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Research Article

A structural model of pre-service teachers' attitude, acceptance, and continuance intention towards mobile augmented reality

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ABSTRACT

The increasing prevalence of mobile augmented reality (MAR) has garnered attention in contemporary times. However, its application within educational settings remains largely untapped, primarily due to its predominant utilization in entertainment domains. MAR presents opportunities for augmenting learning experiences, fostering enhanced adaptability in educational methodologies, and enriching students' academic endeavors. Therefore, this study aims to enhance the use of MAR and formulates a model of MAR usage for pre-service teachers. In the context of this study, MAR learning cardiovascular (MARLCardio) serves as an experimental tool for exemplifying the features of MAR. This study integrates the Unified Theory of Acceptance and Use of Technology (UTAUT), Technology Acceptance Model (TAM), and Expectation Confirmation Model (ECM) as underpinning theories. This study was undertaken to determine factors that influence pre-service teachers' attitude, acceptance, and their intention to continue using MAR in the learning process. Responses from 456 pre-service teachers through a survey were analyzed using structural equation modelling. Findings in this study found that pre-service teachers agree that facilitating condition play a crucial role in shaping pre-service teachers' positive attitude and influencing their intention to continue using MAR. Meanwhile, performance expectancy plays a major role in ensuring pre-service teachers' acceptance of using MAR in their learning process. It was anticipated that the formulated MAR structural model would offer insights and support forthcoming research endeavors aimed at fostering the sustainability of MAR utilization.

Keywords: mobile augmented reality, structural equation modelling, unified theory of acceptance and use of technology, technology acceptance model, expectation confirmation model

INTRODUCTION

The 21st century has witnessed a significant integration of technology into the global education sector. This integration has led to the introduction and advancement of various digital technologies, influencing all levels of educational environments. Presently, students utilize laptops, desktop computers, and mobile devices such as tablets as tools for their learning journey. This trend aligns with the objectives outlined in the 'Malaysia education blueprint 2013-2025', which emphasizes the need for higher education institutions to enrich students' learning experiences by harnessing technology for more personalized learning (Ministry of Education Malaysia, 2015). This initiative stands as a cornerstone for nurturing well-rounded, entrepreneurial individuals.

A few years ago, Malaysian higher education students showed moderate readiness to incorporate mobile learning into their educational journey (Issham et al., 2016). This situation arose as students primarily used their mobile devices for socializing and entertainment. However, in the current landscape, students are increasingly leveraging their mobile devices to aid their learning, especially in the aftermath of the pandemic. This shift presents students with the opportunity to access a wealth of information at their fingertips, opening up avenues for exploration. The growing adoption of mobile devices in learning has prompted researchers (Alotaibi, 2023; Pinto et al., 2022) to investigate the advantages of augmented reality (AR) in mobile learning. AR creates an innovative learning environment by seamlessly integrating digital content into real-world contexts to enhance the learning experience (Azuma, 1997). Concurrently, previous research has demonstrated that AR benefits students by fostering higher levels of engagement (Pinto et al., 2022), offering learning flexibility (Alotaibi, 2023), and promoting active participation (Nizar et al., 2023). These past studies have been conducted due to the fact that students often face significant challenges in learning which MAR has the potential to address, such as limited engagement, difficulty in visualizing complex concepts, and lack of interactive learning experiences. Despite the availability of various AR devices, mobile devices are considered more familiar tools for academic purposes, given that most students possess their own mobile devices. While MAR can enhance learning by providing immersive and interactive environments that make abstract concepts more tangible and engaging, its effectiveness in overcoming these challenges can be compromised by issues such as inadequate resource availability, technical difficulties, and a lack of user-friendly interfaces.

The limitation of mobile augmented reality (MAR) resources has prompted numerous past researchers, both in Malaysia (Hashim et al., 2022; Nizar et al., 2022; Norizan & Ghani, 2022) and elsewhere (Kao & Ruan, 2022; Pinto et al., 2022), to develop their own MAR solutions tailored to their specific user needs. Alongside the shortage of MAR resources in the local Malaysian context, there exists insufficient information to provide a comprehensive understanding of the factors influencing the adoption of MAR (Benharal et al., 2022). Previous researchers have employed various technology adoption theories and models, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) (Pinto et al., 2022), the Theory of Planned Behavior (TPB) (Ates & Garzon, 2023), and the Technology Acceptance Model (TAM) (Bourhim & Labti, 2022), to elucidate these influencing factors. Despite the anticipated success in integrating MAR into education, barriers persist that hinder its widespread adoption in the learning process, echoing students' concerns.

