# Exploring the Pre-Service Teachers Use of Mobile Augmented Reality in Education through an Extended Technology Acceptance Model

Nur Nabihah Mohamad Nizar[1*], Khairezan Rahmat[2]

Department of Educational Foundations and Humanities, Faculty of Education, Universiti Malaya, Malaysia[1]
Department of Art and Design, Faculty of Education, Universiti Teknologi MARA, Malaysia[2]
*Corresponding author: nurnabihah@um.edu.my*

## Abstract

The popularity of Mobile Augmented Reality (MAR) has increased in recent years. However, the potential remains underexplored in education due to the massive penetration in the entertainment industry. It promotes flexibility in learning as well as enriches students' learning experiences. Therefore, this study aims to enhance the use of MAR and formulates a model of MAR usage for pre-service teachers. Since there are limitations in achieving existing MAR technology resource, the present study developed a MAR technology, namely Mobile Augmented Reality Learning Cardiovascular (MARLCardio). In the context of this study, MARLCardio serves as an experimental tool to determine the acceptance level of MAR and the factors that might influence pre-service teachers' decision to use MAR in their learning. Responses from pre-service teachers through a survey were analysed using descriptive analysis and structural equation modelling. Finding in this study found that pre-service teachers are at their moderate level in accepting the use of MAR. In addition, there are four factors that contribute to the pre-service teachers' decision in using MAR for learning which are perceived usefulness (PU), perceived ease of use (PEoU), facilitating condition (FC) and attitude (ATT). The outcome suggests that the benefits gained from the use of MAR technology play a major role in increasing the use of MAR. The easiness of use, usefulness and technical support from people surrounding are also a concern for those who are not familiar with the use of MAR. It can help them to adopt the use of MAR easily. The formulation model of MAR usage perhaps can provide ideas and assist future research towards achieving better success of MAR usage.

**Keywords:** Mobile Augmented Reality, Structural Equation Modelling, Technology Acceptance Model, Pre-service Teachers

**Introduction**

The 21st century beheld a drastic penetration of technology in the field of education all over the world. It has brought to the introduction and development of varieties in digital technologies, which has influenced every level of education setting. Currently, students use laptops, personal computers and mobile devices including tablets as medium for their learning process. This idea is also in accordance with the 'Malaysia Education Blueprint 2013-2025' that emphasized Higher Education Institution to enhance students learning experience by leveraging the use of technology to enhance more personalized learning (Ministry of Education Malaysia, 2015). It is one of the key initiatives to produce holistic, entrepreneurial, and balanced graduates.

In a few years back, Malaysia higher institution students are moderately ready to integrate mobile learning in their learning process (Issham et al., 2016). This scenario happens because students tend to use their mobile devices for socializing and entertainment. However, currently students start to use their mobile devices to assist their learning process especially after pandemic. This scenario provides students with the opportunity to explore the world and grab as much information at their fingertips. The increasing use of mobile devices in learning has urged researchers (Alotaibi, 2023; Pinto et al., 2022) to explore the benefits of augmented reality (AR) in mobile learning. AR offers an innovative learning space through an active interaction of superimposing digital contents into the real context to enhance learning experiences (Azuma, 1997). Concurrently, previous studies have found that AR benefits students in achieving higher levels of engagement in the learning process (Pinto et al., 2022), providing flexibility in learning (Alotaibi, 2023) and promoting active learning (Nizar et al., 2022). Although there are a variety of AR devices, mobile devices are seen as a more familiar AR device for academic purposes because most students have their own mobile devices.

The limitation of getting MAR resources has urged numerous past researchers, regardless in Malaysia (Norizan & Ghani, 2022; Hashim et al., 2022; Nizar et al., 2022) or other country (Kao & Ruan, 2022; Pinto et al., 2022), to develop their own MAR for their target users. In addition to the limitation of MAR resources in the local context of Malaysia, there is also inadequate information providing a clear insight into the influencing factors towards the use of MAR (Benharal et al., 2022). Some of the previous researchers utilized technology adoption theories and models such as Unified Theory of Acceptance and Use of Technology (Pinto et al., 2022), Theory of Planned Behaviour (Ates & Garzon, 2023) and Technology Acceptance Model (Bourhim & Labti, 2022) to determine the influencing factors towards the use of MAR. Although success in integrating MAR in education is expected, there are barriers reinforcement the uptake of MAR in the learning process, which reflects the concern of the students. Therefore, the present study attempts to convey a clearer picture of influencing factors towards students' decisions in integrating Mobile Augmented Reality (MAR) in their learning process.

