLCardio.

Many past studies' findings show that PE had a significant impact towards UB of proposed technology. It is proven in studies by Guest et al. (2018), Paulo et al. (2018), Jaya et al. (2017), Abdullah & Ward (2016) and Mou et al. (2016). Unexpectedly, the present study found a contrary finding. PE is insignificant towards pre-service teachers UB of MARLCardio. It indicates that most of pre-service teachers seem to not get much beneficial impacts when using MARLCardio. This scenario probably happened because of the fact that the pre-service teachers come from different fields of study. Since the content of MARLCardio is more towards the flow of science, thus those who come from a social science field might feel that the benefits of the content provided is minimal. This factor might be one of the reasons affecting the pre-service teacher's PE while using MARLCardio.

Drawing on UTAUT model, the multiple regression analysis of the data in this study found that EE is the main contributor towards the UB of MARLCardio. This contradicts the finding of Venkatesh et al. (2003) in UTAUT model. Nonetheless, the findings of this study is similar in other technology adoption model findings (i.e: TAM; Davis, 1989 and TAM2; Venkatesh & Davis, 2000) and recent past studies (i.e : Bharati et al., 2018; Guest et al., 2018 and Jaya et al., 2017). The result indicates that MARLCardio is easy to use and does not require a lot of mental effort to comprehend the usage. It might be because of the evolution of the AR technology that can be easily adapted by the pre-service teachers since they are from Generation Y who is in constant access to technology.

SI was found to be significant in this study. Although this finding contradicts with the UTAUT model proposition (Venkatesh et al., 2003) where they believe that an individual's

opinion should not be influenced by others, but in a different scenario, peers are really helpful in increasing an individual's use behaviour towards proposed technology. The finding in this study indicates that pre-service teachers always believe their peers and superior's beliefs, which is the use of MARLCardio is important for them to use. It is also because of the environment in the learning process where pre-service teachers always get along with their peers in life as students. This is supported by Bharati & Srikanth (2018) when they argued that a positive or negative influence by people with close relationships can act as an important determinant in the use of proposed technology.

## CONCLUSION

In line with UTAUT model proposition, this study has also proven that FC has positive impacts towards UB of MARLCardio. It is predictable since during the data collection process, researchers were there to help pre-service teachers if they face any difficulties in exploring MARLCardio. However, some difficulties can be solved immediately by pre-service teachers without asking for the researcher's help. In addition, a strong internet connection also contributed to this significant impact. This is because the participants need strong internet connection to download the MARLCardio application that helped them from feeling frustrated. FC is important because the findings from previous studies found that FC is not significant due to the lack of technical supports in particular organizations (Bharati & Srikanth, 2018 and Maillet, 2015)

As a conclusion, EE is the main contributor in explaining the influencing factor towards the use behaviour of augmented reality technology through MARLCardio. It was followed by SI and FC. Future researches can concentrate on adding the field of study as a moderator variable. By doing that, researchers can get a deeper understanding of whether the field of study has actual effects on the relationship between PE and UB or otherwise. Considering the nature of AR technology in Malaysia, it is still at an early stage. The exposure is still at an introductory process especially in the education context. Hence, many researches of AR in education need to be done to get a clearer understanding.

## REFERENCES

- Abd Majid, N. A., & Kamarudin Husain, N. (2014). Mobile learning application based on Augmented Reality for science subject : Isains. *Journal of Engineering and Applied Sciences*, 1455-1460.
- Abdullah, F., & Ward, R. (2016). Developing a General Extended Technology Acceptance Model for E-Learning (GETAMEL) by analysing commonly used external factors. *Computers in Human Behavior*, 238-256.
- Ajzen, I. (1991). *The theory of planned behaviour*. United States: Academic Press. Inc.
- Allen, K. R. (2016). *Building Bridges Between the Virtual and Real: A Study of Augmented and Virtual Realities in the Museum Space and the Collaborations That Produce Them*. United States: ProQuest LLC .

- Azuma, R. T. (1997). A Survey of Augmented Reality. *Teleoperators and Virtual Environments*, 355-385.
- Bharati, V. J., & Srikanth, R. (2018). Modified UTAUT2 model for m-learning among. *Int. J. Learning and Change*, 5-19.
- C.Santos, M. E., Chen, A., & Taketomi, T. (2014). Augmented reality learning experiences : survey of prototype design and evaluation . *IEEE Transactions on Learning Technologies*, 38-54.
- Chung, N., Lee, H., Kim, J.-Y., & Koo, C. (2017). The Role of Augmented Reality for Experience-Influenced Environments: The Case of Cultural Heritage Tourism in Korea. *Journal of Travel Research*, 1-17.
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *Management Information Systems Research Center*, 319-340.
- Estapa, A., & Nadolny, L. (2015). The Effect of an Augmented Reality Enhanced Mathematics Lesson on Student Achievement and Motivation. *Journal of STEM Education*, 40-48.
- Guest , W., Wild, F., Vovk, A., Lefrere, P., Klemke, R., Fominykh, M., & Kuula, T. (2018). A Technology Acceptance Model for Augmented Reality and Wearable Technologies. *Journal of Universal Technology Science*, 192-219.
- Hamari, J., & Koivisto, J. (2015). "Working out for likes" : An empirical study on social influence in exercise gamification. *Computers in Human Behaviour*, 333-347.
- Hanafi, H. F., Said, C. S., Ariffin, A. H., Zainuddin, N. A., & Samsuddin, K. (2016). Using a collaborative Mobile Augmented Reality learning application (coMARLA) to improve student learning. *International Engineering Research and Innovation Symposium* (pp. 1-9). Bristol: IOI Publishing.
- Issham, I., Azizan, S. N., & Gunasegaran, T. (2016). Mobile Learning in Malaysian Universities : Are Students Ready ? *International Journal of Interactive Mobile Technology*, 17-20.
- Jaya, S. N., Nur, M. A., & Faslih, A. (2017). Analysis of Behaviour of E-learning Users by Unified Theory of Acceptance and Use of Technology (UTAUT) Model A Case Study of Vocational Education in Halu Oleo University. *Jurnal Vokasi Indonesia*, 21-25.