In light of all the issues raised, this research focuses on pre-service teachers at public universities in Malaysia, a group that is well-positioned to shape educational policies in the future. The selection of pre-service teachers was justified by considering their insights as change agents (Morton & Rose, 2020). Pre-service teachers are often young adults in their early to mid-20s. As a result, the majority of mobile device users fall into the 20-24 age range and they are categorized under generation Z, who have been shaped by the digital age (Malaysian Communication and Multimedia Commission, 2019). It is crucial to consider respondents who are accustomed to using mobile devices like smartphones. This is because the adoption of mobile devices as the primary medium is encouraged by the MAR exploration. In the context of this study, it was expected that the pre-service teachers would be able to promote and develop strategies towards the use of MAR for their future classroom setting. Therefore, the current study aims to provide a clearer understanding of the factors influencing pre-service teachers' decisions regarding the integration of MAR into their learning journey.

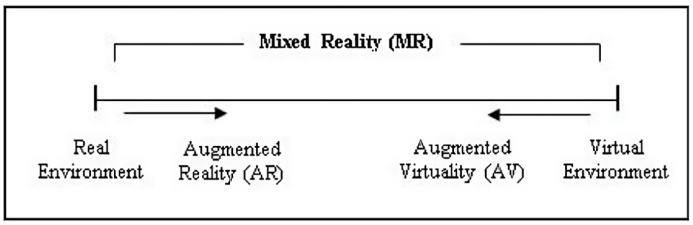

Figure 1. Reality-virtuality continuum (Milgram et al., 1994)

LITERATURE REVIEW

Augmented Reality in Education

Mobile learning is strengthened by Malaysia's widespread internet access, which facilitates broader access to online education, improves teaching and learning quality, lowers delivery costs, and showcases Malaysian expertise globally. Mobile learning applications offer various functionalities, from communication platforms to educational games, catering to different learning needs (Videnovik et al., 2020). AR is particularly promising in mobile learning, offering immersive experiences (Adnan et al., 2019; Anuar et al., 2021).

AR is a concept applied in mobile learning, known as MAR, as demonstrated by the alignment of mobile device capabilities with AR concepts (Ates & Garzon, 2023). Given the rapid technological advancements, the teaching and learning process must evolve alongside technology, with AR emerging as a prominent tool for delivering learning content (Khairuldin et al., 2019). Previous research has consistently shown positive outcomes regarding the use of AR in education (Bourhim & Labti, 2022; Hashim et al., 2022).

Azuma (1997) defines AR as an enhancement of the user's perception of the real world by overlaying computer-generated information. While AR and virtual reality (VR) share similarities, such as computer-generated elements, they differ in their approach. VR immerses users entirely in a synthetic environment, whereas AR integrates virtual elements into the real world. AR facilitates learning through constructivism and discovery, enhancing spatial understanding and social interaction (Alalwan et al., 2020). Milgram et al. (1994) conceptualized the reality-virtuality (RV) continuum, which ranges from purely real environments to purely virtual environments, providing a framework for understanding the relationship between the physical and virtual worlds (**Figure 1**).

As technology evolves, AR has gained popularity in recent years. However, its potential, especially in education, remains largely untapped (Alalwan et al., 2020). Even in explorations, Malaysia is still in the initial stages (Mat-jizat et al., 2016; Nizar et al., 2022), with a lack of competency to implement AR in educational settings (Alalwan et al., 2020). Initially, AR was predominantly associated with gaming and entertainment development, but research efforts have since investigated its potential in education. Local studies in Malaysia have demonstrated the implementation of AR across various fields of study, including Islamic studies, tourism, history, museums, and engineering, indicating its versatility across different disciplines. Given that students are accustomed to the digital era, they can readily adapt to AR concepts.

Despite the emerging benefits of AR, there are numerous challenges and limitations that influence students' adoption of AR in their learning process. The use of AR requires mobile devices with sufficient memory capacity to support the displayed content and small-sized screens may hinder the display of AR content (Ismayatim et al., 2019). In Malaysia, there is a scarcity of experts capable of developing and maintaining AR technology due to budget constraints (Chan et al., 2019). The shortage of MAR resources has prompted numerous researchers, both within Malaysia (Chan et al., 2019; Hashim et al., 2022; Norizan & Ghani, 2022) and globally (Kao & Ruan, 2022; Pinto et al., 2022; Videnovik et al., 2020) to develop their own MAR to meet specific user needs. In addition to the shortage of MAR resources in Malaysia, there exists a paucity of comprehensive information regarding the factors influencing MAR adoption (Benharal et al., 2022). Prior researchers have employed various technology adoption theories and models, such as the UTAUT (Pinto et al., 2022), the TPB (Ates & Garzon, 2023), and the TAM (Bourhim & Labti, 2022), to investigate these influencing factors. Nevertheless, despite the anticipated success of integrating MAR into education, persistent barriers hinder its widespread adoption in the learning process, reflecting students' concerns.

