An integrated model for examining teachers' intentions to use augmented reality in science courses

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Abstract

Many studies show that augmented reality (AR) provides multiple benefits to science education, including learning gains, motivation to learn, and collaborative learning. However, while using AR largely depends on the teachers' willingness, existing literature lacks studies that identify teachers' intentions to use this technology. This study proposes a model to predict science teachers' intentions to use AR in their classes. Our model merges the Theory of Planned Behavior and the Unified Theory of Acceptance and Use of Technology 2. It includes nine hypotheses that were tested with 451 science teachers from different cities in Turkey. The results indicate that our model identifies the factors affecting teachers' intentions to use AR with a stronger explanatory power than the referenced theories. Besides, all hypotheses within the proposed model were statistically supported in determining antecedents of science teachers' intentions. Finally, the study contributes to the theory and practice by focusing on the psychological aspects required for explaining science teachers' intentions to use AR.

1. Introduction

Augmented reality (AR) enhances teaching and learning with virtual information added to real-world objects. This technology has been successfully integrated to enrich education at different levels of education and fields of education. Many studies have shown that AR provides multiple benefits to education, including learning gains (Garzón & Acevedo, 2019), motivation to learn (Georgiou & Kyza, 2018), and collaboration (Ibáñez & Delgado-Kloos, 2018). As stated in the studies by Arici, Yildirim, Caliklar, and Yilmaz (2019) and Garzón and Acevedo (2019), science is the most popular field in educational AR. This popularity obeys the fact that AR helps understand abstract concepts that would be difficult to understand with other pedagogical strategies (Arici et al., 2019).

Despite the multiple benefits of using AR to enrich science teaching, some teachers are skeptical about using this technology in their classes. As noted in the study by Sáez-López et al. (2020), some teachers argue that AR may cause overload and distract the students. Other studies show that some teachers refuse to use this technology because learning to use it would require too much effort (Ali et al., 2022). Therefore, as with other forms of technology, we can infer that bringing the multiple benefits of AR to science education, largely depends on the teachers' willingness to use it. Hence, in order to design plans to motivate teachers to use AR in educational settings, it is important to understand the factors that affect their intentions to use this technology. However, although some studies focus on teachers' perspectives on the use of AR in science education (Salar et al., 2020), existing literature lacks studies that identify their actual intentions to adopt and use it.

Consequently, the purpose of this study is to identify the factors that affect teachers' intentions to use AR in science classes. Our study proposes a model that predicts teachers' intentions and behaviors based on two psychological theories, namely, the Theory of Planned Behavior (TPB) (Ajzen, 1985) and the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) (Venkatesh et al., 2012).

The TPB considers three factors namely, Attitude (ATT), Subjective Norm (SN), and Perceived Behavioral Control (PBC). These factors are rational considerations. However, rational considerations are not sufficient to determine an individual's intentions, especially concerning the use of technology (Khatri et al., 2018). Similarly, the UTAUT2 includes seven constructs namely, Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), Hedonic Motivation (HM), Price Value (PV), and Habit (HT). Nonetheless, to obtain stronger explanatory power, most studies using the UTAUT2, use it in combination with an external theory (Tamilmani et al., 2017).

Accordingly, our study merges the TPB and UTAUT2 into a comprehensive conceptual model to predict the intentions of science teachers to use AR in their classes. Our study contributes to the theory by focusing on the psychological aspects required for explaining science teachers' intentions to use AR. Understanding these aspects allows taking actions aiming to encourage teachers to use AR in educational settings. The rational considerations of the TPB help weigh costs and benefits. On its part, the UTAUT2 is based on primary theories focused on technology acceptance and usage. Therefore, we posit that the TPB and UTAUT2 are suitable for examining associations among constructs, which leads to explaining science teachers' intentions to use AR. As far as we know, this is the first study that predicts teachers' intention to use AR in science education. The study examines the explanatory power of the proposed model, compared to the TPB and UTAUT2. Further, the study examines the importance of the constructs of the TPB and UTAUT2 within our proposed model to determine behavioral intention. Finally, the study validates the suitability of our model in the context of science education and AR.

2. Literature Review

2.1. AR in science education

The study by Garzón and Acevedo (2019) analyzed 32 empirical studies to calculate the impact of AR on science education. The authors found an effect size of $d = 0.62$ on students' outcomes, which indicates a medium impact following Cohen's classification (Cohen, 1992). This result somehow validates learning gains as the main benefit of AR for science education, as indicated in different qualitative studies (Akçayir & Akçayir, 2017; Hung et al., 2016). The study by Georgiou and Kyza (2018) states that these learning gains depend on the students' level of immersion. The authors explain that immersion is predicted by the motivation to learn, and consequently, the use of motivational pedagogical tools leads to higher learning gains. In this regard, many studies show that the second most important benefit of integrating AR into science education is that it increases students' motivation to learn (Akçayir & Akçayir, 2017; Ibáñez & Delgado-Kloos, 2018; Videnovik et al., 2020). Hence, it appears pertinent to use AR applications to increase students' motivation, which leads to improving their learning gains.

Besides learning gains and motivation, collaborative learning has been described as a major benefit of using AR in science education (Akçayir & Akçayir, 2017; Ibáñez & Delgado-Kloos, 2018). Collaborative learning improves students' outcomes as it allows them to interact with their partners, facilitating them to comprehend abstract concepts from sciences. Finally, the study by Garzón et al (2020) describes how pedagogical approaches in AR interventions impact students learning gains in science. The study states that the most popular pedagogical approach to teaching science using AR applications is the Situated Learning approach. However, AR interventions that included the Collaborative Learning approach obtained the best results. Further, the study concludes that interventions conducted in informal settings outside classrooms or laboratories obtained better results than interventions conducted in formal settings.

2.2. Previous work

Many psychological and cognitive-based theories aim to explain individuals' intentions and behaviors concerning the use of technology. The typical set of theories that a researcher can access includes the Theory of Reasoned Action (TRA), the TPB, the Technology Acceptance Model (TAM), the Unified Theory of Technology Acceptance and Use (UTAUT), and the UTAUT2 (Taherdoost, 2018). However, perhaps the two most popular of these theories have been the TRA and the TPB (Ajzen, 2020). The TRA was firstly intended for sociological and psychological research, notwithstanding, it has recently become popular to investigate individuals' technology usage behavior (Kuo et al., 2015). On the other hand, the TPB was developed to improve the predictive power of the TRA (Fishbein & Ajzen, 1975) by adding the PBC. Many studies have compared the efficiency of these theories to explain individual behaviors concerning the use of new technologies. These studies have found the TPB to be more suitable to explain individuals' intentions to use new technologies as it has a stronger explanatory power (Conner, 2020; Jokonya, 2017).

Despite its acceptable efficacy, the TPB includes only rational considerations that are not sufficient to determine a person's intentions, especially regarding the use of technology. Alternatively, many studies have used the TAM, as this model specializes in technology. Nonetheless, the explanatory power of the TPB has been found to be greater than that of TAM (Cheng, 2019). Besides, the TPB model provides fuller explanations of intentions and behavior than the TAM, and consequently, it is more recommendable to understand the factors affecting a person's intentions to use a specific technology. In this regard, some studies recommend using the TPB together with a model specialized in technology. Many studies have found the UTAUT to be an accurate complement to the TPB (e.g. Kaye et al., 2020). The UTAUT explains a significant amount of variance in behavioral intention and usage behavior, however, this model presents three important limitations. First, it includes some relationships that may not apply to all contexts. Second, it omits some relationships that may be crucial for explaining users' acceptance and usage. Third, this model excludes important constructs that may be potentially important concerning newer technologies (Dwivedi et al., 2019).

As an evolution of the UTAUT, Venkatesh et al. (2012) proposed the UTAUT2. The main difference between the UTAUT and the UTAUT2 is that the latter is tailored to a consumer use context (Venkatesh et al., 2012). The UTAUT2 is a powerful framework that effectively explains and analyzes an individual's technology acceptance of novel information technologies such as AR. In addition, it is recommended to use the UTAUT2 together with an external model to improve the explanatory power (Tamilmani et al., 2017), which led us to our model that integrates the TPB and the UTAUT2. Previous studies have successfully combined these two models to identify the factors influencing behavioral intentions to adopt technology (Bai, 2020; Bekti et al., 2022; Yuen et al., 2020). Therefore, we posit that integrating these two models allows us to accurately understand science teachers' intentions to use AR.

