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Evaluation of metaverse use intention in software education of university students: combining technology acceptance model with external variables

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Abstract
Technological advancements in recent years have accelerated the development of information and communication technologies, introducing numerous innovations. One prominent innovation is the concept of the metaverse, which has gained significant popularity and is increasingly influencing various sectors, including the economy, art, entertainment, and education. Despite its growing relevance, there is a practical gap in understanding how management information systems students in Türkiye perceive the use of the metaverse for software education. This study aims to address this gap by exploring students' perceptions and identifying the factors that influence their intentions to use the metaverse. The conceptual model includes adoption characteristics such as traibility, observability, compatibility, and complexity, as well as user satisfaction, personal innovativeness, and the structures of the technology acceptance model. The data of the study were obtained from 877 students, and the collected data were analyzed utilizing the structural equation modeling technique. The results indicate that personal innovativeness positively influences perceived usefulness and perceived ease of use. However, perceived observability, user compatibility, and perceived traibility did not significantly impact user satisfaction. Conversely, perceived usefulness, user satisfaction, and perceived ease of use positively affect students' intentions to use the metaverse for software education. This study offers valuable contributions to the metaverse literature, educators, field experts, and researchers.

Keywords Metaverse · Technology acceptance · Software education · Management information systems

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Introduction

Metaverse is a combination of the words 'meta' and 'universe' and is a hypothetical synthetic environment associated with the physical world. Metaverse is a cyber-social platform that offers a new reality, a world of meaning and cooperation opportunities from a communication perspective, provides infrastructure and interaction opportunities for cultural, intellectual, and economic production, and where different advanced technologies are used simultaneously and in an integrated manner (Kus, 2021). Metaverse connects users online with a character (avatar) in a 3D virtual environment. Metaverse was first mentioned in the 1992 novel 'Snow Crash' by Neal Stephenson. This novel describes the Metaverse as a vast virtual environment parallel to the physical world, where users interact through digital avatars (Joshua, 2017).

Numerous universities and educational institutions have undertaken multiple studies with the metaverse as a focal point. Several academic studies have been conducted on Metaverse (Akour et al., 2022; Kanematsu et al., 2013) employing a problem-based approach to investigate their application in academic settings (Kanematsu et al., 2012). This approach involves learners and educators utilizing 3D classrooms and avatars for virtual problem-solving (Barry et al., 2009). Jeon and Jung (2021) argue that Metaverse provides an enhanced immersive experience, offering learning opportunities and boosting learners' motivation. They posit that Metaverse enables students to foster innovation and engage in independent learning. Other researchers, have explored the significance of metaverse in diverse fields, including its application as a problem-based learning technique (PBL) within an educational framework and its role in visual culture within the "immersive metaverse", viewed through the lens of visual cognition (Han, 2022; Kanematsu et al., 2009; Sahar et al., 2011). In light of this, there is a need to construct a conceptual model that comprehensively captures the influential role of the metaverse system from students' perspectives, examining its effectiveness and impact.

These studies have investigated the importance of metaverse by examining real-life situations where it was utilized to address problems. Given the growing role of the metaverse in educational institutions, there is a need to explore the predictors of technological adoption in learning environments. This study specifically delves into the impact of personal innovativeness (PI) and user satisfaction (US) on user's intention to use the Metaverse system (INT) in educational settings. User satisfaction is contingent upon Perceived Compatibility (PCO), Perceived Traibility (PTR), and Perceived Observability (POB), with higher levels of POB, PTR, and PCO associated with increased user satisfaction (Wu & Wang, 2005). On the other hand, PI is influenced by Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) of the technological innovation (Chang & Tung, 2008).

The attitudes and behaviors of people towards the developments in the metaverse field are of great importance. Both educational institutions and educators need to know the factors affecting the decision of students to adopt Metaverse, a relatively new technology, and the factors that may increase their tendencies and commitment to Metaverse in order to take action for the future. For this reason, this study aims to determine the level of adoption of software education in Metaverse by the students of Management Information Systems and to contribute to the literature with the findings. The study sample is the students from the Department of Management Information Systems in Türkiye. This is because the students studying in this department follow technological innovations closely and have high technological awareness. This study aims to provide a foundation for future research and to advance and enrich the knowledge of Metaverse adoption in software education.