Research Theories

This study utilized the UTAUT proposed by Venkatesh et al. (2003) and the TAM proposed by Davis (1989) as underpinning theories to investigate the factors contributing to the acceptance of MAR through the implementation of the Mobile Augmented Reality Learning Cardiovascular (MARLCardio) application. The UTAUT model focuses on four constructs namely performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FCs) to determine users' intention and usage behavior in technology. Meanwhile, TAM considers perceived ease of use and perceived usefulness as the key factors explaining the acceptance of a technology. The constructs theorized in the UTAUT are related to those in TAM. For instance, perceived usefulness in TAM aligns with PE in UTAUT, while perceived ease of use corresponds to EE. Both TAM and UTAUT stress the importance of the ease and usefulness of technology in ensuring its acceptance. Regarding SI, the UTAUT model emphasizes the role of peer influence in encouraging technology adoption, while FCs address the importance of organizational and technical infrastructure to support technology use. As indicated in TAM, attitudes serve as a mediator variable that influences behavioral intention and indirectly affects individuals' perceptions of technology use. Behavioral intention is typically predictive of an individual's likelihood to engage in a proposed technology before actual use, while TAM defines actual behavior or acceptance as the outcome. In this study, behavioral intention was omitted since pre-service teachers were instructed to utilize and explore the MARLCardio application. Therefore, respondents had the chance to familiarize themselves with the application, rendering them exempt from being categorized under behavioral intention.

Furthermore, the expectation confirmation model (ECM) was employed to ascertain pre-service teachers' intention to continue using MAR. While UTAUT and TAM were designed to forecast the adoption of technologies, ECM takes a different approach by examining factors that influence an individual's intention to continue in using the technology. This model is significant in delineating continued usage intention and has been applied in various research studies (Ibili et al., 2019; Shao et al., 2019). An individual is more likely to continue using a technology if it meets their expectations and brings about self-satisfaction (Bhattacherjee, 2001). ECM underscores that initial usage of a technology does not guarantee automatic continuation; rather, sustained usage signifies the success of the technology.

These models have been utilized in various studies. For instance, a study conducted by Natasia et al. (2022) highlights the significant relationship between perceived usefulness and attitude. The advantages offered by the e-learning platform create a sense of satisfaction and comfort for teachers. However, their study was unable to establish a relationship between perceived ease of use and attitude, as some teachers found it challenging to understand its operation and required ongoing guidance while using it. Additionally, a study by Pinto et al. (2023) revealed that FCs are determinants of MAR usage. Meanwhile, Benharal et al. (2022) found that EE, PE, and SI positively impact user behavior toward technology. The varying outcomes of previous studies prompted researchers to investigate the contributing factors to MAR adoption through the implementation of MARLCardio. Therefore, this study extends UTAUT and TAM with additional constructs from ECM to explore pre-service teachers' acceptance and intention to continue using MAR.

Proposed Research Model

The proposed research model includes seven constructs, namely PE, EE, SI, FC, attitude (ATT), acceptance (ACC), and continuance intention (CI) (**Figure 2**). All the hypothesized paths will be tested using structural equation modelling (SEM) analysis to determine their relationships.

METHODOLOGY

This study utilized a quantitative research approach employing a cross-sectional survey design to gather data. The data collection process aimed to assess pre-service teachers' decisions to accept and their intention to continue using MAR after they explored the use of MARLCardio. MARLCardio is a self-developed application, and an experimental tool used in this study to exemplify features of MAR. Pre-service teachers could experience and explore features of MAR while using MARLCardio. It comes in two versions of AR-objects which are MARLCardio booklet and MARLCardio application. MARLCardio booklet was provided to each of the pre-service teachers to ensure that all had an opportunity to access the AR content in MARLCardio booklet. Pre-

