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Research Article

Augmented Reality (AR) as an Enhancement Teaching Tool: Are Educators Ready for It?

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Abstract

The rapid technological development and revolution have transformed the education field, promoting the betterment of learning and teaching quality. Augmented Reality (AR) is becoming increasingly popular for its ability to help educators to create an engaging and creative method of teaching. The increasing use of technology has piqued researchers' interests in studying its efficiency. Following this observation, this study aims to explore educators' readiness in embracing AR as an enhancement teaching tool in the future. This study employed a quantitative methodology and collected 223 respondents' data from five private universities in Malaysia. The data was analysed using the Partial Least Squares – Structural Equation Modelling (PLS-SEM) software. The results demonstrated that there were significant relationships between educators' innovation towards the intention to adopt AR moderated by perceived usefulness (PU) and perceived ease of use (PEU). This study provides some insightful AR applications in the education industry, which is in line with the Industrial Revolution 4.0 theme. It successfully identifies the importance of motivating educators and students in embracing AR as an enhancement learning tool, providing a valuable discussion for the government, learning institutions, and educators on the implementation of AR in Malaysia.

Keywords: augmented reality, educator innovation, technology acceptance model, perceived ease of use, perceived usefulness

INTRODUCTION

The significant progress of current technology has made an impact on the teaching and learning process. Recent years have seen that digital materials and e-learning tools being heavily incorporated in the education industry. Its practicality is further demonstrated during the disruptive period caused by the COVID-19 pandemic – since schools and universities are not able to function normally, educators switched to digital teaching and learning platform to continue teaching. Such a significant impact increases educators' awareness of the need to adopt technology in their teaching and learning process.

The incorporation of technology in education has been observed to have positive and construction impacts, particularly when combined with adequate pedagogical foundations. Some researches agree that technology-embedded education encourages more innovative and interactive forms of teaching and learning process, increasing students' motivations (Bursali & Yilmaz, 2019; Ebenezer, Kaya, & Kassab, 2018; Fuchsova & Korenova, 2019; Kaewunruen, 2019; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011), while also increasing students' efficacy of learning experiences in the actual world (Weng et al., 2016).

Furthermore, the integration of technology has transformed the learning environment into a more engaging, interactive, authentic, and joyful environment (Cheng, 2018; Gan & Balakrishnan, 2018). Various technologies such as multimedia, internet, mobile devices, Internet of Things (IoT), virtual reality, and AR are integrated into the education system (Kiryakova, Angelova, & Yordanova, 2018). The AR was pioneered by Sutherland (1968) – he developed and introduced the AR interface, which used the head-mounted display to depict 3D graphics. Azuma (1997) has further surveyed on the features of Augmented Reality technology and the tradeoffs between video blending and the optical interventions which served as starting point for AR research. Afterwards, numerous conferences on AR were held, such as the International Symposium on Mixed Reality, the International Workshop and Symposium on Augmented Reality, and the Designing Augmented Reality Environments Workshop.

Real objects are an integral part of AR environments, but a virtual design of some of these environments are also needed for its development. This technology does not require detailed 3D models as it has a significant representation of reality, allowing its users to engage directly and spontaneously with virtual objects through the manipulation of actual objects without the use of costly and sophisticated hardware components (Wojciechowski et al., 2004). Compared to virtual reality, AR users are able to have direct face-to-face contact with each other. Since recent studies tend to focus on virtual reality, the potential of AR as an enhancement teaching tool is yet to be discussed.

The AR technology allows users to experience the visualisation of virtual objects that coexists in the real world (Azuma, 1997), making it a suitable interactive tool to grab students' attention in their learning process (Ma et al., 2016) as it can be used for a lesson such as the three-dimensional anatomy of animals and humans (Kiryakova et al., 2018). Lin, Chen, and Chang (2015) discover that AR-assisted teaching proposal demonstrates the feasibility of AR usage and is highly recommended to be incorporated in teaching materials as it can increase students' learning autonomy. The technology is also able to incorporate elements such as connectivity and activities that are consistent with the learners' needs (Kiryakova et al., 2018), subsequently increasing their motivation.