The subsequent sections of this paper are structured as follows: The following section provides an overview of the primary themes addressed in the existing literature. Subsequently, a section is dedicated to the discussion and elucidation of the conceptual model and the research hypotheses. Section four outlines the methodology employed, while section five delves into the empirical results. A thorough examination of the discussions is undertaken in section six, where their theoretical contributions and practical implications are considered. The conclusion section encapsulates the research findings, identifies limitations, and outlines avenues for future research.

Literature review

In order to illuminate developments in the field of Metaverse, we first introduce the concept, definition and stages of Metaverse. We then examined the broader field of Metaverse research in the field of education, looking for insights that can contribute to our understanding of emerging research trends related to the use of Metaverse in education. Furthermore, a comprehensive review of relevant literature using technology acceptance in software education was conducted, thus informing the methodological approach used for data analysis in our study.

Metaverse idea and definitions

The studies on the Metaverse, which has an etymological history of 30 years, have gained momentum recently. The emergence of technological innovations such as the Internet of Things (IoT), three-dimensional (3D) printers, and blockchain-based technological infrastructures (for example, virtual currencies, NFTs: Non-Fungible Tokens) has made this concept more popular today (Celik, 2022). Bosworth and Clegg (2021) elucidate the metaverse as a collection of online worlds where individuals can interact and explore with others who may not be physically present. In their study, Park and Kim (2022) delineate four fundamental dimensions of the Metaverse narrative: surroundings, connection, societal value, and individual characteristics. These dimensions play a pivotal role in augmenting user interaction and the integration of non-player characters within augmented reality space.

Ko et al. (2021) defined the Metaverse as "a 3-dimensional virtual reality in which daily activities and economic life are carried out through virtual identities, in other words, avatars". Daily activities and economic life are virtual extensions of real life in this environment. The real-world merges with the virtual space, and reality is extended into the virtual space. In other words, a person's real identity defines the virtual identity in the Metaverse. Individuals with virtual identities engage in social, economic, and cultural activities in the metaverse universe. In addition, Lee et al. (2021) defines the Metaverse as "a world in which virtual reality interacts and evolves with reality, and in which social, economic, and cultural activities are carried out to create value." Kar and Varsha (2023) stated that it refers to a virtual world where the practical and the unreal coexist in the routines of daily life.

Metaverse provides a riveting interaction and connects users with various fields such as fashion, events, games, work, entertainment, education, office, and land. Thanks to these features, it is also accepted as a new type of social network (Egliston & Carter, 2021; Kim, 2021). The concept of virtual reality, which means computer-simulated, interactive, and

riveting virtual environments that separate users from their physical environment by using various methods, are the essential feature that distinguishes Metaverse platforms from other digital environments (Dozio et al., 2022; Yılmaz & Ecemiş, 2022). Metaverse has three main aspects: presence, interoperability, and standardization. Presence is the feeling of being and embodying in a virtual space with other individuals. Interoperability is the ability to seamlessly travel between virtual spaces with the same virtual assets, such as avatars and digital items. Standardization ensures the interoperability of platforms and services in the Metaverse.

Lee (2021) stated that there is a paradigm shift in information and communication technologies every ten years. Accordingly, computer communication in the 1990s, the web in the 2000s, and mobile technologies in the 2010s have changed, and the Metaverse is the keyword of the 2020s' paradigm. Dionisio et al. (2013) stated that the Metaverse, which is a three-dimensional virtual world that enables the interaction of the real and virtual world, will increase its popularity. In this context, we will discuss virtual and augmented reality, two critical technologies, much more intensely in the future.

It seems that the three-dimensional virtual world, virtual reality, and augmented reality, which have an important use in the education sector, will take their place in the sector with the Metaverse today. Although the Metaverse concept is increasing its popularity, academic discussions about it are limited (Duan et al., 2021).