- Lazim, N. A., & Abd Rahman, K. A. (2015). State-of-the-art Responses on Augmented Reality Application in Malaysia. *Alam Cipta*, 29-34.
- Lee, K.-F., Wu, M.-S., Hsieh, H.-C., & Chin, K.-Y. (2018). Augmented reality supported mobile self-guided system for enhancing authentic learning activities. *Int. J. Cognitive Performance Support*, 117-131.
- Lin, J., Wang, B., Wang, N., & Lu, Y. (2014). Understanding the evolution of consumer trust in mobile commerce : a longitudinal study. *Information Technology Management*, 37-49.
- Lu, Y. (2017). Industry 4.0 : A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, 1-10
- Madigan, R., Louw, T., Dziennus, M., Graindorge, T., Ortega, E., Graindorge, M., & Merat, N. (2017). Acceptance of Automated Road Transport Systems (ARTS):an adaptation of the UTAUT model. *Transportation Research Procedia*, 2217 – 2226.
- Madigan, R., Louw, T., Wilbrink, M., Schieben, A., & Merat, N. (2017). What influences the decision to use automated public transport? Using UTAUT to understand public acceptance of automated road transport systems. *Transportation Research Part F*, 55-64.
- Maillet, E., Mathieu, L., & Sicotte, C. (2015). Modeling factors explaining the acceptance, actual use and satisfaction of nurses using an Electronic Patient Record in acute care settings : An extension of the UTAUT. *International Journal of Medical Informatics*, 36-47.
- Mat-jizat, J., Osman, J., Yahaya, R., & Samsudin, N. (2016). The use of augmented reality (ar) among tertiary level students : Perception and experience. *Asian Journal of Sustainable Business and Society*, 42-49.
- Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1994). Augmented Reality : A class of display on the reality-virtuality continuum. *Telem manipulator and Telepresence Technologies*, 282-292.
- Ministry of Education Malaysia. (2015). *Malaysia Education Blueprint (Higher Education)*. Putrajaya: Ministry of Education Malaysia.
- Ministry of Health Malaysia (2016). *Pelan Strategik Kementerian Kesihatan Malaysia 2016-2020*. Putrajaya: Ministry of Health.
- Mou, J., Shin, D.-H., & Cohen, J. (2016). Understanding trust and perceived usefulness in the consumer acceptance of an e-service : a longitudinal investigation. *Behaviour & Information Technology*, 1-16.
- Paulo, M. M., Rita, P., Oliveira, T., & Moro, S. (2017). Understanding mobile augmented reality adoption in a consumer context. *Journal of Hospitality and Tourism Technology*, 1-17.

- Serio, A. D., Ibariez, M. B., & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for visual art course. *Computer & Education*, 587-596.
- Shang, D., & Wu, W. (2017). Understanding mobile shopping consumers' continuance intention. *Industrial Management & Data Systems*, 213-227.
- Taylor, S., & Todd, P. A. (2001). Understanding Information Technology Usage : A Test of Competing Models. *Information System Research*, 144-175.
- Teo, T. (2014). Modelling Facebook usage among university students in Thailand : the role of emotional attachment in an extended technology acceptance model. *Interactive Learning Environments*, 1-14.
- Usal, Y., & Sirin, A. (2015). M-Learning in Art Education. *International Journal of Learning and Teaching* , 129-133.
- Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, 186-204.
- Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology : Extending the Unified Theory of Acceptance And Use of Technology. *Mis Quarterly*, 157-178.
- White, G., Cordato, D., O'Rourke, F., Mendis, R., Ghia, D., & Chan, D. (2012). Validation of the stroke rehabilitation motivation scale: A pilot study. *Asian Journal of Gerontology & Geriatrics* , 80-87.
- Wojciechowski, R. (2012). Modelling interactive augmented reality environments. In W.Cellary, & K.Walczak, *Interactive 3D Multimedia Content* (pp. 137-170). London: Springer.
- Wojciechowski, R., & Cellary, W. (2013). Evaluation of learners' attitude towards learning in ARIES augmented reality environments. *Computers & Education*, 570-585.
- Yilmaz, R. M. (2016). Educational magic toys developed with augmented reality technology for early childhood education. *Computer in Human Behaviour*, 240-247.