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Factors influencing behavior intentions to use virtual reality in education

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C H R O N I C L E

Article history:
Received: October 10, 2021
Received in revised format: November 20, 2021
Accepted: March 17, 2022
Available online: March 17 2022

Keywords:
Virtual Reality
Teaching Acceptance Model
SPSS
Factor analysis
Sustainable learning

A B S T R A C T

Virtual reality (VR) is a new technology that has applications in a variety of sectors, including medical, education, gaming, psychology, and sociology. The application of VR in education is intriguing and warrants further examination, but research on the subject is currently restricted. VR can benefit education by allowing students to participate in memorable and engaging experiences that they would not otherwise be able to have. Traditional approaches are still used to teach students, which is an essential element of the curriculum for those who want to conceive problem-solving. As a result, there is a scarcity of study on VR deployment. In this paper, we investigated the factors affecting the adoption of VR in higher educational institutes. To this end, we extended the technology Acceptance Model (TAM) with four additional factors and formulated a set of hypotheses. The hypotheses are then evaluated using a dataset collected from 503 Jordanian students. The result shows that the factors perceived facilitating condition, perceived effort expectancy, and perceived compatibility significantly affected the intention to use VR systems and tools for educational purposes. We believe that this study will help decision makers to build sustainable learning and educational systems in Jordan universities.

1. Introduction

The use of computers and new technologies is essential nowadays. In the 1970's, the needs of technology started increasing. New technologies are playing a big role in the educational and training sections (Cattaneo et al., 2022; Graesser et al., 2022; Mbunge et al., 2022; Molnár, 2022). Documentation, sounds, videos, etc. all participate in transferring knowledge to receivers in all levels (elementary, secondary, undergraduate, and graduate). Most educational and training-based technologies are considered a safe learning environment. However, in the traditional way of training some the experiments need a critical protocol in order to achieve one experiment such as dealing with chemical material labs (Behmadi et al., 2022; Hussein et al., n.d.; Ibodullayev et al., 2022; Moore et al., 2021; Villena-Taranilla et al., 2022). Statistically speaking, human panic when working under pressure and emergencies which leads to huge mistakes and catastrophic events. Therefore, new technologies involved in such a way for training and teaching hazards labs, not to mention any other hazards that involve heat and cold stress, vibration, and noise hazards. All these hazards can be avoided using technology-based teaching such as Virtual Reality (VR) (Adhikari & Integration, n.d.; Bergamo et al., 2022; Chen, 2022; Grobler & van Wyk, 2022; Wolf et al., 2022; Yan et al., 2022; Yang & Miang Goh, 2022). VR is a new technology that allows users to superimpose digital information on their real-world surroundings. It includes interfaces that enable sensory immersion (visual and aural) stimuli (Atiker, 2021; Doerner et al., 2022). In addition, it allows users to navigate as they would in the real world. With the help of VR, users can monitor and synchronize between digital data and the real-world. Due to these features, VR plays a big role in the manufacturing industry for assembly tasks, essential geographical information, and on-site emergency drills (Ran et al., 2022). Despite the fact, VR appears to be a potential tool for crisis management training in theory, it remains questionable if the users will adopt this technology for training and learning purposes (Bolkas et al., 2022). Consequently, it is important to understand the factors that influence the users' acceptability and willingness to use VR technology for education and training purposes. In this

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doi: 10.5267/j.ijdns.2022.3.008

research, we will build a semantic representation regarding factors that will measure the ability of users to adopt virtual reality in the educational and training sectors using TAM. Besides to the original TAM factors, we extended the model with four additional factors (e.g., Usability, Perceived Facilitating Condition, Perceived Effort Expectancy, and Perceived Compatibility). This paper is organized as follows: section 2 presents related work on virtual reality in education and illustrates the concept of Technology Acceptance Model. Section 3 illustrates the research methodology while section 4 presents the research framework. Section 5 shows the results and discussion. Finally, section 6 shows the conclusion of the proposed research model.

2. Literature review

In this section of this research, we will focus on virtual reality based on educational purposes along with the Technology Acceptance Model (TAM).