**Research Objective**

This study was conducted to determine the contributing factors towards the integration of Mobile Augmented Reality (MAR) through the implementation of Mobile Augmented Reality Learning Cardiovascular (MARLCardio) among Malaysian pre-service teachers.

**Research Theories**

This present study employed Technology Acceptance Model (TAM) (Davis, 1989) as an underpinning theory in exploring the contributing factors towards the Mobile Augmented Reality (MAR) acceptance through the implementation of Mobile Augmented Reality Learning Cardiovascular Application (MARLCardio). TAM theories that perceived ease of use and perceived usefulness are the determined factors explaining one technology's acceptance.

Additionally, TAM emphasised the importance of external variables as a factor that possibly will influence perceived ease of use and perceived usefulness. As example, Zhang et al. (2022) emphasized perceived playfulness and Rad et al. (2022) focussed on perceived enjoyment. As established in TAM, Attitudes play a role as mediator variable to influence behavioural intention and indirectly influence how people perceived the use of technology. Behavioural intention is more likely to predict behaviour of individual will be performed before using any proposed technology, while actual use or acceptance in TAM posit actual behaviour. For the purposes of this study, behavioural intention excluded as the respondents were asked to use and explore MARLCardio application. In other words, respondents had the opportunity to learn more and explore the application. Thus, they are not considered under behavioural intention.

Beside TAM, Unified Theory of Acceptance and Use of Technology (UTAUT) was also developed to describe user intention to use and use behaviour towards the technology (Venkatesh et al., 2003). The UTAUT model emphasized 4 constructs namely Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions in determining users' intention and thus use behaviour in technology. The theorized constructs in UTAUT model are related to constructs in TAM. As an example, the Perceived Usefulness in TAM brings the same meaning as Performance Expectancy in UTAUT. Meanwhile, Perceived Ease of Use in TAM is like Effort Expectancy. Both TAM and UTAUT model believe that the degree of ease and usefulness of technology are important to ensure the acceptance of that technology. In terms of Social Influence, the UTAUT model posits the importance of people surrounding them in encouraging others to use technology. Meanwhile, Facilitating Conditions play a role in terms of organization and technical infrastructure should exist to support the use of any technology.

These models have previously been employed in numerous studies. As a case in point, study conducted by Natasia et al. (2022) asserts the significant relationship between perceived usefulness and attitude, which the advantages provided in e-learning platform create a feeling of contentment and comfort for teachers. However, their study was not able to confirm the relationship between perceived ease of use and attitude. It is because some of the teachers find it difficult to comprehend how it operates and need constant guidance while using it. In addition, a study from Pinto et al. (2023) revealed that Facilitating Condition is one of the determinants of Mobile Augmented Reality usage. Meanwhile, Benharal et al. (2022) yielded that Effort Expectancy, Performance Expectancy and Social Influence provide a positive impact in determining user behaviour of technology. The inconsistent outcome from previous studies urged researchers to explore the contributing factors towards MAR through the implementation of MARLCardio. Therefore, this study extended the TAM model with additional of 2 constructs from UTAUT (Social Influence and Facilitating Conditions) to explore the contributing factors.