3. Theoretical Framework

3.1. Theory of Planned Behavior

The TPB is a behavioral model that aims to explain all the behaviors over which people can exert self-control (see Fig. 1) (Ajzen, 1985). The TPB encompasses the basic factor of individuals' intentions to perform a particular action (Ajzen, 1991). The TPB states that behavioral intentions are influenced by ATT, SN, and PBC (Ajzen, 1991). The TPB has been implemented to predict and explain a broad range of intentions and behaviors (Conner, 2020; Jokonya, 2017). Specifically, this theory has proven to be effective to explain teachers' decisions to use educational technology (Ateş & Garzón, 2022), teachers' intentions to integrate digital literacy into classroom practice (Mustafa & Hajan, 2022), and pre-service teachers' thinking about teaching media literacy (Watson & Rockinson-Szapkiw, 2021).

3.1.1 Attitude toward the behavior

This construct refers to the personal appraisal of a person over a particular behavior; thus, if the appraisal is positive, the intention increases (Fishbein & Ajzen, 1975). In this study, *attitude toward the behavior* is defined as the personal assessment of a science teacher on AR systems. The study by Díaz, Toledo, and Hervás-Gómez (2017) showed that a positive attitude toward AR increases teachers' intentions to use this technology in their classes. Hence, we posit that teachers that have a positive attitude toward AR will also have a high intention to use this technology for educational purposes. Based on this, the first hypothesis of the study establishes that:

H1: Attitude toward the use of AR in science classes positively influences teachers' intentions to use AR systems in their classes.

3.1.2 Subjective norm

This construct refers to the individual's normative beliefs and is linked to the perceived social pressure toward the adoption of a particular behavior (Fishbein & Ajzen, 1975). Thus, in this study, *subjective norm* is defined as the extent to which science teachers believe that other people will approve that they use AR systems in their classes. Previous studies (e.g., Akar, 2019; Sungur-Gül & Ateş, 2021) found that SN is influential on behavioral intention, suggesting that teachers will use the technology if important referents advise them to do so. Similarly, the study by Jeong and Kim (2016) found that SN had the strongest effect on teachers' acceptance of technology in early childhood education. Hence, the second hypothesis of the study establishes that:

H2: Subjective norm positively influences science teachers' intentions to use AR systems in their classes.

3.1.3 Perceived behavioral control

This construct refers to the perceived ease or difficulty in performing a specific behavior (Ajzen, 1991). In this study, *perceived behavioral control* is defined as science teachers' perception of the ease or difficulty of using AR in their classes. This construct evaluates individuals' perception of how efficiently they can control factors that can enable or limit the actions necessary to face a specific situation. Ajzen (2002) stated that a high level of perceived control tends to strengthen an individual's intention to perform the behavior. The study by Teo et al. (2016) found that after ATT, PBC has the largest influence on technology usage intention. Thus, the third hypothesis of the study establishes that:

H3: Perceived behavioral control positively influences science teachers' intentions to use AR systems in their classes.

3.2. Unified Theory of Acceptance and Use of Technology 2

This is a theoretical model that aims to explain and analyze individuals' acceptance behaviors of information technology products (see Fig. 2). The UTAUT2 suggests that seven constructs (PE, EE, SI, FC, HM, PV, and HT) are direct determinants of behavioral intention and, ultimately, behavior. The UTAUT2 has been implemented to explain pre-service teachers' intentions to use immersive virtual reality in education (Bower et al., 2020) and the factors affecting teachers' adoption of mobile technologies (Hu et al., 2020).

3.2.1 Performance Expectancy

This construct refers to an individual's perception that an information system simplifies the completion of a task (Venkatesh et al., 2003). Consequently, in this study, *performance expectancy* is defined as the degree to which science teachers believe that using AR systems will improve their classes. Venkatesh et al. (2003) posit PE as the strongest predictor of behavioral intention. In this regard, the study by Funmilola et al. (2019) concluded that PE is a strong determinant of teachers' behavioral intention to use technologies in education. Similarly, the study by Morais et al. (2018) found a positive correlation between educators' programming proficiency and their expectancy of performance. Therefore, the fourth hypothesis of the study establishes that:

H4: Performance expectancy positively influences science teachers' intentions to use AR systems in their classes.

3.2.2 Effort Expectancy

This construct refers to an individual's evaluation of the effort required to complete a task using a particular information system (Venkatesh et al., 2003). Thus, in this study, *effort expectancy* is defined as the degree of ease that science teachers associate with the use of AR systems. Using the UTAUT model, the study by Nizar et al. (2019) evaluated the factors that influence pre-service teachers using an AR application to learn about Cardiovascular disease. The study found EE as the dominant factor to explain the actual use of the application. The study concludes that this result can be explained by the great usability of the application and the fact that this technology positively influences users' motivation. Hence, the fifth hypothesis of the study establishes that:

H5: Effort expectancy positively influences science teachers' intentions to use AR systems in their classes.

3.2.3 Social Influence

This construct refers to the degree to which people perceive that important others believe they should use a new system (Venkatesh et al., 2003). Hence, in this study, we define SI as the extent to which science teachers perceive the approval of using AR in their classes by important referents. SI is similar to SN in the TPB. Therefore, although SI and SN have different labels, both constructs include the idea that individuals' behavior is influenced by their perceptions of what others will think of them for having used a specific system (Venkatesh et al., 2003). Hence, we merged SI and SN and proposed the second hypothesis (H2) as stated in subsection 3.1.2.

3.2.4 Facilitating Conditions

This construct represents the extent to which a person believes that there is an adequate infrastructure to facilitate the use of a system (Venkatesh et al., 2003). Hence, in this study, we define *facilitating conditions* as the degree to which a science teacher believes that there is an organizational and technical infrastructure to support the use of AR systems. The study by Groves and Zemel (2000) found that technical support, related to FC, highly affects teachers' use of technology. This construct has also a high influence on individuals' attitude toward AR use. Specifically, the study by Nizar et al. (2019) found that a high-level technical support is responsible for promoting positive attitudes toward AR use (Nizar et al., 2019; Siang et al., 2019; Xian & Shen, 2020). Hence, the sixth hypothesis of the study establishes that:

H6: Facilitating conditions positively influence science teachers' intentions to use AR systems in their classes.

3.2.5 Hedonic Motivation

This construct refers to the extent to which individuals believe that using an information system is entertaining (Venkatesh et al., 2012). In this study, we define *hedonic motivation* as the degree of satisfaction of science teachers when using AR systems. This construct has been described as the most important addition to the UTAUT (Martins et al., 2014). The study by Bower et al. (2020) places HM as the most important predictor of pre-service teachers' intention to use virtual reality in education. Similarly, the study by Moorthy et al. (2019) also found that HM has the highest influence on mobile learning behaviors among university students in Malaysia. Hence, the seventh hypothesis of the study establishes that:

H7: Hedonic motivation positively influences science teachers' intentions to use AR systems in their classes.

3.2.6 Price value

This construct refers to the trade-off of consumers between the perceived benefits of information systems and the monetary cost of using them. (Venkatesh et al., 2012). In this study, we define *price value* as science teachers' cognitive trade-off between the perceived benefits of AR systems and the monetary cost of using them. This price is expected to be high when the benefits of using the systems are perceived as greater than the monetary cost and that value has a positive impact on intention (Venkatesh et al., 2012). A meta-analysis conducted by Tamilmani et al. (2018) found that 17 studies reported a positive influence of PV on behavioral intention. The study concluded that this construct is appropriate to examine technologies that emphasize their utilitarian value, as is the case with AR. Therefore, the eighth hypothesis of the study establishes that:

H8: Price value positively influences science teachers' intentions to use AR systems in their classes.

3.2.7 Habit

This construct represents the extent to which individuals tend to perform automatic behaviors due to learning. (Venkatesh et al., 2012). In this study, we define *habit* as the degree to which science teachers tend to use AR automatically based on learning. A Review of UTAUT2-based empirical studies by Tamilmani et al. (2018), establishes that HT was the most important theoretical construct added to UTAUT2. The study describes HT as a function of behavioral intention and behavior, stating that behavior occurs automatically because of past habits without the formation of evaluation and intention. Thus, the ninth hypothesis of the study establishes that:

H9: Habit positively influences science teachers' intentions to use AR systems in their classes.