2.1 Virtual Reality in Education

In (Özgen et al., 2019) authors study the use of virtual reality in basic design education and focus only on the usability of VR for problem solving activities. They make two groups, one group for paper-based and the other used VR technology. They used four components for TAM for each group. The authors discovered that there is a statistically significant difference between the VR and paper-based groups in terms of (intention to use and reported enjoyment). As a result of the research provided, authors found that using VR is more fun. Also, VR enhances problem-solving activities. In (P. K. Kwok et al., 2020) study the adoption of virtual reality for crisis management training among users. The authors use TAM and Theory of Planned Behavior (TPB) as a theoretical basis for the model development using a total of six factors from both. The authors' findings revealed that users' attitudes toward the VR-based training system and their perceived behavioral control are both positively related to their behavioral intentions, implying that a positive attitude toward using the system and a sense of having enough control over the system are good starting points to simulate the intention to try the system. This finding supports the Theory of Planned Behavior. Unlike the TAM, which claimed that perceived usefulness only partially mediates the influence of perceived ease of use on attitude, our findings revealed that perceived usefulness entirely mediates the effect of perceived ease of use on attitude. In the study (Vallade et al., 2020) authors experiment college students' intentions for adopting VR headsets and 360-degree videos for rehearsing speeches through the technology acceptance model. TAM predicts that college students will have a more positive attitude toward using technology. The authors in (Jimenez et al., 2021) focused on the most often utilized external factors in e-learning, agriculture, and virtual reality applications are identified for further validation in an e-learning tool for EU farmers and agricultural entrepreneurs. The analysis based on Quality Function Deployment (QFD) reveals that computer self-efficacy, individual innovativeness, computer anxiety, perceived enjoyment, social norm, content and system quality, experience, and facilitating conditions are the most common determinants addressing technology acceptance. Furthermore, research revealed that external variables had varying effects on the TAM Model's two primary beliefs, perceived usefulness PU and perceived ease of use PEOU.

2.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a theory in information systems that describes how users accept and use technology. The endpoint at which humans use technology is the actual system utilization. The element that drives people to use technology is their behavioral intention (Alsharhan et al., 2022; Bodendorf & Franke, 2022; Kabir et al., 2022; Katebi et al., 2022; Metallo et al., 2022). The attitude, which is the overall impression of the technology, has an impact on behavioral intention. In the beginning of technology's integration into people's daily lives, there was a rising need to understand why technology was adopted or rejected. The science of psychology provided the foundation for the first ideas seeking to explain and anticipate those decisions. TAM began with the TRA, which emerged with the Theory of Planned Behavior (Lin et al., 2022; Milutinović, 2022; Su et al., 2022).

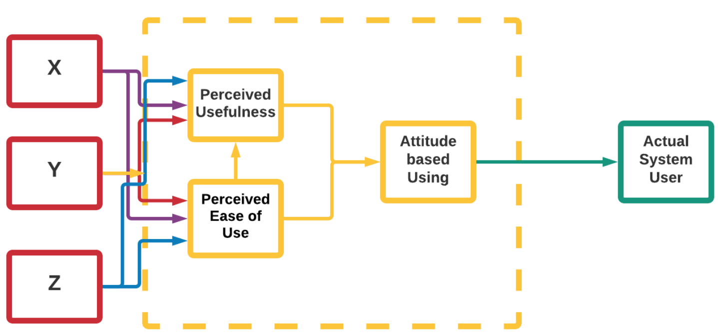

Fig. 1. Teaching Acceptance Model (TAM) (Davis, 1985)

Fred Davis updated the Theory of Reasoned Action (TRA) and introduced the TAM to construct a credible model that could anticipate actual use of any specific technology. He believed that real system use is fundamentally a behavior, and that the TRA would be an appropriate model for explaining and predicting such behavior(Lai, n.d.; Venkatesh, 2013). TAM proposed that three elements might explain a user's motivation such as perceived ease of use, perceived utility and attitude toward utilization. Davis theorized that a user's attitude toward the system was a crucial factor of whether the system would be used or rejected. He defined perceived usefulness as the degree to which a person feels that using a certain system would improve her or his work performance, whereas perceived ease of use is the degree to which a person believes that utilizing a specific system will be painless (Marangunić & Granić, 2014). Finally, the system design elements were expected to have a direct impact on both beliefs as illustrated in Fig. 1. TAM has been proved to be a major scientific paradigm for examining student, teacher, and other stakeholder adoption of learning technology over time (Teo et al., 2011). According to (Granić & Marangunić, 2019; Šumak et al., 2010), TAM is the most often cited ground theory in the literature on e-learning acceptance. Expanding or changing the TAM research model with other relevant components was usually used to characterize a user's willingness to use an e-learning tool.