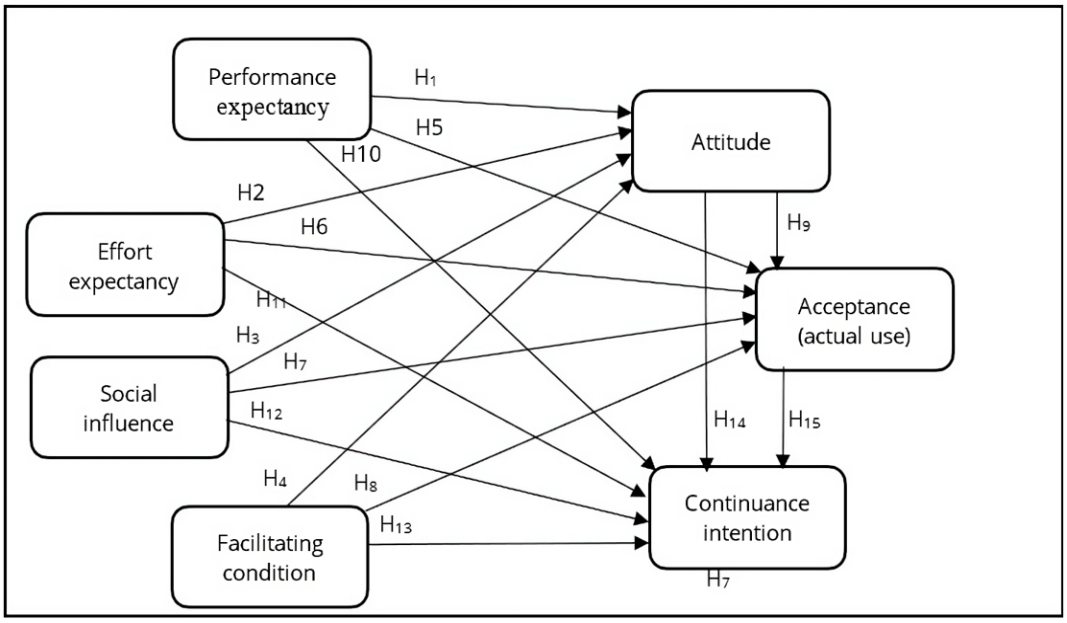

Figure 2. Proposed research model (Source: Authors)

service teachers can explore the AR content in MARLCardio booklet by scanning the marker image in the booklet using the MARLCardio application. The pre-service teachers were asked to download the MARLCardio application through Google Play or the IOS platform to assist them in exploring AR content in MARLCardio booklet by using their own mobile devices. Both the MARLCardio booklet and the MARLCardio application should be used in tandem to obtain meaningful AR experiences. The pre-service teachers can browse the content in the MARLCardio booklet and start scanning the AR image using the MARLCardio app to get more information on a particular topic. Responses from the pre-service teachers after using MARLCardio were tested to determine the factors influencing their decisions regarding the integration of MAR using a survey.

The survey was distributed among 445 pre-service teachers enrolled in education and teaching programs at three different public universities in Malaysia. All the participants were from three different academic disciplines: science, social sciences, and technical and vocational education and training (TVET). Prior to answering the survey, all participants were given a MARLCardio booklet and were asked to download the MARLCardio application to experience and explore the features of AR. The survey link was provided after they experienced the features of AR through MARLCardio. Data collected from the respondents were analyzed using SEM to determine the structural relationship of the hypothesized path.

University A contributed 157 participants (35.3%), followed by University B with 149 participants (33.5%), and University C with 139 participants (31.2%). The majority of participants were female, totaling 381 (85.6%), while the remaining 14.4% were male. In terms of prior experience with AR, 208 participants (46.7%) indicated that they had prior experience before exploring MARLCardio, while 237 participants (53.3%) reported no prior experience. This prior experience with AR offers valuable insights into participants' expectations when using MARLCardio.

Instrument

This study developed instruments to assess pre-service teachers' attitude, acceptance, and their intention to continue using MAR. All the questions were adapted from UTAUT2, TAM, and ECM questionnaires. The instrument utilizes a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The instrument consists of seven items for PE, EE, SI, and FCs, eight items for ATT and ACC, and four items for CI. PE reflects pre-service teachers belief using MAR would enhance their learning performance by improving their understanding of the lesson. EE signifies the degree to which pre-service teachers believe they will experience minimal effort when utilizing MAR in their learning endeavors. SI encompasses the viewpoints of peers and educators who can persuade pre-service teachers about the significance of incorporating MAR into the learning process. FC reflects the extent to which pre-service teachers perceive the technical support, assistance from mobile