LITERATURE REVIEW

Studies pertaining to AR technology discovers that it offers a range of advantages, especially in the education field (Garzón, Pavón, & Baldiris, 2019; Hockly, 2019; Kiryakova et al., 2018; Masmuzidin & Aziz, 2018; Richardson, 2016; Yip et al., 2019). Nonetheless, its application as an enhancement teaching tool is still yet to be discussed adequately. It has demonstrated its ability in other fields, such as providing on-site experiences to reduce the information gap about the real world and improving efficiency and productivity in manufacturing, training, and product development (Porter & Heppelmann, 2017). It has also been used to improve the education systems for learners and staffs in academic and corporate settings (Richardson, 2016; Lee, 2012), and to provide immersive and student-centred learning for medical students on their anatomical education (Kugelmann et al., 2018; Moro et al., 2017). Furthermore, Karakus, Ersozlu, and Clark (2019) pointed out AR technology enables the learner to build team spirit among other learners for knowledge gain purposes.

The implementation of AR is typically perceived as costly (Garzón et al., 2019), particularly if it is to be integrated into the education sector. Nonetheless, it has been implemented through the integration of digital technology and advanced devices in an effort to improve the education setting (Ozdemir, 2018). The technology's instructional value can be based on both its application and as a notion in the teaching and learning environments (Wu et al., 2013), making the environments more engaging and enjoyable for the students, ultimately increasing their interest and motivation (Acosta et al., 2019; Chang et al., 2020; Kiryakova et al., 2018).

Furthermore, Garzón and Acevedo (2019) assess the difference between the use of AR and other pedagogical tools and discover that learners are better at exploring and understanding the concepts when AR is adopted and implemented as the medium of delivery. Several studies corroborate this notion (Abrar et al., 2019; Garzón & Acevedo, 2019; Tekedere & Göker, 2016), while one claiming that AR helps educators to deliver the contents more efficiently in terms of physical, cognitive, and contextual views, enabling students to comprehend the abstract concepts betted (Bujak et al., 2013). Addition to the point above, Hiranyachattada and Kusirirat (2020) also proven that mobile AR effectively applied as a teaching tool for demonstrating the 3D rendering work concept to the students in a university in Thailand.

The AR technology's core benefits in education are assisting practical skills, spatial ability, and conceptual understanding, in addition to allowing inquiry-based activities (Cheng & Tsai, 2013). Furthermore, the technology helps to reduce the exorbitant cost of teaching resources such as laboratory equipment and supplies, in addition to providing a safe environment for unskilled learners to explore the potentially hazardous environment. Following these advantages of AR, this study aims to analyse and discover educators' readiness in adopting the AR technology for teaching purposes.

Augmented Reality in Education

Past studies that analyse the potential advantages of AR and its possible technology design to be implemented in learning, such as Bujak et al. (2013), claim that the AR technology has great potential to be positively implemented in the education field and to increase educators' teaching competency. The technology is able to transform dull and monotonous learning instructions into an exciting and engaging environment (Ibáñez et al., 2014; Kim et al., 2018; Lu & Liu, 2015; Savela et al., 2020), eventually improving the students' performances (Akçayır & Akçayır, 2017; Squires, 2017; Liu & Tsai, 2013). Muñoz Cristóbal et al. (2015) support these researches while explaining that AR improves student engagement within due course. Huang, Li, and Fong (2016) observe that stakeholders – class teachers, principal, ICT teachers, and parents – in Hong Kong display a positive response towards the emerging use of technology in the teaching and learning process. Educators' attitude towards AR is pertinent in the implementation of AR as a teaching tool.

The intention and readiness are mainly affected by PU (Pikkarainen, Pikkarainen, & Karjaluoto, 2004), which inspires users to take on progressive and user-friendly technology that delivers more freedom. As demonstrated by Hassanzadeh, Kanaani, and Elahi (2012), technical intention influence the use of online learning in Iranian universities. Motaghian, Hassanzadeh, and Moghadam (2013) further support the study by proving that PEU, PU, and system quality can influence instructors' intention to employ web-based learning systems in two e-learning pioneer universities in Iran.