3. Research Method

This study's goal is to examine and investigate the aspects that shape and influence students and lecturers' attitudes regarding VR. The research model for this study is shown in Figure 2, with "Intention to Use VR" as a dependent variable. Students and lecturers in universities were the study's target group. It should be mentioned that this group will have more variance than the others, therefore it cannot be deemed homogeneous. Furthermore, the use of technology in the teaching process of one major differs greatly from that of the others. Individual notions of determinants were adapted from prior studies to ensure the validity of all measurements.

TAM model is adopted for this research which consist of several factors such as Perceived Usefulness (PU), Perceived Ease of Use (PEoU), Attitude (A), Usability (USB), Perceived Facilitating Condition (PFC), Perceived Compatibility (PCOM), Perceived Effort Expectancy (PEE) and Intention to Use (ITU). To put this research in the field a survey has been built and validated. The survey infrastructure can be split into four parts. The first- and second-part concern about if the user has a general knowledge about the VR and the usability of it. The third part focuses on the usage of the VR specifically if it is easy to use or not. Finally, the last part of the survey focuses on the needs of VR for teaching purposes. All poll items were graded on a 5-point Likert scale, with 1 indicating strong disagreement and 5 indicating strong agreement (Fernández et al., 2022; Mellinger & Hanson, 2021; Robershaw et al., 2022; Robie et al., 2022; Temel Aslan et al., 2022). The survey was filled by 503 participants from different majors' students and lecturers. There were 255 females and 248 males, the age range of all participants lay between 19 – 66 years old. Moreover, the major of each participant has been registered.

4. Research Framework

This paper applied using the TAM model. In this part an extension of the TAM model factors will be illustrated.

4.1 TAM Factors

TAM consists of four major factors which are PU, PEoU, A and ITU. Four more factors have been added to the TAM model (Le et al., 2022; socio, n.d.). The added factors are Usability (USB) (Brandon-Jones & Kauppi, 2018), Perceived Compatibility (PCOM)(G. C. Moore & Benbasat, 1991), Perceived Effort Expectancy (PEE) and Perceived Facilitating Conditions (PFC). Inside of each one of these factors there are several measurements as illustrated in Table 1.

Table 1
TAM Factors and Measurements

Usability (USB):	
The system is always accessible.	**USB1**
The system switches screen quickly.	**USB2**
The system provides easy navigation via the order process.	**USB3**
Perceived Compatibility (PCOM1):	
Using the system is compatible with most aspects of my life.	**COM1**
Using the system fits my lifestyle.	**COM2**
Using the system fits well with the way I like to interact with the components in my home.	**COM3**
Perceived Effort Expectancy (PEE):	
I expect that it will be easy for me to become skillful at using Virtual Reality services in a short time	**EE1**
I expect to find the Virtual Reality Services Easy to Use.	**EE2**
Learning to Use Virtual Reality Services is Easy for Me.	**EE3**
My interaction with Virtual Reality Services would be clear and understandable for performing Tasks.	**EE4**
Perceived Facilitating Conditions (PFC):	
I Have the Needed Resources Necessary to use Virtual Reality Services	**FC1**
I have the knowledge necessary to use Virtual Reality Services	**FC2**
Technical Staff in My University is Available for Assistance with Virtual Reality Services difficulty.	**FC3**
I think that Virtual Reality Services Technologies Fits Well with the way I work.	**FC4**

4.1 Research Model

The proposed model of this research is illustrated in figure 02, that shows factors adopted in the TAM model to measure the acceptance of VR in educational sectors.