**Research Model**

The research model for this study was developed based on TAM and has been extended by adding another two variables derived from UTAUT model. The proposed framework has six constructs namely Social Influence, Facilitating Condition, Perceived Usefulness, Perceived Ease of Use, Attitude, and Acceptance (Figure 1). The model introduces the user's Social Influence and Facilitating Condition as external variables. Perceived Ease of Use and Perceived Usefulness are independent variables, while acceptance is the dependent variable. Meanwhile, Attitude was designated as mediator variable. All the hypothesized paths will be tested using Structural Equation Modelling (SEM) analysis to determine their relationship.
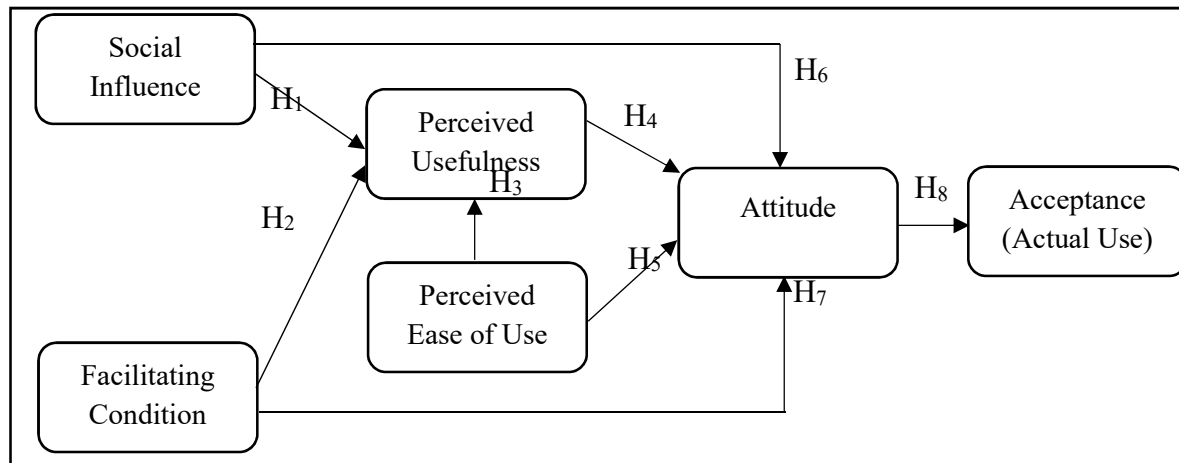
**Figure 1.** Research Model

## Research Methodology
### Research Design

To achieve the research objectives, this study employed a quantitative research approach through cross-sectional survey design to collect data. The data collection process was conducted to determine pre-service teachers' decision in accepting the use of Mobile Augmented Reality after they explored the potential of MARLCardio. MARLCardio is a self-developed application used to exemplify features of MAR.

### Population and Sampling

A survey was conducted on 357 pre-service teachers at three public universities in Malaysia through face-to-face data collection. The respondents were selected based on a two-stage sampling technique. Three public universities in Malaysia that provide education and teaching programmes were chosen randomly for the first stage. Volunteerism served as the basis for the second stage of selection.

### Data Collection and Data Analysis

The data collection process was conducted through survey. The questionnaire consisted of items related to six constructs (Perceived Usefulness, Perceived Ease of Use, Social Influences, Facilitating Condition, Attitude and Acceptance) and each of the constructs had 5 items. All pre-service teachers were obliged to discover the features in MARLCardio before answering the questionnaire. Data gathered from the respondents was analysed using Structural Equation Modelling (SEM) analysis to attain the structural relationship of the hypothesized path.

Cronbach's alpha value was used to evaluate the validity and internal consistency of questionnaire items. Cronbach's alpha greater than 0.7 implies an acceptable level of reliability, whereas larger than 0.8 suggests a very good level of reliability (Ursachi et al., 2015). However, values greater than 0.95 are not recommended due to redundancy of items (Hulin et al., 2001). As seen in Table 1, all the six constructs achieved the threshold value. The value of Cronbach's alpha for Social Influence, Facilitating Condition, Perceived Usefulness, Perceived Ease of Use, Attitude and Acceptance were 0.875, 0.802, 0.862, 0.837, 0.806 and 0.824, respectively. This value indicated that the Cronbach's Alpha value for all construct in a very good reliability ($>0.8 \ \alpha <0.95$)