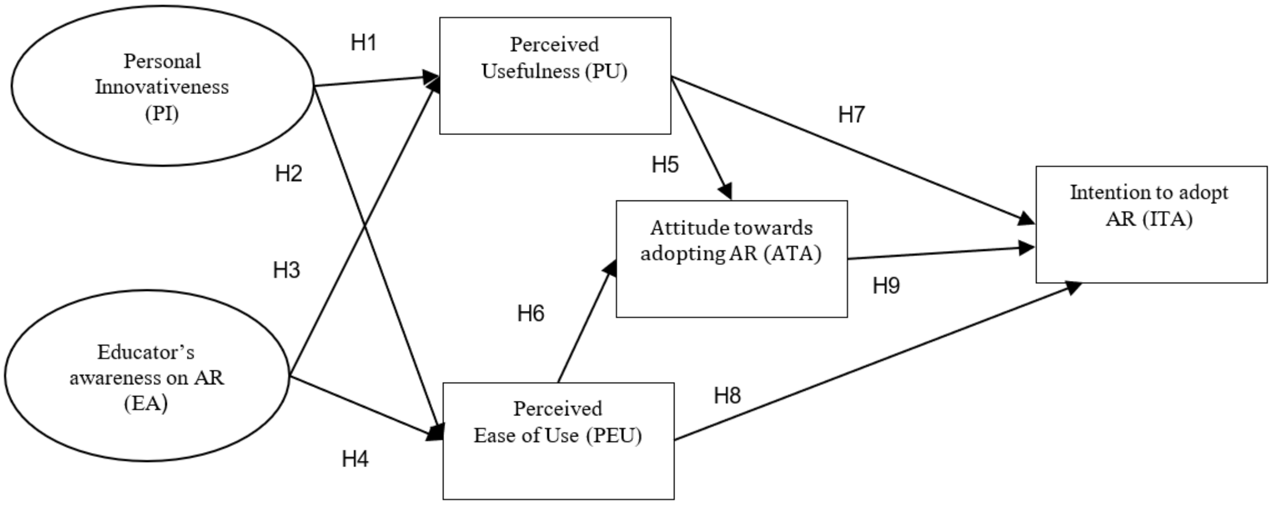
In terms of attitude, acceptance of new technologies varies among different individuals – they might adapt or refuse new technologies. Therefore, it is believed that educators' attitudes towards new technologies influence the effectiveness of the product application in the teaching and learning processes. Highlighting the educators' attitudes towards AR applications is critical in assessing the possibility of successful implementation of AR technology in the education sector. It is worth noting that there is a lack of studies on educators' attitudes towards AR applications.

Technology Acceptance Model (TAM)

In this study, the TAM (Davis, 1989) was employed to examine the educators' readiness in adopting AR as an enhancement teaching tool. The model states that the PU variable – an individual's belief that a technology system will increase performances – is determined by PEU – an individual's belief on the technology system's ease of use, operation, and maintenance (Davis, 1989). The model also assesses the acceptance of a technology-based on a user's attitude and intention to use the technology, which are determined by their PU and PEU of the technology. The PU and PEU can be influenced by external factors – the factors considered in this study are personal innovation (PI) and educator's awareness (EA) on AR. The PI pertains to the educator's existing knowledge on the technological related devices, while Educator's Innovation on AR pertains to the information related to AR that is accessible to the educators before this study. The TAM is used to examine if the educator believes that the technology will generate positive or negative impacts on the teaching and learning process.

The TAM has been used in previous studies (Fathema, Shannon, & Ross, 2015; López Belmonte et al., 2019; Scherer, Siddiq, & Tondeur, 2019; Zaineldeen, Hongbo, & Hassan, 2020), with some demonstrate the factors that positively influence an individual's technology acceptance (Huang et al., 2020; Siyam, 2019; Teeroovengadum, Heeraman, & Jugurnath, 2017). Some studies claim that the original TAM lack several attributes that may influence computer acceptance (Siyam, 2019; Zaineldeen et al., 2020). Meanwhile, Alalwan et al., (2018), Al-Daihani (2016), and Lee, Kim, and Choi (2019) prove the significant positive influence between the perceived enjoyment on using the technology system and suggested the characteristic be included in the TAM.

Theoretical Model



METHODOLOGY

This quantitative study employed a questionnaire survey that was distributed to educators from five private universities in Malaysia upon approval from the universities. After filtering 350 questionnaires that were given to respondents, 223 valid questionnaires were computed into the Statistical Packages for Social Sciences (SPSS) software version 23.0 to generate a descriptive analysis of the respondents' profile. The data were also analysed using the Partial Least Squares – Structural Equation Modelling (PLS-SEM) software version 3.0 to generate the inferential analysis.

The questionnaire was comprised of two sections. Section A pertained to demographic questions such as gender, ethnicity, age, marital status, and highest educational level, while Section B was made of items to be scaled using the 5-points Likert scale ranging from 1 representing "strongly disagree" to 5 representing "strongly agree". All measurement items are presented in **Table 1**.