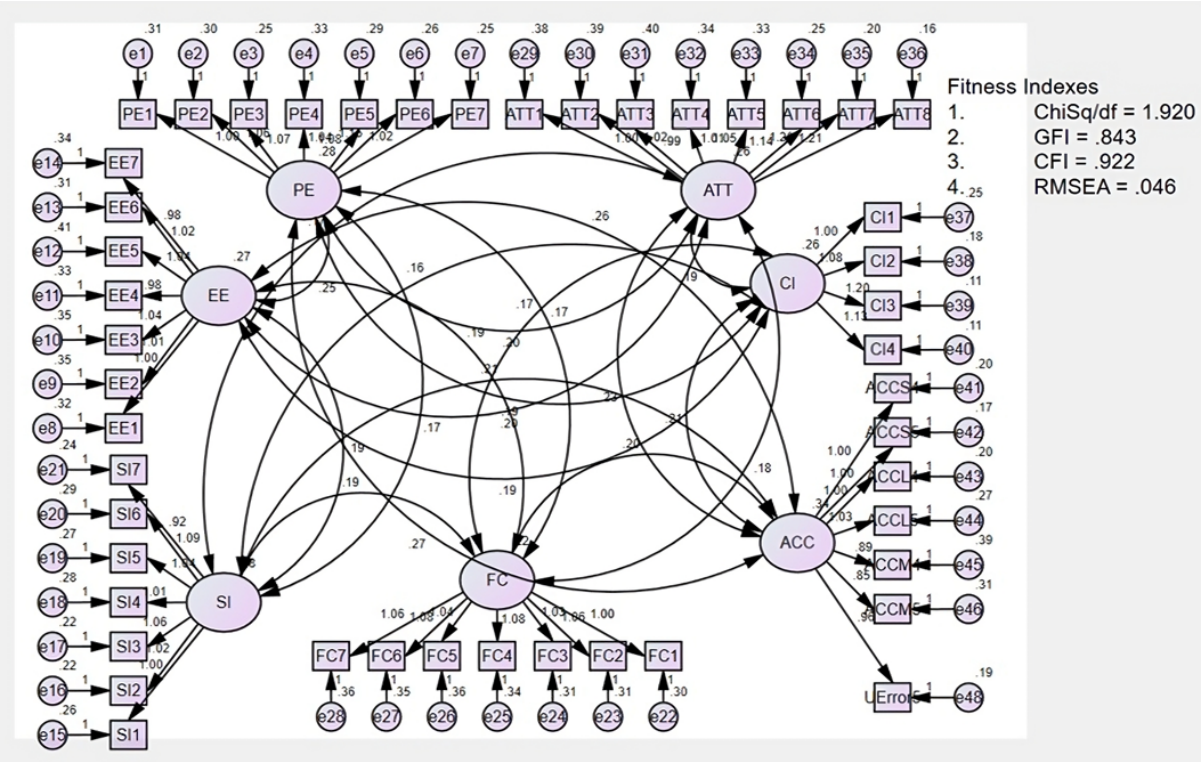

Figure 3. Measurement model (Source: Authors)

devices, and Internet connectivity as facilitating the utilization of MAR in their learning process. ATT denotes the extent to which pre-service teachers hold a positive or negative attitude towards MAR when utilizing MARLCardio. A positive attitude is evident when pre-service teachers perceive MAR as making the learning process more engaging, enjoyable, and providing opportunities to enhance learning experiences. ACC denotes the degree to which pre-service teachers decide to integrate MAR into their learning process and CI pertains to the level of intention among pre-service teachers to persist in using MAR within their learning process. The CI construct holds significance in comprehending pre-service teachers' decisions regarding the continuation or discontinuation of MAR usage in the future, which is crucial for sustaining MAR stability over the long term.

Measurement Model

A measurement model was conducted to determine the correlation between all the variables simultaneously. After analyzing the model, one item from ACC (no 7) was excluded due to the low value of factor loading (< 0.3). The fitness index for measurement model as presented in **Figure 3**. All values for ChiSq/df (1.920), GFI (0.843), CFI (0.922), and RMSEA (0.046) achieve the specified threshold value. Taken together, these findings suggest that the measurement model demonstrates exceptional quality (Awang, 2012; Kline, 2005).

Cronbach's alpha, composite reliability, and AVE were calculated to evaluate the internal consistency of the constructed items in each variable (**Table 1**). The Cronbach's alpha value for all variables meets the threshold of 0.7, indicating an acceptable level of reliability. Additionally, values exceeding 0.8 suggest a very good level of reliability, although values surpassing 0.95 are not recommended due to item redundancy (Hulin et al., 2001). The composite reliability value is deemed acceptable if it exceeds 0.7 for all variables in the structural model, which is the case according to our analysis. In the structural model, all values are within the acceptable range. The AVE values in the structural model range from 0.424 to 0.664. According to Fornell and Larcker, if the AVE is below 0.5 but the composite reliability exceeds 0.6, the convergent validity of the construct is still considered adequate and acceptable. Although the AVE values for EE and FCs are below 0.5, their validity remains acceptable as the composite reliability exceeds 0.6 (EE = 0.851, FC = 0.837). Overall, all AVE values are within acceptable ranges, reflecting the reliability and validity of the results.

Table 1. Cronbach's alpha, composite reliability, and AVE

Variable	Cronbach's alpha	Composite reliability	AVE
Performance expectancy	0.885	0.885	0.524
Effort expectancy	0.850	0.851	0.449
Social influence	0.890	0.891	0.539
Facilitating condition	0.837	0.837	0.424
Attitude	0.888	0.890	0.505
Acceptance	0.899	0.901	0.568
Continuance intention	0.884	0.887	0.664

Table 2. Correlation analysis

	EE	SI	FC	ATT	ACC	CI
PE	.893***	.621***	.695***	.758***	.862***	.701***
EE		.695***	.764***	.759***	.855***	.699***
SI			.766***	.630***	.665***	.589***
FC				.741***	.718***	.700***
ATT					.781***	.745***
ACC						.715***

A correlation analysis was conducted prior to structural model analysis in order to determine the relationship between all the designed paths. The correlation analysis was presented in **Table 2** demonstrates all the variables were positively significant (p = 0.000) to each other's. The correlation value in between 0.59 (SI and CI) and 0.893 (PE and EE).