**Table 1.** Cronbach's Alpha Value for Six Constructs

| Construct | Cronbach's Alpha (α) | No of Items |
|---|---|---|
| Social Influence (SI) | .875 | 5 |
| Facilitating Condition (FC) | .802 | 5 |
| Perceived Usefulness (PU) | .862 | 5 |
| Perceived Ease of Use (PEoU) | .837 | 5 |
| Attitude (ATT) | .806 | 5 |
| Acceptance | .824 | 5 |

**Research Findings**

The path analysis of the projected research model was analysed with 500 bootstrap samples with a confidence interval of 95 percent. The result of the tested hypothesis was summarized in Table 2 based on the following hypotheses:

$H_1$: There is a significant relationship between Social Influence & Perceived Usefulness

$H_2$: There is a significant relationship between Facilitating Condition & Perceived Ease of Use

$H_3$: There is a significant relationship between Perceived Ease of Use & Perceived Usefulness

$H_4$: There is a significant relationship between Perceived Usefulness & Attitude

$H_5$: There is a significant relationship between Perceived Ease of Use & Attitude

$H_6$: There is a significant relationship between Social Influence & Attitude

$H_7$: There is a significant relationship between Facilitating Condition &Attitude

$H_8$: There is a significant relationship between Attitude & Acceptance

The statistical output in Table 2 shows that the relationship of the hypothesized path was evaluated using the β-value, t-statistic, and significant value (p-value). The β-value reflects the amount of change in the dependent variable for every unit change in the independent variable, and it can be negative or positive. For t-statistics, the closer the value is to zero, the less probable there is a significant difference. If the p-value is 0.05 or less, the result is considered as significant.

There was a positive relationship between Social Influence and Perceived Usefulness with β=0.092, t-statistic=2.178 and p-value is 0.030. Thus, hypothesis 1 was accepted. There was a statically significant relationship between Facilitating Condition and Perceived Usefulness β =0.143, t-statistic=2.880 and p-value is 0.004. Hence, hypothesis 2 was accepted. There was a significant relationship between the Perceived Ease of Use and Perceived Usefulness with β=0.625, t-statistic=15.076 and p-value is highly significant. Therefore, hypothesis 3 was accepted. The relationship between Perceived Usefulness and Attitude was significant with β=0.263, t-statistics=4.280 and p-value is 0.001. Thus, hypothesis 4 was accepted. The hypothesized path between Perceived Ease of Use and Attitude is positively significant with β=0.222, t-statistics=3.621 and p-value is 0.001. Hence, hypothesis 5 was accepted. There was no relationship between Social Influence and Attitude as p-value exceeded the minimum of 0.05. Thus, hypothesis 6 was rejected. There was a statically significant relationship between Facilitating Condition and Attitude β =0.323, t-statistic=5.552 and p-value is 0.001. Hence, hypothesis 7 was accepted. There was a significant relationship between Attitude and Acceptance with β=0.597, t-statistic=15.784 and p-value is highly significant. Therefore, hypothesis 8 was accepted. In conclusion, all the hypotheses in Table 2 were accepted except for hypothesis 6.

**Table 2.** Results of Hypotheses Path

| Independent Variable | Dependent Variable | β | t-statistic | p-value | Result |
|---|---|---|---|---|---|
| Social Influence | Perceived Usefulness | .092 | 2.178 | .030 | Accepted |
| Facilitating Condition | | .143 | 2.880 | .004 | Accepted |
| Perceived Ease of Use | | .625 | 15.076 | .001 | Accepted |
| Perceived Usefulness | Attitude | .263 | 4.280 | .001 | Accepted |
| Perceived Ease of Use | | .222 | 3.621 | .001 | Accepted |
| Social Influence | | .034 | .691 | .490 | Rejected |
| Facilitating Condition | | .323 | 5.552 | .001 | Accepted |
| Attitude | Acceptance | .597 | 15.784 | .001 | Accepted |

*Mediation Analysis*

The mediation analysis was conducted to analyse the indirect effect of Social Influence, Facilitating Condition, Perceived Usefulness and Perceived Ease of Use towards Acceptance. In this path, Attitude serves as a mediator variable. Finding presented in Table 3 shows the value of t-statistics and p value for the hypothesized path. Data conclude that, Attitude able to serve as mediator variable to determine the Acceptance of Mobile Augmented Reality for Perceived Usefulness (t-statistic=4.280, p-value=.001), Perceived Ease of Use (t-statistic=3.621, p-value=.001) and Facilitating Condition (t-statistic=5.552, p-value=0.001). On other hand, Attitude was not able to mediate the relation between Social Influence and Acceptance as the p-value exceeds the minimum of 0.05. These results indicated that the mediator path was significant only for Facilitating Condition, Perceived Usefulness and Perceived Ease of Use.