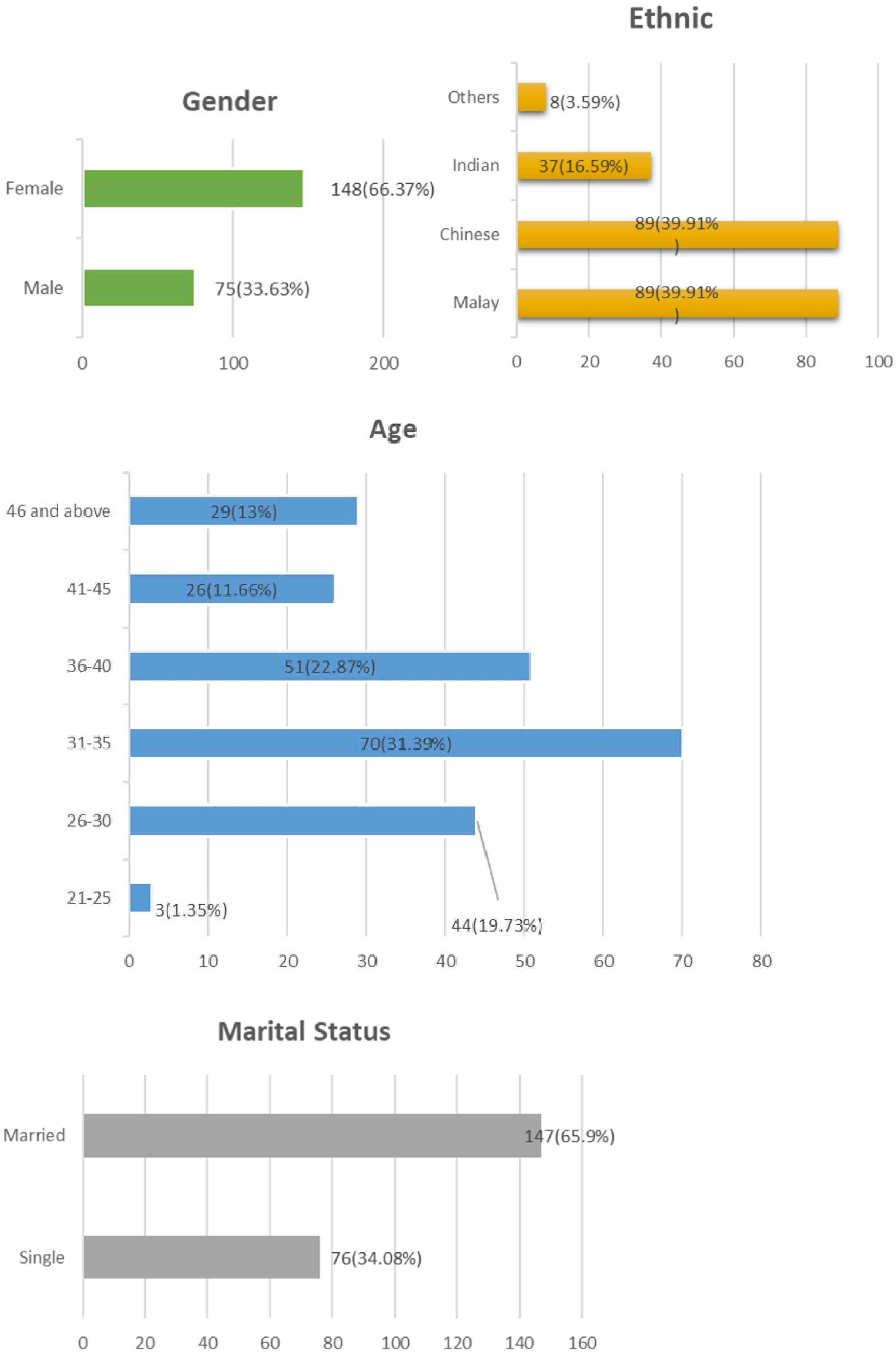
Table 1. Measurement items

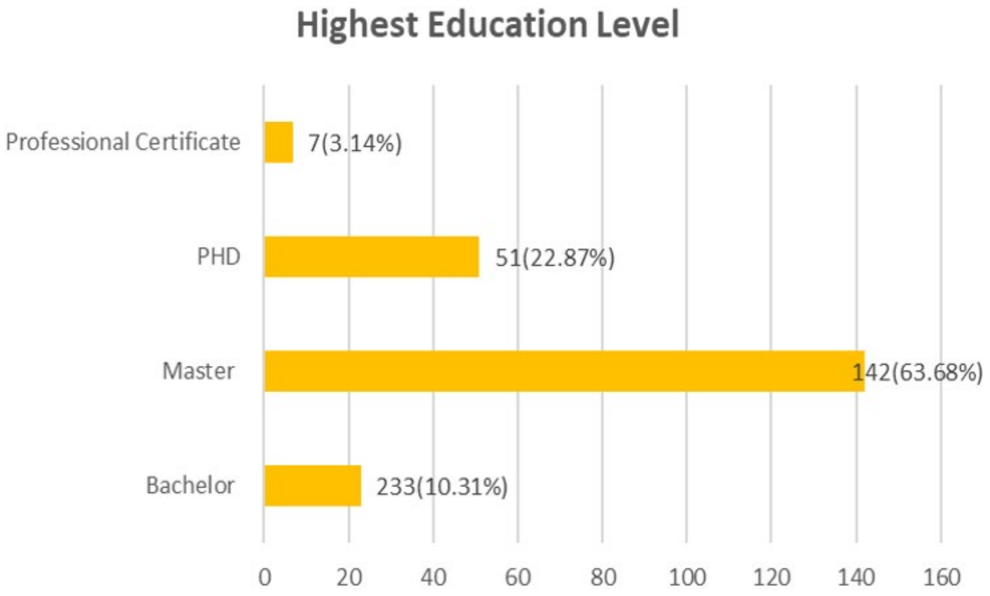
Constructs	Items	Descriptions
Awareness of AR	AW1	I am aware that AR can be used as teaching aids.
	AW2	I know that AR enables us to see the image using AR applications.
	AW3	I know that AR can be applied in various fields.
Educator's innovative	EI1	I enjoy teaching my students via the digital learning platform. (i.e: Kahoot, Blendspace).
	EI2	I am up-to-date with the new digital technology in education.
	EI3	I feel confident with digital technology in education.
	EI5	I often search for better teaching aids.
Perceived usefulness	PU1	I believe that AR will enhance my teaching preparation effectively.
	PU2	Being able to use AR as my teaching aid will be useful.
	PU3	Using AR in my teaching will reduce my time in repeating explanations to the students.
	PU4	I can effectively manage my teaching with AR designing.
	PU5	AR will help me explain difficult concepts.
Perceived ease of use	PEU1	I feel comfortable to explore AR in my teaching as a teaching tool.
	PEU2	I feel convenient in using AR as my teaching aid.
	PEU3	I have fun using AR as my teaching aid.
	PEU4	I feel that it is easy to use AR in my teaching.
	PEU5	It will be easy for me to be skillful in IT when using AR.
	PEU6	My interaction with AR will be clearer.
Attitude to adopt AR	AT1	I like the idea of using AR as an enhancement for teaching aid.
	AT2	I think using AR in my teaching plan is a good idea.
	AT3	I think AR enables my students to enjoy the reality of the images.
	AT4	I feel good with AR designing in my teaching plan.
	AT5	I am able to accept AR as my teaching aid.
	AT6	I feel good about adopting AR in my teaching.
Intention to adopt AR	IN1	I intend to use AR as my teaching aid.
	IN2	I would like to use AR in my daily teaching.
	IN3	I am interested to include AR in my teaching plan.
	IN4	I will apply AR in my teaching materials.
	IN5	I will use AR soon.
	IN6	I would recommend my colleague to use AR as their teaching aid.