FINDING

Structural Model

To analyze the contributing factors towards the acceptance and intention to continue using MAR, all the hypothesized paths were analyzed using SEM. **Figure 4** presents the structural model fitness index. Good model fit is shown from the direct effects among the hypothesized paths. Each of the values for RMSEA (0.064), GFI (0.801), CFI (0.857), ChiSq/df (2.838), and GFI (0.801) fulfils the specified threshold. This finding indicated that the exceptional quality for the structural model (Awang, 2012; Kline, 2005).

Results of Hypotheses Path

The statistical output in **Table 3** 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. If the p-value is 0.05 or less, the result is considered as significant.

Pre-service teachers' attitude toward the usage of MAR application were tested based on four hypotheses. There was a positive relationship between Performance and ATT with β = 0.34 and p-value is 0.000. Hence, hypothesis 1 was accepted. EE and ATT demonstrated a significant relationship, with β = 0.29 and a p-value of 0.000. As a result, hypothesis 2 was confirmed. There is no relationship between SI and ATT with β = 0.06 and p-value = 0.108. In consequence, hypothesis 3 was rejected. A direct relationship was observed between FC and ATT, with β = 0.44 and p-value is 0.000. Thus, hypothesis 4 was accepted.

Five hypotheses were tested to determine factors that influence pre-service teachers' acceptance of MAR. PE and ACC exhibited a positive relationship, with β = 0.42 and p-value of 0.000. Accordingly, hypothesis 5 was validated. The relationship between EE and ACC was significant with β=0.32 and p-value is 0.000. Thus, hypothesis 6 was accepted. The hypothesized path between SI and ACC is positively significant with β = 0.15 and p-value is 0.000. Hence, hypothesis 7 was accepted. There appears to be no significant correlation between FC and ACC, with β = 0.07 and p-value of 0.244. As a result, hypothesis 8 was rejected. There was a positive relationship between ATT and ACC with β = 0.24 and p-value is 0.004. Hence, H9 was accepted.

There are six hypotheses were tested to determine factors that influence pre-service teachers' CI to use MAR. There was a positive relationship between PE and CI with β = 0.18 and p-value is 0.009. Hence, hypothesis 10 was accepted. There is no relationship between EE and CI with β = 0.08 and p-value = 0.182. In