3.3. Proposed model

The proposed model integrates the TPB and UTAUT2 to provide important information to determine the factors affecting science teachers' intentions to use AR. Based on the constructs of these two models, Fig. 3 presents the proposed model and the 9 hypotheses of the study. This model is strong to explain teachers' intentions to use new technologies from technological and psychological perspectives. Therefore, we posit that this model could be accurately implemented in further studies involving any new technological system and perhaps in any domain subject.

4. Methods

4.1. Data collection and Participants

Study data were collected using the questionnaire survey method. The self-determined scales were administered to participants who voluntarily participated in the study and determined by the convenience sampling method. The scales within the scope of the research were collected in the school environment and took approximately 30 minutes. At the beginning of this process, the first author of the study explained the process. Then, the participants were asked to carefully read the explanation about the purpose of the survey. Participants were asked to answer all items on the scales and return the completed survey to achieve a higher response rate and increase available responses.

In the first stage, 498 science teachers were included in the study. However, 47 of them were excluded during the data cleaning process because of some reasons such as multicollinearity problems, missing points in the survey, and carelessness. As a result, 451 science teachers attended the study (257 women, 194 men; 25 to 60 years old, *M* = 38.85, *SD* = 9.74). The participation rate (91%) meets the suggested survey response rate requirement (Deutskens et al., 2004). The science teachers who participated in this study work in public middle schools in five large cities in Turkey, with a population of more than 1 million. The schools have similar educational opportunities such as uncrowded classes, smart boards, and science laboratories. The family, economic and socio-cultural situations of the students in the schools are similar. Teachers' average professional experience is 15.36 years. Sixty-four percent of the teachers are married or live with a permanent couple. The teachers are well-trained, 29% claim to hold a master's or doctorate. In Turkey, the Ministry of National Education provides courses, webinars, and workshops related to AR to teachers through an education information network. During this process, teachers are trained on AR with a project called Twinning. This project is coordinated by the European Schoolnet (EUN) and Erasmus and offers a platform for teachers working in schools in European countries to communicate, collaborate, develop, and share projects (Twinning Community, 2021). In addition, teachers use some AR mobile applications such as EYEJACK, Quiver, FETCH! Lunch Rush, AR Flashcards, and Anatomy 4D (Daqri) and are trained on QR Code Creation and use QR Codes in Education (General Directorate of Innovation and Educational Technologies, 2021). Science teachers included in our study participated in this process. However, AR technology is not used in all science courses because of some reasons such as economy and time. Although 60% of teachers use technologies in the classroom, 75% of them believe that they have enough knowledge to use AR in the course and only 40% of them stated that they use AR in science courses. Therefore, this study focused on intention rather than behavior.

4.2. Measuring Tools

Study data were collected via several structured instruments. First, a survey instrument was constructed after relevant literature related to the theoretical models used in the study was reviewed (e.g., Ajzen, 2006; Davis, 1989; Venkatesh et al., 2003; 2012). Second, based on previous studies, initial statements were included in the scales to measure the constructs of the proposed models. Third, face and content validity were tested to identify whether the items in the models are properly prepared and can theoretically include the constructs (Gravetter & Forzano, 2018). Pre-test of scales was made by a total of 121 pre-service science teachers studying in faculties of education. Based on the results, some minor revisions were made. The scales were then examined by two experts in two departments including science education and computer and instructional technologies. The first version of the scales was prepared in English and then translated into Turkish using the blind translation-back-translation method (Esfandiar et al., 2020).. Considering the constructs in the proposed model, TPB includes ATT, SN, and PBC, while PE, EE, SI, FC, HM, PV, and HT are involved in UTAUT2. However, since the constructs of SN and SI measure the same properties (Venkatesh et al., 2003), only one (SN) was included in the scale and the proposed model even though the analysis of TPB and UTAUT2 used SN/SI interdependently. Finally, the intention scale used commonly for both models is involved. Information related to constructs, items, and reliability values of scales is included in Table 1. Each item in Table 1 was scored using a 7-point Likert scale, where each level ranges from “Strongly disagree” (1) to “Strongly agree” (7).

Table 1
Constructs, Items, and Results of Reliability and Validity

Construct	Item	Statements	FL	α	AVE	CR
Attitude	ATT 1	I think that using AR in science classes is interesting.	0.82	0.81	0.64	0.88
	ATT 2	I think that using AR in science classes is a good idea for students' achievements.	0.79			
	ATT 3	I think that using AR in science classes is important for effective learning.	0.73			
	ATT 4	I think that using AR in science classes is beneficial to arouse students' interests.	0.85			
Subjective Norm	SN 1	People who are important to me think I should use AR in science classes.	0.71	0.72	0.54	0.70
	SN 2	People who influence me think I should use AR in science classes.	0.76			
Perceived Behavioral Control	PBC 1	Using AR in science classes is entirely under my control.	0.75	0.76	0.59	0.81
	PBC 2	I have the ability to use AR in science classes.	0.76			
	PBC 3	I can use AR skillfully in science classes.	0.79			
Performance Expectancy	PE 1	I find AR useful for my science classes.	0.75	0.74	0.55	0.78
	PE 2	Using AR would allow me to accomplish teaching tasks more quickly.	0.76			
	PE 3	Using AR in my science classes would increase my teaching productivity.	0.71			
Effort Expectancy	EE 1	I would find AR in science classes easy to use.	0.70	0.79	0.53	0.82
	EE 2	Learning how to use AR in teaching science would be easy for me.	0.75			
	EE 3	My interaction with AR would be clear and understandable.	0.76			
	EE 4	It would be easy for me to become skillful at using AR in teaching science.	0.71			
Facilitating Conditions	FC 1	I have the resources necessary to use AR in science classes.	0.88	0.82	0.62	0.86

Note. FL: Factor Loading, α = Cronbach's Alpha AVE: Average Variance Extracted, CR: Composite Reliability

Construct	Item	Statements	FL	α	AVE	CR
	FC 2	I have the knowledge necessary to use AR in science classes.	0.77			
	FC 3	AR is compatible with other technology I use.	0.75			
	FC 4	I can get help from other science teachers when I am having difficulties using AR.	0.73			
Hedonic Motivation	HM 1	Using AR in science classes is fun.	0.79	0.85	0.63	0.84
	HM 2	Using AR in science classes is enjoyable.	0.82			
	HM 3	Using AR in science classes is very entertaining.	0.78			
Price Value	PV 1	AR technology is reasonably priced.	0.74	0.79	0.53	0.77
	PV 2	AR technology offers good value for the money.	0.73			
	PV 3	At the current price, AR technology provides a good value.	0.71			
Habit	HT 1	Using AR would become a habit for me in my science classes.	0.75	0.82	0.61	0.83
	HT 2	I would be addicted to using AR in my science classes.	0.81			
	HT 3	I must use AR in my science classes.	0.79			
Intention	INT 1	I will continue using AR in the future.	0.81	0.80	0.69	0.87
	INT 2	I will always try to use AR in my science classes.	0.83			
	INT 3	I plan to keep using AR frequently.	0.86			

Note. FL: Factor Loading, α = Cronbach's Alpha AVE: Average Variance Extracted, CR: Composite Reliability

4.3. Data analysis

In the current study, SPSS 21 and AMOS 20 were used together to analyze the data. The items and constructs of TPB and UTAUT2 used in the study were adapted from other studies conducted with different participants in a variety of cultures. This situation causes its reproducibility to be questioned. Therefore, a preliminary application was made with 76 science teachers working in middle schools to ensure the validity and reliability of the data., In the first process of data analysis, exploratory factor analysis (EFA) which aims to discover the factor structure of a measurement tool in a particular study group or sample was conducted (Osborne & Fitzpatrick, 2012). Prior analysis showed that Bartlett's test of sphericity is significant ($p < .05$) and Kaiser-Meyer-Olkin (0.923) is bigger than 0.60, meaning that the results are suitable for EFA (Tabachnick et al., 2018). During the EFA, principal component analysis was performed to extract salient factors using the varimax rotation. The results revealed that the total variance was explained with 82.81%, the eigenvalues were higher than 1.0 and the factor loading of items in TPB and UTAUT2 models are above 0.5 (See Table 2).