**Table 3.** Indirect effect of the structural model

| Independent Variable | Mediator Variable | Dependent Variable | t-statistic | p-value |
|---|---|---|---|---|
| Perceived Usefulness | Attitude | Acceptance | 4.280 | .001 |
| Perceived Ease of Use | | | 3.621 | .001 |
| Social Influence | | | .490 | .490 |
| Facilitating Condition | | | 5.552 | .001 |

*Structural Model with $R^2$ Value*

Figure 2 presents the structural model, β value and $R^2$ value for all hypothesized paths in this study. The goodness of model was established by the strength of each hypothesized path determined by the $R^2$ value for the dependent variable and the $R^2$ value should be equal to or more than 0.1. The first structural model for Perceived Usefulness as the dependent variable showed that the $R^2$ value is 0.619. This indicates that 61.9 percent proportion of the variance in Perceived Usefulness could be attributed to the Social Influence, Facilitating Condition and Perceived Ease of Use as independent variables. The second structural model with Attitude as dependent variable, shows that $R^2$ value is 0.500. This value indicated that 50 percent of

changes in Attitude could be attributed to Social Influence, Facilitating Condition, Perceived Usefulness and Perceived Ease of Use. The third structural model of Acceptance as dependent variable shows that $R^2$ value is 0.412. This value indicated that 41.2 percent of changes in Acceptance could be attributed to the independent variable of Attitude. The $R^2$ value for these three structural models exceeds the minimum value of 0.1. This indicated that the predictive statistical measure of fit is established.
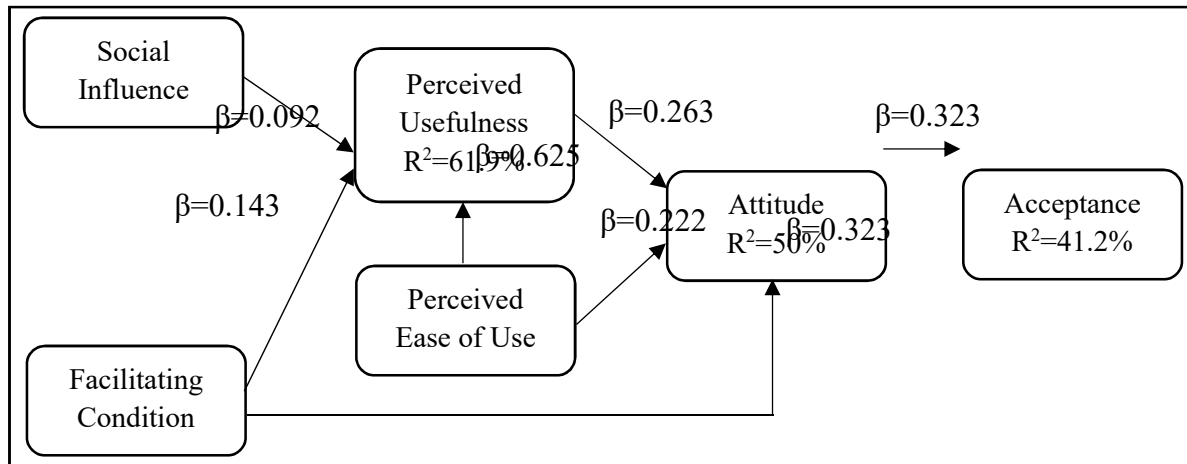