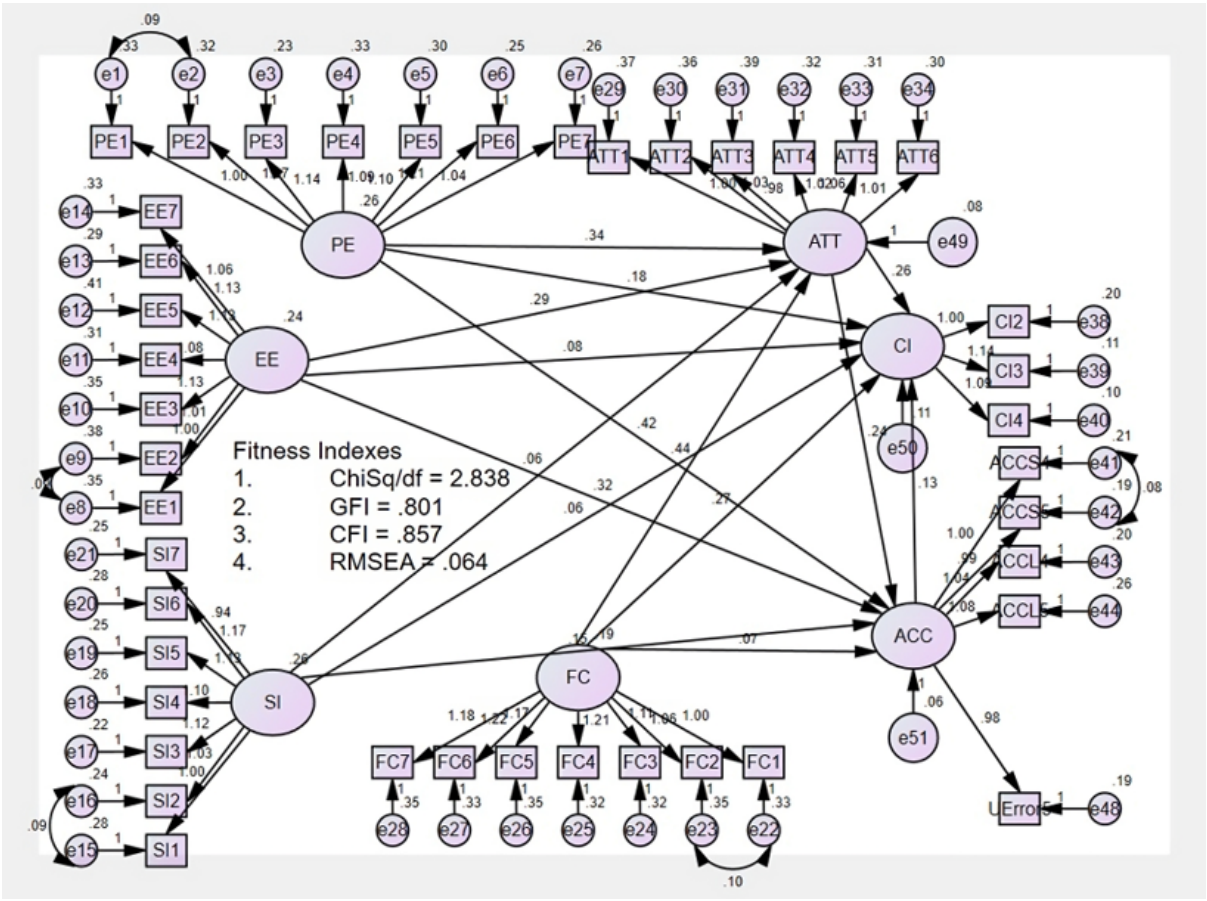

Figure 4. Structural model (Source: Authors)

Table 3. Results of hypotheses path

Hypothesis	Independent variable	Dependent variable	Estimate	p-value	Result
H_1	PE	ATT	0.34	***	Accepted
H_2	EE		0.29	***	Accepted
H_3	SI		0.06	.108	Rejected
H_4	FC		0.44	***	Accepted
H_5	PE	ACC	0.42	***	Accepted
H_6	EE		0.32	***	Accepted
H_7	SI		0.15	***	Accepted
H_8	FC		0.07	.244	Rejected
H_9	ATT		0.24	.004	Accepted
H_{10}	PE	CI	0.18	.009	Accepted
H_{11}	EE		0.08	.182	Rejected
H_{12}	SI		0.06	.135	Accepted
H_{13}	FC		0.27	***	Accepted
H_{14}	ATT		0.26	.008	Accepted
H_{15}	ACC		0.13	.213	Rejected

consequence, hypothesis 11 was rejected. The relationship between SI and CI was significant with β = 0.06 and p-value is 0.135. Thus, hypothesis 12 was accepted. The hypothesized path between FC and CI is positively significant with β = 0.27 and p-value is 0.000. Hence, hypothesis 13 was accepted. ATT and CI demonstrated a significant relationship, with β = 0.26 and a p-value of 0.008. As a result, hypothesis 14 was confirmed. There is no relationship between ACC and CI with β = 0.13 and p-value = 0.213. In consequence, hypothesis 15 was rejected.

In summary, the hypothesized path for 11 out of 15 hypotheses demonstrated significant relationship of the designed paths. Meanwhile, the rest of hypotheses failed to validate the significant relationship between independent and dependent variables.

DISCUSSION

In this study, MARLCardio serves as a MAR technology to determine its contribution that influences pre-service teachers' attitude, acceptance and thus reflecting their continuance intention in using MAR. Findings from this study help to explain how pre-service teachers' behaviors toward the use of MAR based on the adaptation of UTAUT, TAM and ECM models. Respondents were asked about their belief in PE, EE, SI, and FC towards their ATT in their use of MAR.

Data indicated that the use of MAR is able to enhance pre-service teacher learning performance, and they feel that it is easier in using the application. Their adaptation of using MAR could be related to their being categorized under generation Z, who have been shaped by the digital age. Data in this study supports their positive attitude towards the use of MAR. It is reasonable to believe that PE will raise pre-service teachers' trust in the application's capacity to fulfil the required functions, hence directly increasing their likelihood of using and continuing to use MAR. Pre-service teachers might find the benefits of using MAR and encourage them to continue its usage to enhance learning experience, personalized learning paths, motivation, and flexibility in accessibility (Alotaibi, 2023). MAR offers an immersive and interactive learning environment, making educational content more engaging and memorable. Students benefit from visualizing complex concepts in 3D, leading to better understanding and retention of information. In addition, the interactive nature of MAR captures pre-service teachers' interest and motivation, encouraging active participation in the learning process (Han et al., 2022). This heightened engagement leads to increased motivation to learn and explore learning topics. Overall, the advantages of MAR enable pre-service teachers to engage with educational content in innovative ways, fostering continued usage and exploration of its potential in enhancing learning outcomes.