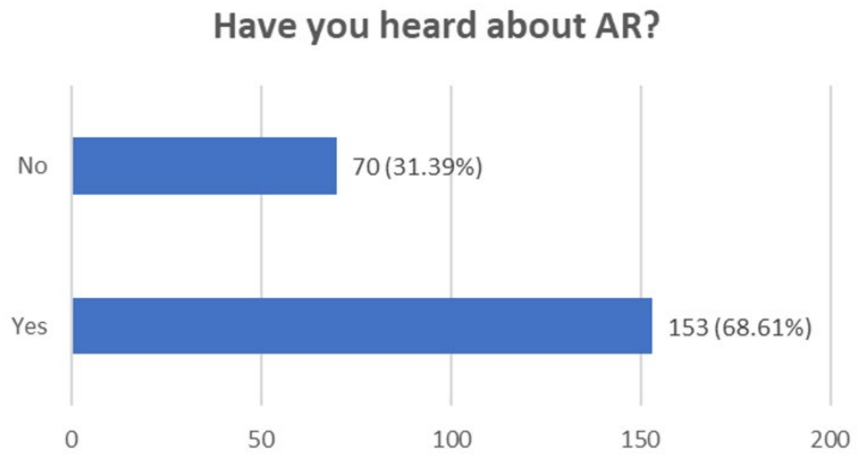
RESULTS

Descriptive Analysis

As presented in figures below, 66.37% of the respondents were female with ages ranging from 31 to 35 years old. Among the respondents, 147 participants (65.92%) were married. In addition, 39.91% of the respondents were Malay, another 39.91% were Chinese, and 16.59% were Indians. Most participants (63.68%) possessed a Master's degree, while 22.87% possessed a Doctorate. Over 65% of the respondents were aware of the AR technology before this study.


Gender
Female
148(66.37%)
Male
75(33.63%)
0
100
200
Ethnic
Others
8(3.59%)
Indian
37(16.59%)
Chinese
89(39.91%
)
Malay
89(39.91%
)
0
20
40
60
80
100
Age
46 and above
29(13%)
41-45
26(11.66%)
36-40
51(22.87%)
31-35
70(31.39%)
26-30
44(19.73%)
21-25
3(1.35%)
0
10
20
30
40
50
60
70
80
Marital Status
Married
147(65.9%)
Single
76(34.08%)
0
20
40
60
80
100
120
140
160





Measurement Model

Convergent validity

The latent constructs' convergent validity was analysed using standardised factor loading (> 0.6), extraction of the average variance (AVE > 0.5), and composition reliability (CR > 0.7) (Hair et al., 2010). **Table 2** shows that the value of factor loading for all items (attitude to adopt AR, awareness on AR, educator's innovation, intention to adopt AR, PEU, and PU) were over 0.7 of the recommended value (Chin, Gopal, & Salisbury, 1997). The reliability values for each construct ranged from 0.801 to 0.931 were fulfilled by the composite reliability threshold value of 0.7 (Hair et al., 2010), while the Average Variance Extracted (AVE) for each of the constructs ranged from 0.638 to 0.744 were above the threshold of 0.5 (Hair et al., 2010).

Table 2. Factor loading and reliability

Variable	Items	Loading	Composite Reliability	Average Variance Extracted	Cronbach Alpha
Attitude to adopt AR	AT1	0.860	0.910	0.692	0.931
	AT2	0.869			
	AT3	0.750			
	AT4	0.851			
	AT5	0.822			
	AT6	0.831			
Awareness of AR	AW1	0.831	0.807	0.721	0.886
	AW2	0.821			
	AW3	0.893			
Educator's innovation	EI1	0.818	0.801	0.715	0.883
	EI2	0.879			
	EI3	0.838			
Intention to adopt AR	IN1	0.879	0.931	0.744	0.946
	IN2	0.808			
	IN3	0.906			
	IN4	0.909			
	IN5	0.871			
	IN6	0.797			
Perceived ease of use	PEU1	0.879	0.896	0.660	0.921
	PEU2	0.808			
	PEU3	0.906			
	PEU4	0.909			
	PEU5	0.871			
	PEU6	0.797			
Perceived usefulness	PU1	0.866	0.857	0.638	0.897
	PU2	0.888			
	PU3	0.720			
	PU4	0.734			
	PU5	0.771			

Table 3. Discriminant validity

Variable	ATA	AW	ITA	PEU	EI	PU
Attitude to adopt AR (ATA)	0.832					
Awareness on AR (AW)	0.574	0.849				
Intention to adopt AR (ITA)	0.765	0.467	0.863			
Perceived ease of use (PEU)	0.677	0.482	0.726	0.812		
Educator's innovation (EI)	0.500	0.386	0.504	0.569	0.846	
Perceived usefulness (PU)	0.669	0.528	0.602	0.654	0.438	0.799

Discriminant validity

Discriminant validity is an analysis to determine the correlation between the variables to ensure low correlations between variables by using heterotrait-monotrait (HTMT). As shown in **Table 3**, the value of discriminant validity for each construct was less than the square root of the average variance extracted and passed the HTMT threshold.