Table 2
Factor loadings results of exploratory factor analysis

Items	Factor loadings of theoretical models									
	ATT	SN	PBC	PE	EE	FC	HM	PV	HT	INT
ATT 1	0.79									
ATT 2	0.74									
ATT 3	0.80									
ATT 4	0.83									
SN 1		0.77								
SN 2		0.73								
PBC 1			0.79							
PBC 2			0.81							
PBC 3			0.76							
PE 1				0.78						
PE 2				0.74						
PE 3				0.76						
EE 1					0.71					
EE 2					0.77					
EE 3					0.73					
EE 4					0.79					
FC 1						0.81				
FC 2						0.74				
FC 3						0.82				
FC 4						0.79				
HM 1							0.81			
HM 2							0.88			
HM 3							0.75			
PV 1								0.71		
PV 2								0.78		
PV 3								0.77		

Items	Factor loadings of theoretical models									
	ATT	SN	PBC	PE	EE	FC	HM	PV	HT	INT
HT 1									0.79	
HT 2									0.75	
HT 3									0.73	
INT 1										0.84
INT 2										0.81
INT 3										0.77

In this study, path analysis using a structured equation model (SEM) was performed in two stages, namely the measurement model and the structured model (Anderson & Gerbing, 1988). In the measurement model, confirmatory factor analysis (CFA) with maximum likelihood estimation was performed. Model fit indicated acceptable data (*χ^2 = 962.92, df = 356; p < .05; χ2/df = 2.70; GFI = 0.91 TFI = 0.93; IFI = 0.92, TLI = 0.92 CFI = 0.92; RMSEA = 0.06; SRMR = 0.05*). The composite reliability (CR) values were supported as they exceeded the recommended value of 0.60 (between 0.70 and 0.80) (Anderson & Gerbing, 1988). The average variance extracted (AVE) ranged from 0.53 and 0.69 which is higher than the suggested value of 0.50 (Anderson & Gerbing, 1988). The Cronbach's Alpha (α) values were found reliable since they were above the recommended value of 0.70 (Anderson & Gerbing, 1988). In the last analysis, all square roots of the AVE values are above correlations between constructs. Therefore, internal consistency, convergent validity, and discriminant validity were supported. Tables 1 and 3 shows the result of the CFA.

Table 3
Mean, standard deviation, correlation between constructs, and discriminant validity

Constructs	ATT	SN	PBC	PE	EE	FC	HM	PV	HT	INT
ATT	**0.80**									
SN	0.39	**0.73**								
PBC	0.35	0.33	**0.77**							
PE	0.43	0.63	0.55	**0.74**						
EE	0.48	0.43	0.39	0.48	**0.73**					
FC	0.35	0.39	0.42	0.38	0.63	**0.79**				
HM	0.25	0.23	0.31	0.38	0.31	0.22	**0.79**			
PV	0.24	0.20	0.28	0.29	0.16	0.21	0.22	**0.73**		
HT	0.32	0.41	0.46	0.46	0.33	0.35	0.28	0.18	**0.78**	
INT	0.44	0.32	0.42	0.51	0.37	0.53	0.43	0.37	0.56	**0.83**
M	5.22	3.77	5.26	4.23	5.03	4.97	4.31	4.91	4.05	4.81
SD	1.03	1.15	1.08	1.19	1.11	1.19	1.42	1.03	1.23	1.29

Note. The Diagonal elements are $\sqrt{AVE}$, *$p < .01$

5. Results

5.1. Goodness Fit Statistics of the Models and Explanatory Power

In the second stage, the structured model was evaluated with goodness fits using SEM for TPB, UTAUT2, and the proposed model. The results in Table 4 showed that the structured model accurately fits the data for all three models. Furthermore, the proposed model ($\chi2 /df = 3.38$) had a better fit than TPB ($\chi2 /df = 3.32$) and UTAUT2 ($\chi2 /df = 3.09$). It was also revealed that the proposed model ($R^2 = 0.423$) had stronger explanatory power than TPB ($R^2 = 0.409$) and UTAUT2 ($R^2 = 0.391$). Results of explanatory power are shown in Table 4.

Table 4
Model fit indices and explanatory powers for TPB, UTAUT2, and proposed model

Goodness Fit Statistics & R^2	TPB	UTAUT2	Proposed model
χ^2	382.67	368.46	378.56
df	115	119	112
χ^2 /df	3.32	3.09	3.38
CFI	0.94	0.93	0.95
GFI	0.95	0.92	0.94
TLI	0.92	0.90	0.93
RMSEA	0.03	0.05	0.03
SRMR	0.04	0.05	0.03
R^2 (Adjusted)	0.409	0.391	0.423

5.2. Structural equation modeling

The SEM analysis was conducted through three steps. First, the results related to constructs of TPB were provided, second, the path analysis among the UTAUT2 model was tested, and finally, the path analysis results were presented in the proposed model. The results showed that among TPB constructs, ATT toward using AR ($\beta = 0.42$, $t = 5.5214$, $p < .01$), SN ($\beta = 0.39$, $t = 4.899$, $p < .01$), and PBC ($\beta = 0.50$, $t = 6.022$, $p < .01$) had a significant direct effect on the intention to use AR in science classes.

The results of the constructs included in UTAUT2 showed that SI ($\beta = 0.36$, $t = 5.965$, $p < .01$), PE ($\beta = 0.33$, $t = 5.132$, $p < .01$), EE ($\beta = 0.26$, $t = 4.258$, $p < .01$), and FC ($\beta = 0.35$, $t = 5.332$, $p < .01$) were significantly related to intention to use AR. Furthermore, the extended constructs including HM ($\beta = 0.45$, $t = 7.026$, $p < .01$), PV ($\beta = 0.31$, $t = 4.844$, $p < .01$), and HT ($\beta = 0.21$, $t = 3.854$, $p < .01$) were found to be statistically significant concerning the intention to use AR.

The path relationship within the proposed model indicated that the influence of the ATT toward using AR ($\beta = 0.32$, $t = 5.984$, $p < .01$), SN ($\beta = 0.28$, $t = 5.512$, $p < .01$), and PBC ($\beta = 0.41$, $t = 7.013$, $p < .01$) on intention to use AR were significant. In addition, PE ($\beta = 0.23$, $t = 5.123$, $p < .01$), EE ($\beta = 0.14$, $t = 3.899$, $p < .01$), FC ($\beta = 0.26$, t = 5.321, $p < .01$), HM ($\beta = 0.33$, $t = 6.225$, $p < .01$), PV ($\beta = 0.18$, $t = 4.268$, $p < .01$), and HT ($\beta = 0.11$, $t = 3.247$, $p < .01$) proved to be statistically significant associated with the intention to use AR. Results of the path analysis are included in Table 5 and Fig. 4.

Table 5. SEM results of the proposed models

Paths	Standardized estimate (β)			t-value			Hypothesis	Hypothesis situation
	TPB	UTAUT2	Proposed Model	TPB	UTAUT2	Proposed Model		
ATT → INT	0.422	-	0.315	5.214	-	5.984	H1	Supported
SN → INT	0.388	0.362	0.277	4.899	5.965	5.512	H2	Supported
PBC → INT	0.498	-	0.412	6.022	-	7.013	H3	Supported
PE → INT	-	0.325	0.231	-	5.132	5.123	H4	Supported
EE → INT	-	0.255	0.142	-	4.258	3.899	H5	Supported
FC → INT	-	0.354	0.261	-	5.332	5.321	H6	Supported
HM → INT	-	0.448	0.334	-	7.026	6.225	H7	Supported
PV → INT	-	0.311	0.182	-	4.844	4.268	H8	Supported
HT → INT	-	0.213	0.112	-	3.854	3.247	H9	Supported

6. Discussion

The study used the TPB and the UTAUT2 as its theoretical framework and further attempted to combine both models by proposing a new robust model. In this study, a series of structural analyses showed that merging ATT, SN, PBC, PE, EE, FC, HM, PV, and HT into one conceptual proposed framework is effective to explain science teachers' intentions to use AR. The principal advantage of the proposed model is that it is comprehensive and sufficient. In addition, it is extensively useful for model developments in a wide range of educational technology contexts. Further, the conceptual proposed model can be applied to different educational contexts, providing a clear understanding of how science teachers make their decisions regarding the use of technology.