In designing MAR, the most important aspect is to make the application pleasant to use and able to provide moments of enjoyment (Pinto et al., 2022). EE instills confidence in the user's ability to successfully explore the application and derive satisfaction. According to TAM, those who have no prior experience with similar applications will be more concerned with simplicity of use. This is due to the fact that 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 the extent to which 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. EE holds significance in determining acceptance and the intention to continue using MAR due to its direct impact on the perceived ease of use. When individuals find it easy and convenient to use, they are more likely to embrace it and continue its usage over time (Alotaibi, 2023). Lower perceived effort translates into smoother interactions with the technology, reducing barriers to adoption and encouraging sustained engagement. Therefore, ensuring that MAR platforms and applications are user-friendly and require minimal effort can significantly influence both initial acceptance and ongoing intention to utilize this technology.

A plethora of empirical analyses, over the years, implemented on a varying number of IS/IT domains and in a wide variety of settings have revealed that the SI aspect is an imperative and influential indicator in influencing individuals' behavioral patterns and intentions in technology adoption domains (Faqih & Jaradat, 2021). In this study, SI does not show any contribution in determining pre-service teachers' attitude but is capable of directly influencing pre-service teachers' in accepting the use of MAR. A potential explanation might lie in the contrasting perceptions of the advantages and drawbacks linked with MAR. People might be more receptive to accepting MAR because they see potential benefits such as entertainment, convenience, or enhanced experiences. These positive aspects could be highlighted and reinforced by those around them, leading to acceptance. However, fostering a positive attitude toward MAR might require more personal experiences or direct exposure to its advantages. Positive attitudes often stem from firsthand encounters that demonstrate its utility, creativity, or practicality. If the people they are surrounded by haven't had these experiences or haven't effectively communicated them, it might hinder the development of pre-service teachers' positive attitude toward MAR, despite its acceptance. Additionally, perceptions of privacy, security, or unfamiliarity with the technology could play a role. Concerns about data privacy or security breaches might overshadow the benefits they gain, making it harder for individuals to develop a positive attitude.

In addition, FC is able to enhance students' positive attitude but does not reflect pre-service teachers' acceptance. In the realm of MAR usage, FCs encompass various factors that facilitate or hinder individuals' ability to utilize MAR effectively (Pinto et al., 2022). This condition points to the users' awareness and perceptions of the existence of the essential level of resources such as knowledge, training, technical infrastructure, and services required to deliver the desired support for implementing AR systems and methods successfully, productively and effortlessly within the educational perspective (Faqih & Jaradat, 2021). In addition, factors of internet connectivity, device compatibility and user interface design of the MAR also become a concern among pre-service teachers. Although FC does not show a direct influence toward pre-service teachers' acceptance, with a positive attitude they still can influence their intention to continue using MAR. A possible reason for this is that initial perception and willingness to adopt MAR, while intention to continue suggests the likelihood of sustained use. It's possible that the facilitation condition didn't strongly influence their initial acceptance, but it did impact their determination to keep using MAR after some exposure or experience with it. Pre-service teachers might require time and experience with MAR to fully appreciate its benefits and ease of use. The FC able to accelerate pre-service teachers' learning process or provided necessary guidance, making them more inclined to continue the usage as they become more proficient with the technology. Over time, as pre-service teachers interact more with MAR, they might realize its practical value in their learning process. The FC might have aided in showcasing this utility, leading to a stronger intention to continue use despite initial reservations.

In summary, pre-service teachers agree that FC play a crucial role in shaping pre-service teachers' positive attitude and influencing their intention to continue using MAR. FCs act as strong support assistance to simplify the process of adopting MAR by removing barriers and providing essential elements. Meanwhile, PE plays a major role in ensuring pre-service teachers' acceptance in using MAR in their learning process. It shapes pre-service teachers' beliefs about how well MAR can assist them in accomplishing their learning objectives, directly impacting their motivation to utilize and sustain the use of MAR.

CONCLUSION AND RECOMMENDATION

The results showed that eleven out of fifteen hypotheses (H1, H2, H4, H5, H6, H7, H9, H10, H12, H13, and H14) were accepted. The remaining four hypotheses (H3, H8, H11, and H15) failed to prove a significant path among the variables. From these results, it can be concluded that the acceptance of MAR is fairly good and thus reflects the pre-service teachers' intention to continue using MAR in the learning process. Although most of the pre-service teachers indicated that the use of MAR is easy and beneficial for them, intensive training and facilities require attention to provide meaningful experiences for pre-service teachers.

To broaden the understanding of pre-service teachers' acceptance and their intention to continue using MAR, future researchers are suggested to explore more potential variables. Potential variables such as perceived enjoyment, motivation and moderator variables (age, experience, gender, voluntarism) as projected in UTAUT model to obtain a broader understanding of MAR. Furthermore, another suggested direction for future research in sustaining the utilization of MAR entails investigating the influence of personalized learning experiences within AR applications. This includes assessing how adapting content and interactions to align with pre-service teachers' preferences and learning styles can enhance their engagement and foster long-term usage.

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Data availability: Data generated or analyzed during this study are available from the authors on request.

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