After the composite reliability and the discriminant validity were confirmed, bootstrapping was tested using 5000 resamplings to access the significance of the path coefficients. The results are presented in **Table 4**. Meanwhile, the *t*-value can be compared with a critical value for significance levels of 5 per cent or the probability of error is 1.96 (two-tailed test). All the results were supported except for the PU towards ITA.

Table 4. Summary of the structural model

Variable	Hypothesis	Path coefficient	t-value	Results
Educator's innovation -> Perceived usefulness	H1	0.275	4.440***	Supported
Educator's innovation -> Perceived ease of use	H2	0.450	6.300***	Supported
Awareness of AR -> Perceived usefulness	H3	0.422	6.718***	Supported
Awareness on AR -> Perceived ease of use	H4	0.309	5.086***	Supported
Perceived usefulness -> Attitude to adopt AR	H5	0.395	5.558***	Supported
Perceived ease of use -> Attitude to adopt AR	H6	0.418	6.128***	Supported
Perceived usefulness -> Intention to adopt AR	H7	0.024	0.330	Not Supported
Perceived ease of use -> Intention to adopt AR	H8	0.370	5.438***	Supported
Attitude to adopt AR -> Intention to adopt AR	H9	0.501	6.282***	Supported

Note: all p-values are two-tailed, * significant at 0.05, *** significant at 0.001

DISCUSSION

The results demonstrate that there is a significant relationship among educators' innovation towards intention to adopt AR moderated by PU and PEU at 0.05 levels, which is consistent with Cheng et al.'s (2012) study, which demonstrates that managerial support and job support can influence the acceptance of e-learning system through PU. The findings are also consistent with Hassanzadeh et al. (2012) and Motaghian et al. (2013), suggesting that educators' innovation awareness on AR influenced both PEU and PU.

Furthermore, Hypothesis 5 and Hypothesis 6, showing that PU and PEU significantly influence educators' attitude in adopting AR at 0.05 levels, which is consistent with Motaghian et al.'s (2013) study on web-based learning systems in two e-learning pioneer universities in Iran. Nonetheless, this research observes that PEU (path coefficient = 0.418) has stronger impacts on the educator's attitude to adopt AR compared to PU (path coefficient = 0.395). The results suggest that AR can improve students' learning engagement.

Based on **Table 4**, Hypothesis 7 is rejected, implying that PU impacted ITA at a 5% significance level. The result supports Hassanzadeh et al.'s (2012) research on e-learning in Tehran Universities. Also, the attitude to adopt AR has a 5% significance level on the impact on the intention to adopt AR.

The findings are consistent with previous studies, agreeing that AR transforms dull instructions into exciting learning environment (Ibáñez et al., 2014; Lu & Liu, 2015) and making AR-based games leads learning more entertaining (Bressler & Bodzin, 2013; Mohd Yusof et al., 2014; Muñoz Cristóbal et al., 2015), increasing students' engagement and performance (Chang et al., 2014; Liu & Tsai, 2013). The results support the findings of previous studies – AR can enhance the teaching and learning process (Chung & Tan, 2004; Wu, Chen, & Lin, 2007; Yuen & Ma, 2002; Teo & Noyes, 2011). It is also observed that educators are ready to implement AR as a teaching enhancement tool.

CONCLUSION

The move to online learning caused by the unexpected outbreak of the COVID-19 pandemic gives a rise to AR prominence. Following this observation, this paper has examined the applications of AR as an enhancement teaching tool through the TAM. Previous studies have observed that AR reshape monotonous instructions to an interactive learning environment (Ibáñezet al., 2014; Kim et al., 2018; Lu & Liu, 2015; Savela et al., 2020). To further assess this notion, this research analysed 223 valid questionnaire surveys to investigate the application of AR in learning using the SPSS and Partial Least Squares – Structural Equation Modelling (PLS-SEM). Based on **Table 4**, the structural model demonstrates that AR plays a role in teaching, supporting the observations of previous studies (Chung & Tan, 2004; Teo Noyes, 2011; Wu et al., 2007; Yuen & Ma, 2002).

Nevertheless, the results are limited to only private universities in Penisular Malaysia and do not consider the role of the universities' top management as one of the variables. Future researches may consider recruiting students as respondents. This insightful study may be of interest to the government, learning institutions, educators, and others on the implementation of AR in Malaysia's educational sector. The implementation of this study may accelerate Malaysia's move towards Industrial Resolution 4.0 and the exploration of IoT, in addition to strengthening the education sector and increasing the effectiveness in nurturing future leaders.

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

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