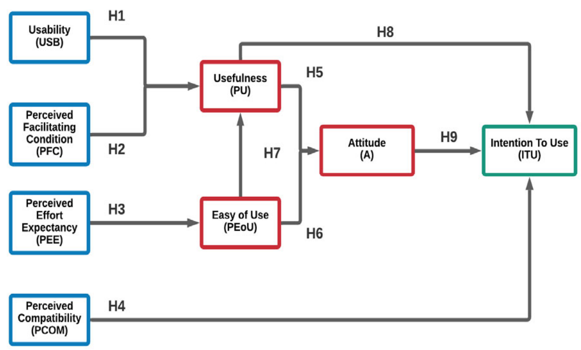

Fig. 2. Proposed TAM model

4.2 Research Hypotheses

Research hypotheses are the hypotheses mapped to the factors coming from the TAM model. Table 2 illustrates the mapped process with the research hypotheses.

Table 2
Research Mapped Hypotheses

Hypotheses	
H1	USB has a direct effect on PU.
H2	PFC has a direct effect on PU.
H3	PEE has a direct effect on PEoU.
H4	PCOM has a direct effect on ITU.
H5	PU has a direct effect on A.
H6	PEoU has a direct effect on A.
H7	PEoU has a direct effect on PU.
H8	PU has a direct effect on ITU.
H9	A has a direct effect on ITU.

4.3 Questionnaire Design

The structure of the questionnaire is similar to TAM factors and measurements mentioned in table 01. The questionnaire consists of 14 questions, each question measured using a scale of points starting from “Strongly Disagree” to “Strongly Agree”. Moreover, to make it easy to analyze the data a Likert rating scale is used to measure how much participants agree or disagree with the question/statement (Ghozali et al., 2022a, 2022b; Kwok et al., 2022).

4.4 Data Analysis

The data was statistically evaluated using the Partial Least Square (PLS) technique and the Structural Equation Model (SEM). The total model should be able to be determined and examined as a single unit using this method. It may also look at models with several independent factors, even if there are correlations between them, as well as correlations between unusual dependent factors. Furthermore, the route coefficients' quality must be checked, and the hypotheses must be tested using a suitable technique based on the form of the obtained data.

3. Results and Discussion

Once the questioner is distributed and the data is collected an analyzing process takes place using IBM SPSS Statistical software. To further comprehend the data, descriptive statistics and frequencies were produced. Furthermore, Cronbach's Alpha was used to determine the acceptable level of dependability for each of the constructions.

5.1 Reliability Analysis

Consistency is measured by reliability, which means that the study technique may be repeated, and the same findings should be produced (da Silva et al., 2022; Picot et al., 2022). The alpha values were used with a limit of 0.7 to achieve this. In this case, alpha values are utilized to see if the factors are stable enough to be employed as a scale (Kind et al., 2007; Montero-

Martín et al., 2009; Montero-Martin et al., 2009; Obamiro et al., 2016). As shown in Table 3, all the factors have scores over 0.7, indicating that they are stable enough to be employed as a scale.

Table 3
Internal Consistency of the Used Questionnaire

Factor	No. of Questions	Cronbach's Alpha
Intention to Use	3	0.971
Perceived Usefulness	6	0.769
Ease of Use	6	0.865
Attitude	3	0.936
Perceived Facilitating Condition	4	0.753
Perceived Compatibility	3	0.937
Perceived Effort Expectancy	4	0.776
Perceived Usability	3	0.783
All Factors	32	0.826

5.2 Normality Testing

Normality tests are used in statistics to examine if a data set is well-modeled by a normal distribution and to compute the likelihood that a random variable underlying the data set is normally distributed (Shapiro et al., 1968; Yap & Sim, 2011; Yazici & Yolacan, 2007). In this research, both Skewness and Kurtosis features are measured to test whether the overall shape of distribution differs from normal distribution along with compared to the tails of the normal distribution, respectively (Ma et al., 2022; Ojo, 2022; Razak et al., 2022). Table 4 illustrates the resulting features for each TAM factor.