The results showed that the proposed model has better utility than the TPB and the UTAUT2 to explain AR use intention among teachers in Turkey. Accordingly, the present study approved the efficacy of the proposed model as a research model useful for predicting science teachers' intentions to use AR in their classes. Results indicate that constructs of the TPB including ATT, SN, and PBC were significantly related to science teachers' intentions to use AR. The results showed that science teachers successfully manage obstacles as PBC is revealed as the most significant factor in the intention to use AR. Moreover, science teachers' intention to use AR was also predicted by their ATT and SN. This implies that it is important to have a positive ATT toward the use of AR among science teachers. Additionally, this result indicates that the use of AR has become a social norm in Turkey, a developing country. The results are consistent with previous studies suggesting that ATT increases the intention to adopt AR in education (Díaz et al., 2017) and people are more likely to comply with others' expectations when using technology in education (Ateş & Garzón, 2022).

Among the constructs of UTAUT2, it is important to note that HM has the strongest effect on the intention to use AR followed by FC. The findings imply that science teachers place more importance on the fun of the lesson than other factors. The results are consistent with previous studies. For example, Moorthy et al. (2019) revealed that HM is one of the most important factors in the use of technology in education.

Similarly, Bower, DeWitt, and Lai (2020) found that pre-service teachers had a lot of fun when using immersive virtual reality, meaning that HM toward this technology is more important than any other factor. It can also be inferred that it is very important to provide resources and support to use AR in science classes. Additionally, PE and EE are strong predictors of the intention to use AR, as found in previous studies in different task environments (Funmilola et al., 2019; Morais et al., 2018). Another significant finding is that intentions were affected by PV, as consistent with previous studies (Tamilmani, Rana, Dwivedi, et al., 2018). This finding has great importance since the cost and charges of AR in science classes influence teachers' intention in applying the technology. In addition, science teachers are inclined to adopt the technology when it provides more benefits compared to cost. Finally, HT was found to be a significant predictor of intention to use AR in science classes. This implies that science teachers who are used to using AR as a learning tool tend to have favorable intentions, as stated in previous studies (Tamilmani, Rana, & Dwivedi, 2018).

6.1. Implications

The present study is the first attempt to examine science teachers' intentions to use AR in their classes. The results showed that merging the TPB and the UTAUT2 increases the variance accounted by the overall model, as it examines both the technological and psychological aspects of intentions to use AR. Previous studies on AR have focused on students' role in terms of achievement, attitude, and laboratory skills (Akçayir & Akçayir, 2017; Garzón & Acevedo, 2019). However, teachers play a critical role in providing an effective educational environment. For this, determining antecedents of their intentions toward this technology will allow us to predict at what level they will be involved in the class. Supporting this view, according to Ajzen (1991), the variable that has the strongest impact on behavior is intention. Therefore, the study contributes to theoretical development by focusing on the psychological aspects required for explaining science teachers' intentions to use AR.

The study also provides some practical implications for researchers, policymakers, education stakeholders, school administrators, educators, and designers of AR technology. The results of the proposed model indicated that PBC is the most powerful construct of TPB. This finding implies that science teachers overcome the obstructive factors when using AR in their classes. This highlights the importance of creating beneficial conditions for usability that facilitate the use of AR technology in the classroom. Thus, school administrators and policymakers can provide technical and administrative possibilities that lead to increasing science teachers' intentions to use AR in their classes. Moreover, HM is the most influential factor from UTAUT2. This implies that science teachers place importance on fun in classes and accordingly, classrooms should be designed in a way that promotes joyful learning and teaching environments. Therefore, it can be stated that effective management of the use of AR in science classes has the potential for science teachers to make lessons more effective, efficient, and enjoyable. This implies that the provision of AR technology for educational purposes should be reinforced and encouraged, making classes suitable for this technology. Further, researchers can develop and design new applications that enable AR technology to adapt to science classes to maximize the benefits of such technology.

6.2. Limitations and future studies

The study has some limitations which should be addressed in future studies. First, the proposed model was tested with science teachers, and the items in the constructs were particularly prepared to be appropriate for using AR in science courses. Therefore, generalizing these results to other types of educational studies (e.g., mathematics or pre-school education) should be done carefully. In future studies, the proposed model should be applied to educators in different fields by adjusting the scale used in this study. Second, the study was conducted in school environments to decrease extraneous variance and enhance internal validity, response rate, and generalizability. Future studies can use a Web-based scale to reach a larger and more diverse sample. Third, although there was no problem with the sample of this study (n = 451), it cannot be claimed that the data were collected from a very large sample (Tabachnick et al., 2018). New studies with a larger sample size can strengthen the generalizability and external validity of the proposed model. Fourth, even though the study proposed successfully merging the TPB and the UTAUT2, new constructs (e.g., demographic variables, personal innovativeness, perceived playfulness, and perceived credibility) can be included in future studies. This will provide a more extensive comprehension of the use of AR in science classes. Fifth, future research could consider teachers performing the learning activity with AR technology and then conducting the questionnaire survey. This experiment would allow observing the change in teachers' intentions, which potentially would provide a stronger explanatory power to the model. Sixth, future research could consider surveying students' perspectives when teachers use AR technology in the course. This would allow us to understand the students' feelings in any form, and to further explain the critical factors regarding the adoption of AR technology. Finally, since the study uses a cross-sectional design, in the future, researchers can conduct longitudinal studies as indicated with latent growth models.

7. Conclusion

The present study determined several predictors of intention that are expected to foster the integration of AR in educational settings. Particularly, our proposed model including nine constructs and hypotheses was satisfactorily supported and not only focused on rational considerations, but also highlighted the role of habit, price, and motivational factors in understanding science teachers' intentions to use augmented reality. In addition, the study is unique in proposing and testing a conceptual model applying the framework of the TPB and UTAUT2. The study has also confirmed the feasibility of a well-established social-psychological model by examining science teachers' intentions to use AR in their classes. Combining TPB with UTAUT2, which focused on how and why individuals adopt AR, strengthens the utility, robustness, and predictive power of the proposed model. Therefore, this study provided considerable implications and unique insights into this important topic. The current study can also contribute to enriching the computer and instructional technologies and science education literature and help educators and AR technology designers develop better technology-based strategies. Finally, identifying what motivates the use of AR can provide a useful roadmap for educational uses of AR and thus improve the quality of the teaching-learning process.

Declarations

Conflict of Interest: None

Data Availability

The datasets are available from the corresponding author on reasonable request.

References

1. Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In *Springer Series in Social Psychology* (pp. 11–39). Springer Berlin Heidelberg.
2. Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.
3. Ajzen, I. (2002). Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior. *Journal of Applied Social Psychology.*, *32*(4), 665–683.
4. Ajzen, I. (2020). The theory of planned behavior: Frequently asked questions. *Human Behavior and Emerging Technologies*, *2*(4), 314–324. https://doi.org/10.1002/hbe2.195
5. Akar, S. (2019). Does it matter being innovative: Teachers' technology acceptance. *Education and Information Technologies*, *24*(6), 3415–3432.
6. Akçayir, M., & Akçayir, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, *20*, 1–11. https://doi.org/10.1016/j.edurev.2016.11.002
7. Ali, N., Sadiq, M., Albabawat, A., & Salah, R. (2022). Methods and Applications of Augmented Reality in Education: A Review. *2022 International Conference on Computer Science and Software Engineering (CSASE)*, 175–181. https://doi.org/doi: 10.1109/CSASE51777.2022.9759807.
8. Anderson, J., & Gerbing, D. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423.
9. Arici, F., Yildirim, P., Caliklar, Ş., & Yilmaz, R. M. (2019). Research trends in the use of augmented reality in science education: Content and bibliometric mapping analysis. *Computers and Education*, *142*(March), 103647. https://doi.org/10.1016/j.compedu.2019.103647
10. Ateş, H., & Garzón, J. (2022). Drivers of teachers' intentions to use mobile applications to teach science. *Education and Information Technologies*, *27*(2), 2521–2542. https://doi.org/10.1007/s10639-021-10671-4
11. Bai, X. (2020). *Examining Factors Influencing Behavioral Intention to Adopt Centralized Digital Currencies (CDC):An Empirical Study Based on the Integrated Model of UTAUT2 and TPB*.
12. Bekti, D. B. M., Prasetyo, Y. T., Redi, A. A. N. P., Budiman, A. S., Mandala, I. M. P. L., Putra, A. R., Persada, S. F., Nadlifatin, R., & Young, M. N. (2022). Determining factors affecting customer intention

to use rooftop solar photovoltaics in Indonesia. *Sustainability (Switzerland)*, *14*(1). https://doi.org/10.3390/su14010280