**Figure 2.** Structural Model of Acceptance for Mobile Augmented Reality

**Discussion and Recommendations**

In this study, MARLCardio serves as a proposed technology to determine contributing that influence pre-service teachers' acceptance of MAR. Findings from this study help to explain the idea on how pre-service teachers' behaviours towards the use of MAR based on the adaption of extended Technology Acceptance Model. Respondents were asked about their belief in Social Influence, Facilitating Condition and Perceived Ease of Use towards MAR's usefulness. Data indicated that pre-service teachers agree that all these three constructs play a role in determining the usefulness of MAR. In other words, they perceived and believe people surrounding's believe about the importance of using MAR and thus lead to their behaviour to use it too. In other hand, the support from organization or even the developers of MARLCardio also plays a role in assisting them whenever they were technical issue to be solved. Among these three constructs, Perceive Ease of Use appears as the most factor considered to predict the usefulness of MAR. In other words, the easiness on how to operate MARLCardio is vital in determining pre-service teachers' performance in learning.

In addition, respondents were also asked about their believe in Social Influence, Facilitating Condition, Perceived Usefulness and Perceived Ease of Use towards their Attitude in accepting MAR. Data indicated that, the use of MAR able to enhance pre-service teacher learning performance and they feel easier in using the application. Their adaptation in using MAR could be related as they are categorized under generation Z, who are shaped by the digital age. Data in this study supports their positive attitude towards the use of MAR. It is reasonable to believe that Perceived Usefulness will raise students' trust in the application's capacity to fulfil the required functions, hence indirectly increasing their degree of Acceptance. Meanwhile, Perceived Ease of Use provides confidence in the user's ability to successfully explore the application and provides satisfaction. According to TAM, those who have no prior experience with similar applications will be more concerned with simplicity of use. This is since they must become acquainted with and understand the fundamentals of the application before using it for learning purposes. Meanwhile, those who have used similar applications will

focus on to what extent the application can contribute to their learning performance and how useful the application is in facilitating their learning process. It is because they are no longer concerned with the application's ease of use because they understand how it works. As a result, the usefulness of the application has become their main concern. In short, to increase pre-service teachers' acceptance of the MAR having an appropriate ease of use combined with usefulness is essential. On other hand, Social Influence does not show any contribution in determining pre-service teachers' Attitude. In a simple word, influence from people surrounding were not able to help pre-service teachers to perceive a positive Attitude in using MAR but only can help in convince them it is useful. The significant relationship between Attitude and Acceptance indicates that the pre-service teachers' satisfaction in using MAR. The explained variance of Acceptance (41.2%) appears quite high. This variance does not indicate the model fit of the data, instead that all the variability of the response data around its mean and attitude construct highly influence pre-service teachers' acceptance of MAR. In addition, the pre-service teachers also responded that they become more confident in using the application and become more knowledgeable after using it. This scenario also can be concluded that there is a high tendency from pre-service teachers to continue using MAR in the future.

Based on the outcome of this study as well as feedback from the pre-service teachers, several aspects need to be improved so that the value of acceptance of the MAR can be increased. The recommendations that can be given are exploring the adaption of other possible variable such as perceived enjoyment, motivation, and moderator variables (age, experience, gender, volunterism) as projected in Unified theory of Acceptance and User Technology (UTAUT) obtain broad understanding in related MAR. Although pre-service teachers yielded that MAR easy to use, some of them do not fully understand how MAR works. Hence, intensive, and comprehensive training for pre-service teachers regarding the use of MAR can be considered.

## Conclusion

The results showed that all the seven hypotheses (H1, H2, H3, H4, H5, H7, H8) except for H6 and the four hypotheses for structural model (H9, H10, H11) were accepted. From these results, it can be concluded that the acceptance of MAR is relatively good and thus reflects the pre-service teachers' acceptance in using MAR for learning purposes. Although most pre-service teachers dedicated that the use of MAR is easy but intensive training should be conducted for better understanding to provide meaningful experiences among pre-service teachers. To expand broad understanding of MAR's acceptance, future researchers are suggested to explore more independent variables (perceived enjoyment, motivation) and moderator variables (age, experience, gender, volunteerism).

## References

Alotaibi, S. J. (2023). UTAUT Model For The Use of Augmented Reality in Education and Training. *Romanian Journal of Information Technology and Automatic Control, 33*(1), 21-32.