Table 4
Normality of the Dataset

Factor		**Skewness**	**Kurtosis**
Intention to Use	**ITU1**	0.259	-1.329
	ITU2	0.318	-1.194
	ITU3	0.258	-1.326
Perceived Usefulness	**PU1**	0.037	-0.513
	PU2	0.282	-0.565
	PU3	0.185	-0.721
	PU4	0.242	-0.756
	PU5	0.062	-0.081
	PU6	-0.028	-0.231
Ease of Use	**PEOU1**	0.107	-0.89
	PEOU2	0.1	-0.903
	PEOU3	0.137	-0.906
	PEOU4	0.188	-1.087
	PEOU5	0.127	-0.466
	PEOU6	0.093	-0.616
Attitude	**ATT1**	-0.318	-0.854
	ATT2	-0.126	-0.983
	ATT3	-0.132	-1.08
Perceived Facilitating Condition	**PFC1**	-0.351	-0.802
	PFC2	-0.565	-1.05
	PFC3	-0.435	-1.103
	PFC4	-0.17	-1.026
Perceived Compatibility	**PC1**	0.008	-1.164
	PC2	0.239	-1.081
	PC3	0.154	-1.232
Perceived Effort Expectancy	**PEE1**	-0.005	-0.897
	PEE2	0.09	-0.907
	PEE3	-0.157	-0.806
	PEE4	0.052	-1.179
Usability	**PCV1**	0.206	-0.918
	PCV2	0.129	-1.052
	PCV3	0.362	-0.015

5.3 Convergent Validity

The new scale's convergent validity refers to how well it correlates with other variables and measures of the same construct (Machorro et al., 2022; Siyam et al., 2022; Utami et al., 2022). The concept should not only correlate with related variables, but also with variables that are different and unconnected. In the beginning, factor loading was calculated which is considered a data reduction technique that uses a lower number of factors to explain the correlations between observable variables. Table 5 shows the obtained results regarding factor loading.

Table 5
Factor Loading

Factor		PU	PEOU	ATT	PCV	PFC	PC	PEE	ITU
Perceived Usefulness	PU1	.686							
	PU2	.726							
	PU3	.738							
	PU4	.640							
	PU5	.890							
	PU6	.901							
Perceived Ease of Use	PEOU1		.833						
	PEOU2		.853						
	PEOU3		.829						
	PEOU4		.867						
	PEOU5		.789						
	PEOU6		.664						
Attitude	ATT1			.815					
	ATT2			.870					
	ATT3			.880					
Usability	PCV1				.793				
	PCV2				.702				
	PCV3				.767				
Perceived Facilitating Condition	PFC1					.718			
	PFC2					.856			
	PFC3					.881			
	PFC4					.754			
Perceived Compatibility	PC1						.888		
	PC2						.945		
	PC3						.957		
Perceived Effort Expectancy	PEE1							.728	
	PEE2							.886	
	PEE3							.877	
	PEE4							.705	
Intention to Use	ITU1								.933
	ITU2								.871
	ITU3								.927

Once the factor analysis measured the convergent validity calculated by measuring both the average variance and composite reliability. In this research, the threshold of Average Variance (AV) is 0.5 and the threshold of Composite Reliability (CR) is 0.7 (Alcaraz et al., 2022; Nandal et al., n.d.; Nascimento et al., 2022; Shafi M.K & Reddy, 2022; Singh et al., n.d.). Table 6 shows the resulting values accepted if it is over 0.5 for AV, and accepted if it is over 0.7 for CR.

Table 6
Convergent Validity

Factor	*No. of Questions*	*Average Variance Extracted (> 0.50)*	*Composite Reliability (> 0.70)*
Intention To Use	3	0.8294	0.9358
Perceived Usefulness	6	0.5926	0.8956
Ease Of Use	6	0.6539	0.9184
Attitude	3	0.7318	0.8910
Perceived Facilitating Condition	4	0.6482	0.8797
Perceived Compatibility	3	0.8658	0.9508
Perceived Effort Expectancy	4	0.6452	0.8780
Usability	3	0.5699	0.7986

Table 7 shows the results of KMO and Bartlett's Tests including Chi-Square. KMO results of the measurement adequacy (which determines if the responses given with the statements are adequate or not), values between 0.7-0.8 are greater than 0.5 and therefore they are considered acceptable. Indicating that the data are suitable for structure detection. The value of Chi-Square (9523.313) is greater than the tabulated value at the degrees of freedom of 496 which is equal to 124.342 at $\alpha \leq 0.05$, indicating that the data is suitable for analyses. In addition, Bartlett's Test of Sphericity is significant (0.000 less than 0.05) which means that correlation matrix is not an identity matrix (Cerny & Kaiser, 1977).