13. Bower, M., DeWitt, D., & Lai, J. W. M. (2020). Reasons associated with preservice teachers' intention to use immersive virtual reality in education. *British Journal of Educational Technology*, *51*(6), 2214–2232. https://doi.org/10.1111/bjet.13009
14. Cheng, E. W. L. (2019). Choosing between the theory of planned behavior (TPB) and the technology acceptance model (TAM). *Educational Technology Research and Development*, *67*(1), 21–37. https://doi.org/10.1007/s11423-018-9598-6
15. Cohen, J. (1992). Quantitative Methods in Psychology. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155
16. Conner, M. (2020). Theory of planned behavior. In *Handbook of Sport Psychology* (pp. 3–18). John Wiley & Sons.
17. Deutskens, E., De Ruyter, K., Wetzels, M., & Oosterveld, P. (2004). Response rate and response quality of internet-based surveys: An experimental study. *Marketing Letters*, *15*(1), 21–36.
18. Díaz, M., Toledo, P., & Hervás-Gómez, C. (2017). Augmented Reality Applications Attitude Scale (ARAAS): Diagnosing the Attitudes of Future Teachers. *The New Educational Review*, *50*(4), 215–226.
19. Dwivedi, Y. K., Rana, N. P., Jeyaraj, A., Clement, M., & Williams, M. D. (2019). Re-examining the Unified Theory of Acceptance and Use of Technology (UTAUT): Towards a Revised Theoretical Model. *Information Systems Frontiers*, *21*(3), 719–734. https://doi.org/10.1007/s10796-017-9774-y
20. Esfandiar, K., Dowling, R., Pearce, J., & Goh, E. (2020). Personal norms and the adoption of pro-environmental binning behaviour in national parks: An integrated structural model approach. *Journal of Sustainable Tourism*, *28*(1), 10–32.
21. Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Addison-Wesley.
22. Funmilola, B., Olalere, Y., Oluwole, O., Modupe, A., & Ayodeji, A. (2019). Examining Performance Expectancy And Effort Expectancy As Determinants Of Secondary School Teachers' Behavioural Intention To Use Mobile Technologies For Instruction In Kaduna State, Nigeria. *Association for Innovative Technology Integration in Education*, 31–39.
23. Garzón, J., & Acevedo, J. (2019). Meta-analysis of the impact of Augmented Reality on students' learning effectiveness. *Educational Research Review*, *27*, 244–260. https://doi.org/10.1016/j.edurev.2019.04.001
24. Garzón, J., Kinshuk, Baldiris, S., Gutiérrez, J., & Pavón, J. (2020). How do pedagogical approaches affect the impact of augmented reality on education? A meta-analysis and research synthesis. *Educational Research Review*, *31*, 1–19. https://doi.org/https://doi.org/10.1016/j.edurev.2020.100334
25. Georgiou, Y., & Kyza, E. A. (2018). Relations between student motivation, immersion and learning outcomes in location-based augmented reality settings. *Computers in Human Behavior*, *89*, 173–

181. https://doi.org/10.1016/j.chb.2018.08.011

26. Gravetter, F., & Forzano, L.-A. (2018). *Research methods for the behavioral sciences*. Cengage Learning.
27. Groves, M., & Zemel, P. (2000). Instructional technology adoption in higher education: An action research case study. *International Journal of Instructional Media*, *27*(1), 57–65.
28. Hu, S., Laxman, K., & Lee, K. (2020). Exploring factors affecting academics' adoption of emerging mobile technologies-an extended UTAUT perspective. *Education and Information Technologies*, *25*(5), 4615–4635.
29. Hung, Y.-H., Chen, C.-H., & Huang, S.-W. (2016). Applying augmented reality to enhance learning: a study of different teaching materials. *Journal of Computer Assisted Learning*, 1–15. https://doi.org/10.1111/jcal.12173
30. Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers and Education*, *123*, 109–123. https://doi.org/10.1016/j.compedu.2018.05.002
31. Jeong, H., & Kim, Y. (2016). The acceptance of computer technology by teachers in early childhood education. *Interactive Learning Environments*, *25*(4), 496–512.
32. Jokonya, O. (2017). Critical literature review of theory of planned behavior in the information systems research. *2nd International Conference on Advances in Management Engineering and Information Technology*, 177–181.
33. Kaye, S. A., Lewis, I., Forward, S., & Delhomme, P. (2020). A priori acceptance of highly automated cars in Australia, France, and Sweden: A theoretically-informed investigation guided by the TPB and UTAUT. *Accident Analysis and Prevention*, *137*(May 2019), 105441. https://doi.org/10.1016/j.aap.2020.105441
34. Khatri, V., Samuel, B. M., & Dennis, A. R. (2018). System 1 and System 2 cognition in the decision to adopt and use a new technology. *Information and Management*, *55*(6), 709–724. https://doi.org/10.1016/j.im.2018.03.002
35. Kuo, B. C. H., Roldan-Bau, A., & Lowinger, R. (2015). Psychological Help-Seeking among Latin American Immigrants in Canada: Testing a Culturally-Expanded Model of the Theory of Reasoned Action Using Path Analysis. *International Journal for the Advancement of Counselling*, *37*(2), 179–197. https://doi.org/10.1007/s10447-015-9236-5
36. Martins, C., Oliveira, T., & Popovič, A. (2014). Understanding the internet banking adoption: A unified theory of acceptance and use of technology and perceived risk application. *International Journal of Information Management*, *34*(1), 1–13. https://doi.org/10.1016/j.ijinfomgt.2013.06.002
37. Moorthy, K., Yee, T. T., T'ing, L. C., & Kumaran, V. V. (2019). Habit and hedonic motivation are the strongest influences in mobile learning behaviours among higher education students in Malaysia. *Australasian Journal of Educational Technology*, *35*(4), 174–191. https://doi.org/10.14742/ajet.4432
38. Morais, E., Morais, C., & Paiva, J. (2018). The Perspective of Higher Arts and Design Educators on Teaching Computer Programming. *ICERI2018 Proceedings*, 2043–2050.

39. Mustafa, F., & Hajan, B. H. (2022). The effect of an authentic learning experience on low-performing efl pre- service teachers ’ intentions to use e -learning for teaching. *Computer Assisted Learning*, *23*(1), 294–311.
40. Nizar, N., Rahmat, M., Maaruf, S., & Damio, S. (2019). Examiningthe Use Behaviour Of Augmented Reality Technology Through Marlcardio: Adapting The Utaut Model. *Asian Journal of University Education*, *15*(3), 198–210.
41. Osborne, J., & Fitzpatrick, D. (2012). Replication analysis in exploratory factor analysis: What it is and why it makes your analysis better. *Practical Assessment, Research, and Evaluation*, *17*(1), 1–8.
42. Sáez-López, J. M., Cózar-Gutiérrez, R., González-Calero, J. A., & Carrasco, C. J. G. (2020). Augmented reality in higher education: An evaluation program in initial teacher training. *Education Sciences*, *10*(2). https://doi.org/10.3390/educsci10020026
43. Salar, R., Arici, F., Caliklar, S., & Yilmaz, R. M. (2020). A Model for Augmented Reality Immersion Experiences of University Students Studying in Science Education. *Journal of Science Education and Technology*, *29*(2), 257–271. https://doi.org/10.1007/s10956-019-09810-x
44. Siang, T. G., Aziz, K. B. A., Ahmad, Z. B., & Suhaifi, S. Bin. (2019). Augmented Reality Mobile Application for Museum: A Technology Acceptance Study. *2019 6th International Conference on Research and Innovation in Information Systems (ICRIIS)*, 1–6.
45. Sungur-Gül, K., & Ateş, H. (2021). Understanding pre-service teachers’ mobile learning readiness using theory of planned behavior. *Educational Technology & Society*, *24*(2), 44-57.
46. Tabachnick, B., Fidell, L., & Ullman, J. (2018). *Using multivariate statistics*. Pearson.
47. Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, *22*, 960–967. https://doi.org/10.1016/j.promfg.2018.03.137
48. Tamilmani, K., Rana, N., & Dwivedi, Y. (2017). A Systematic Review of Citations of UTAUT2 Article and Its Usage Trends. In *Lecture Notes in Computer Science* (Vol. 10595, pp. 38–49). Springer. https://doi.org/10.1007/978-3-319-68557-1
49. Tamilmani, K., Rana, N., & Dwivedi, Y. (2018). Use of‘Habit’Is not a Habit in UnderstandingIndividual Technology Adoption: A Reviewof UTAUT2 Based Empirical Studies. *International Working Conference on Transfer and Diffusion of IT*, *533*, 277–294.
50. Tamilmani, K., Rana, N., Dwivedi, Y., Sahu, G., & Roderick, S. (2018). Exploring the Role of “Price Value” forUnderstanding Consumer Adoption ofTechnology: A Review and Meta-analysis ofUTAUT2 based Empirical Studies. *PACIS 2018 Proceedings*, 64.
51. Teo, T., Zhou, M., & Noyes, J. (2016). Teachers and technology: development of an extendedtheory of planned behavior. *Educational Technology Research and Development*, *64*(6), 1033–1052.
52. Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *Mis Quarterly*, *27*(3), 425–478. https://doi.org/10.2307/30036540
53. Venkatesh, V., Thong, J., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *Mis Quarterly*, *36*(1), 157–178.