Ates, H., & Garzon, J. (2023). An Integrated Model For Examining Teachers' Intention to Use Augmented Reality in Science Courses. *Education and Information Technologies*, 1299-1321.

Azuma, R. T. (1997). A Survey of Augmented Reality . *Teleoperators and Virtual Environments*, 355-385.

Benharal, M., Bourhim, E. M., Dahane, A., Labti, O., & Akhiate, A. (2022). UTAUT2 Model to Explain the Adoption of Augmented Reality Technology in Education: An Empirical

Study in Morocco. *2nd International Conference on Emerging Technologies and Intelligent Systems* (pp. 491-500). United States: Springer, Cham.

Bourhim, E. M., & Labti, O. (2022). User Acceptance of Augmented Reality in Education: An Analsyis Based on the TAM Model. *2nd International Conference on Emerging Technologies and Intelligent Systems* (pp. 481-490). United States: Springer Cham.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of informational technology. *Management Information Systems Research Center, 13*(3), 319-340. doi:https://doi.org/10.2307/249008

Hashim, N. C., Majid, N. A., Arshad, H., Hashim, H., & Alyasseri, A. A. (2022). Mobile Augmented Reality Based on Multimodal Inputs for Experiental Learning. *IEEE Access*, 78963-78969.

Hulin, C., Netemeyer, H. C., & Cudeck, R. (2001). Can a reliability coefficient be too high. *Journal of Consumer Psychology, 10*, 55-58. doi:https://doi.org/10.1207/S15327663JCP1001&2_05

Issham, I., Azizan, S. N., & Gunaseraran, T. (2016). Mobile learning in Malaysia Universities: Are Students Ready? *International Journal of Interactive Mobile Technology*, 17-20.

Kao, G. Y.-M., & Ruan, C.-A. (2022). Designing and Evaluating A High Interactive Augmented Reality System For Programming Learning. *Computers in Human Behaviour*, 1-16.

Ministry of Education. (2015). *Malaysia Education Blueprint (Higher Education).* Putrajaya: Ministry of Education Malaysia.

Natasia, S. R., Wiranti, Y. T., & Parastika, A. (2021). Acceptance analysis of NUADU as e-learning platform using the Technology Acceptance Model (TAM) approach. *Procedia Computer Science, 197*(2022), 512-520. doi:https://doi.org/10.1016/j.procs.2021.12.168

Nizar, N. N., Rahmat, M. K., Maaruf, S. Z., & Damio, S. M. (2022). The Development of Mobile Augmented Reality: 3-Dimensional Video. *International Journal of Service Management and Sustainability, 7*(1), 107-124.

Norizan, N. A., & Ghani, Z. A. (2022). Using Augmented Reality (AR) in Creating Digital Art Magazine to Promote Malaysian Arts. *Journal of Computing Technologies and Creative Content, 7*(1), 22-29.

Pinto, A. S., Abreu, A., Costa, E., & Paiva, J. (2022). Augmented Reality For A New Reality: Using UTAUT-3 to Assess the Adoption of Mobile Augmented Reality in Tourism (MART). *Journal of Information Systems Engineering and Management, 7*(2), 1-9.

Rad, D., Egerau, A., Roman, A., Dughi, T., Balas, E., Maier, R., . . . Rad, G. (2022). A preliminary investigation of the technology acceptance model (TAM) in early childhood education and care. *Broad Research in Artificial Intelligence and Neuroscience, 13*(1), 518-533. doi:https://doi.org/10.1007/978-3-030-49913-6_23

Ursachi, G., Horodnic, I. A., & Zait, A. (2015). How reliable are measurement scales? External factors with indirect influence on reliability estimators. *Procedia Economic and Finance*, 679-686.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward A Unified View . *MIS Quarterly*, 425-427.

Zhang, M., Shu, L., Luo, X., Yuan, M., & Zheng, X. (2022). Virtual reality technology in construction safety training: Extended technology acceptance model. *Automation in Construction, 135*, 104-113. doi:https://doi.org/10.1016/j.autcon.2021.104113