Table 7
KMO and Bartlett's Tests

Kaiser-Meyer-Olkin Measure of Adequacy.		**0.789**
Bartlett's Test of Sphericity	**Approx. Chi-Square**	**9523.313**
	Degree of Freedom	**496**
	Sig.	**0.000**

5.4 Results and Discussion

The hypotheses were tested and analyzed to see the intention of using VR in educational sectors. The level of significant (P) value is acceptable if it is less than 0.01. The results clarified that the factors have significant P coefficients at p< 0.01. Table 8 shows the hypothesis status for the adopted variables, all the hypotheses have supported results except for the PC.

Table 8
Hypothesis Status

	Hypothesis			*P*	*Hypothesis Status*
H1	Usability	→	Perceived Usefulness	*0.532*	*Not Supported*
H2	Perceived Facilitating Condition	→	Perceived Usefulness	*0.011*	*Supported*
H3	Perceived Effort Expectancy	→	Ease of Use	***	*Supported*
H4	Perceived Compatibility	→	Intention to Use	*0.008*	*Supported*
H5	Ease of Use	→	Perceived Usefulness	***	*Supported*
H6	Ease of Use	→	Attitude	***	*Supported*
H7	Perceived Usefulness	→	Attitude	***	*Supported*
H8	Perceived Usefulness	→	Intention to Use	***	*Supported*
H9	Attitude	→	Intention to Use	***	*Supported*

The hypothesis status shows that PFC and EoU have significant effects on PU. However, no significant effect of USB on PU was found, so H1 was rejected. Also, the result shows that PC, PU and A have new significant paths to ITU, with a regression value of PCOM equal to 0.008 (indicating significant effects of ITU). Finally, EOU and PU also have significant effects on A. Moreover, all the proposed hypotheses (H2, H3 and H4) were supported by the hypotheses results indicating the relationships among the original TAM were significant.

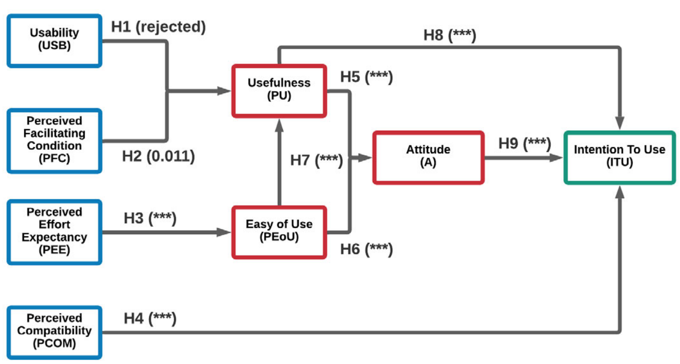

Fig. 3. Hypotheses TAM model

4. Conclusion

This research identified the factors that influence the students and lecturers to use Virtual Reality devices for educational purposes in Jordan universities. Therefore, a questionnaire has been made and distributed over 255 females and 248 males with age range between 19 – 66 years old. After that, a TAM model has been applied in order to study the factors and hypotheses added to the model. Then, statistical analysis has been applied using SPSS v25.0 and AMOS v23.0 in order to test the hypotheses and obtain the results. Several statistical techniques applied such as Reliability Analysis, factor loading, Convergent Validity, Kaiser-Meyer-Olkin and Bartlett's Test of Sphericity to get the detailed result and achieve the final hypotheses status. In addition, P-Value has been used to get the significance of the results.

Acknowledgements

The authors are grateful to the Applied Science Private University, Amman-Jordan, for the full financial support granted to cover the publication fee of this research article.

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