https://doi.org/10.1109/MWSYM.2015.7167037

54. Videnovik, M., Trajkovik, V., Kiønig, L. V., & Vold, T. (2020). Increasing quality of learning experience using augmented reality educational games. *Multimedia Tools and Applications*, *79*(33–34), 23861–23885. https://doi.org/10.1007/s11042-020-09046-7
55. Watson, J. H., & Rockinson-Szapkiw, A. (2021). Predicting preservice teachers' intention to use technology-enabled learning. *Computers and Education*, *168*(April), 104207. https://doi.org/10.1016/j.compedu.2021.104207
56. Xian, X., & Shen, H. (2020). Assessing Intentional Use of AR in Cultural Heritage Learning. *20 International Symposium on Educational Technology (ISET)*, 93–96.
57. Yuen, K. F., Huyen, D. T. K., Wang, X., & Qi, G. (2020). Factors influencing the adoption of shared autonomous vehicles. *International Journal of Environmental Research and Public Health*, *17*(13), 1–16. https://doi.org/10.3390/ijerph17134868

Figures

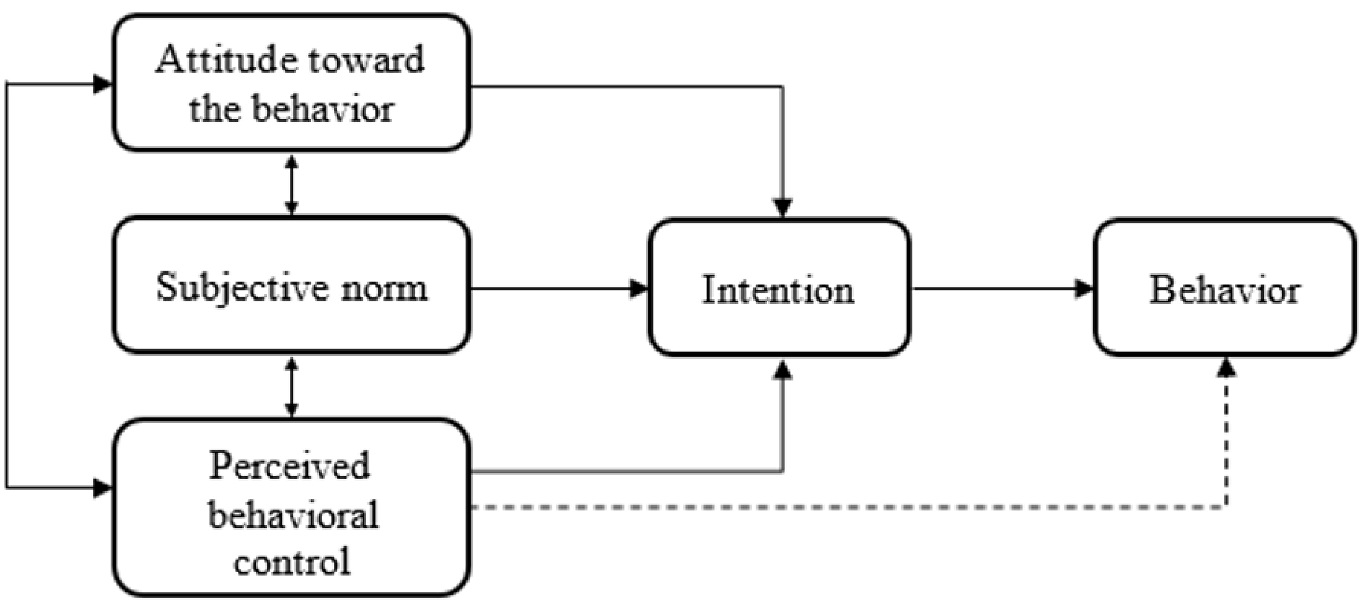

Figure 1

TPB adapted from Ajzen (1991).

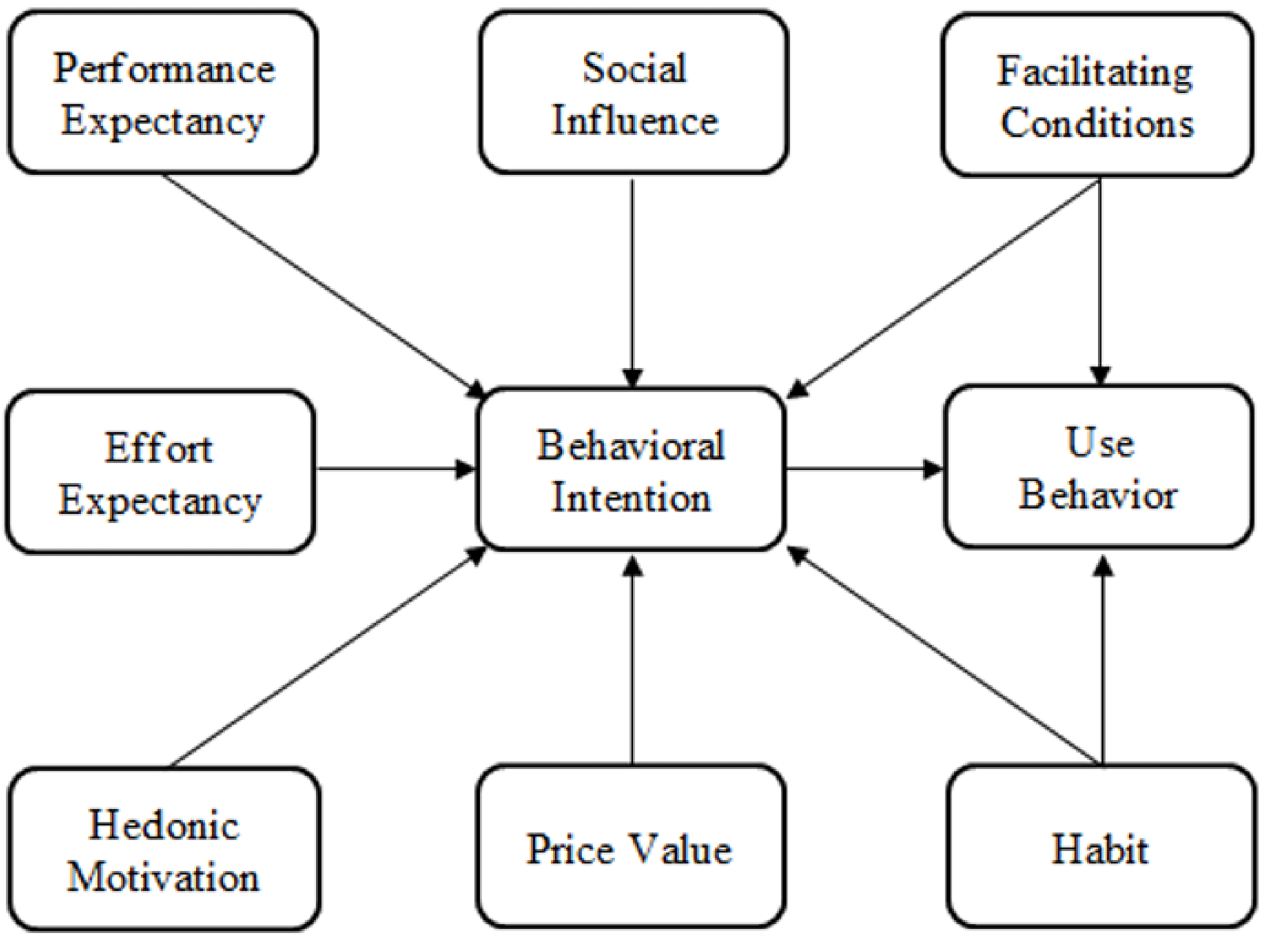

Figure 2

UTAUT2, adapted from Venkatesh et al. (2012).

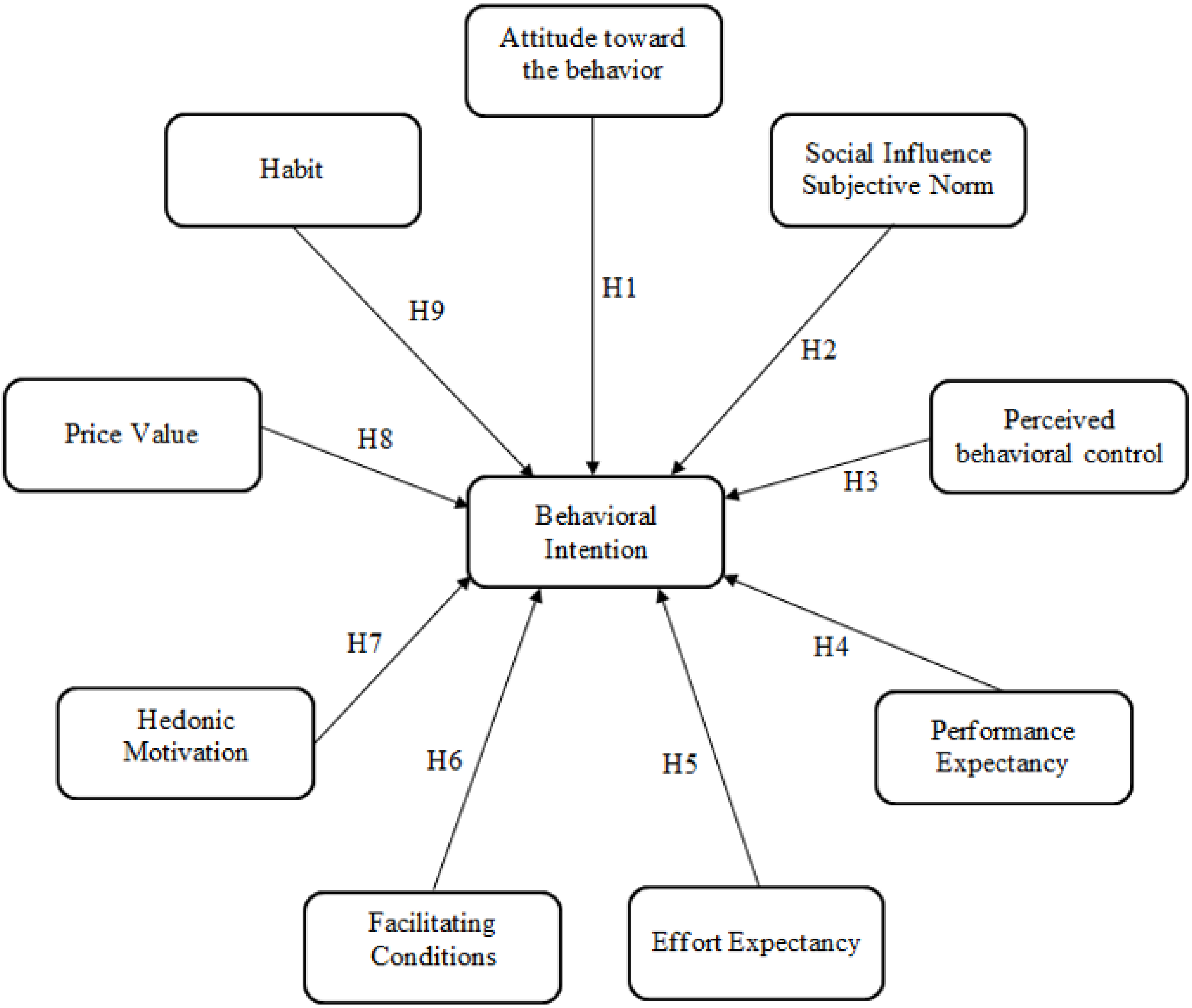

Figure 3

Proposed model.

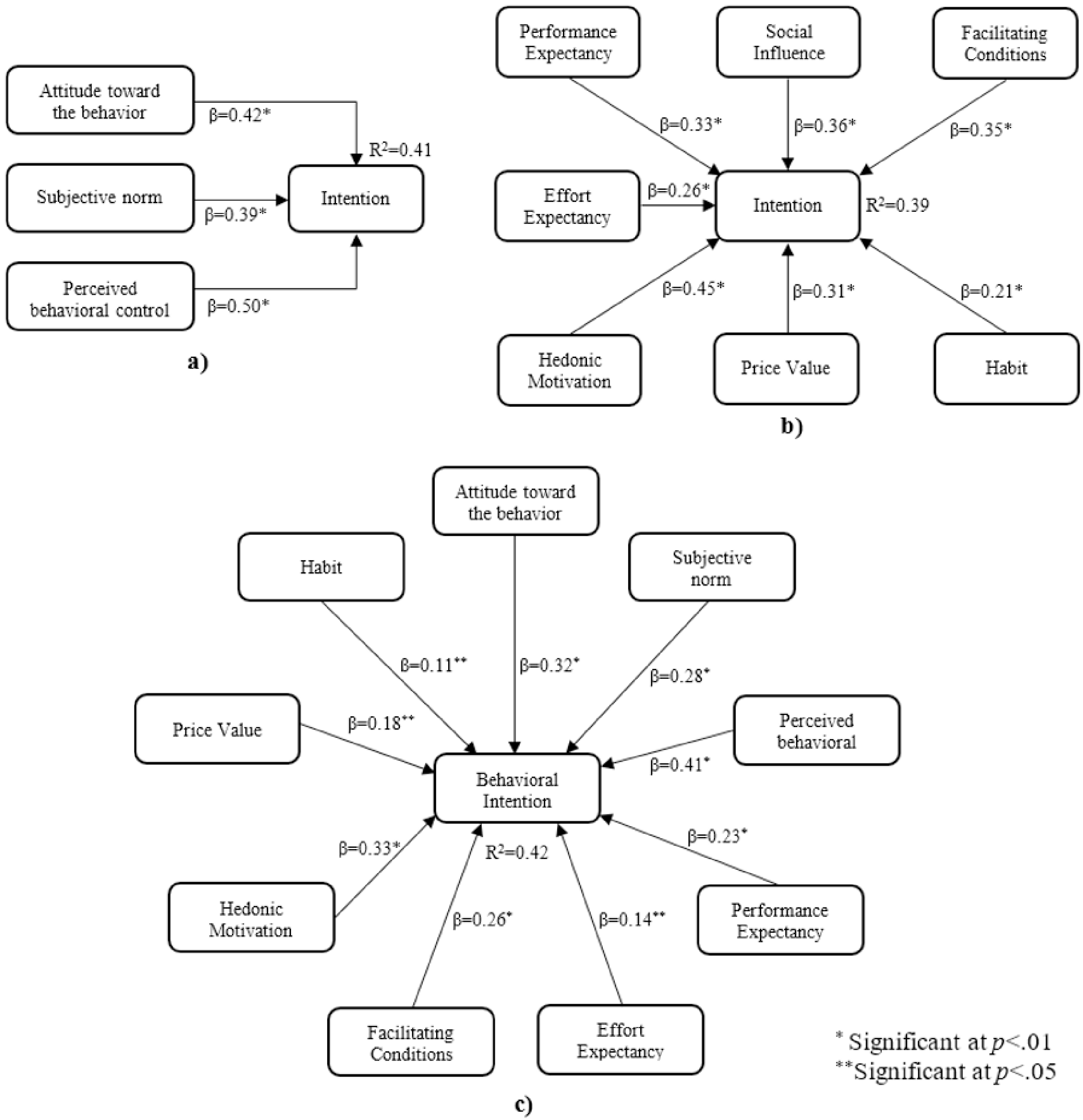

Figure 4

Results of the structural models.

Note: a, b, and c represent results of TPB, UTAUT 2, and the proposed model, respectively.