Review of the literature on metaverse and technology acceptance studies in education

In a scholarly exploration of the metaverse, Damar (2021) asserted that the metaverse topic is extensively addressed through the application of virtual reality and augmented reality technologies, garnering significant attention in the education sector. Furthermore, posited that the metaverse is likely to permeate various facets of our existence over the next 15–20 years, molding our lives through advancing. Although the Metaverse in education has not yet received widespread attention, diligent research on this innovative technology has yielded valuable insights (Guo & Gao, 2022). Investigations into the educational applications of the Metaverse and technology adoption have predominantly focused on domains such as science education, medical education, e-learning, engineering education, and applications involving augmented reality/virtual reality (AR/VR).

İbili et al. (2023) conducted an investigation into the intentions of undergraduate students to continue learning computer hardware concepts. Utilizing the Technology Acceptance Model (TAM) and the Generalized Extended Technology Acceptance Model for E-Learning (GETAMEL), the study examined factors influencing the usage of a Metaverse-based system. Findings indicate that Perceived Usefulness and Hedonic Motivation have a significant positive impact on Behavioral Intention. In a study by Al-Adwan and Al-Debei (2023), a model integrating UTAUT2 with Personal Innovativeness in IT (PIIT) was evaluated among 537 Jordanian Generation Z students. Results show that Generation Z's adoption intentions for the metaverse in higher education learning environments are significantly and positively influenced by various determinants, including social influence.

Teng et al. (2022) examined factors influencing student adoption of an educational metaverse platform, incorporating an extended Unified Theory of Acceptance and Use of Technology (UTAUT) model and perceived risk. Findings suggest that performance expectancy, effort expectancy, social influence, and facilitating conditions significantly influence students' satisfaction with the metaverse. The study also found that student satisfaction

positively affects their intention to continue using the metaverse, and students' intention to use the metaverse decreases after perceiving risks. Wiangkham and Vongvit (2023) employed an extended UTAUT model to investigate the adoption of metaverse technology in engineering education. Findings reveal that factors such as cybersecurity, performance expectancy, social influence, and hedonic motivation significantly affect the behavioral intention to use metaverse technology for learning. Alkhwaldi (2023) aimed to determine user intentions towards Metaverse technology for educational purposes in Jordanian higher education institutions. Data from 441 Jordanian university students were collected, and a structural equation model was used to assess significant factors influencing user's intentions to use Metaverse. Almarzouqi et al. (2022) assessed perceptions of United Arab Emirates (UAE) students regarding the application of Metaverse in medical education. Based on a survey of 1858 university students, the study identified User Satisfaction (US) as a significant determinant influencing students' intentions to use the metaverse system. Akour et al. (2022) examined the perceptions of Gulf region students regarding the use of the metaverse system for educational purposes. The conceptual model included adoption characteristics such as traibility, observability, compatibility, and complexity, as well as user satisfaction, personal innovativeness, and the TAM structures. The study revealed that Perceived Usefulness (US) is a significant determinant influencing users' intentions to use the metaverse system.

Rationale importance and contribution of the present study

The primary objective of this study is to examine the predictors of users' intention to use the Metaverse system (INT) in the software education. Specifically, the study aims to investigate the impact of Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) on INT in the software education. Additionally, the study intends to assess the effect of PEOU and PU on Personal Innovativeness (PI), while also evaluating the impact of User Compatibility (UC), Perceived Observability (POB), and Perceived Traibility (PTR) on User Satisfaction (US). Therefore, the conceptual model of the present study is designed to predict the value of PEOU and PU on INT and the predictors of PU and PEOU.

The contribution of each of the studies discussed in the previous section to the field is undoubtedly valuable. However, studies investigating the perceptions of metaverse usage in the field of education are limited (Akour et al., 2022; Almarzouqi et al., 2022; Handoko et al., 2023). In particular, the perspectives of students in higher education regarding the intention to use metaverse in software education have not been investigated. Therefore, this study is important as it is a pioneering study that examines the intention to use the Metaverse from the perspective of students based on TAM. In this context, the current study is of great significance as a pioneering investigation into the expansion of metaverse usage intention predictors in software education.

Conceptual model and hypotheses

Researchers have used various theories and models in their efforts to validate users' intention to use Metaverse in education and the key factors that influence it. These include TAM (Wang & Shin, 2022), UTAUT (Alkhwaldi, 2023), UTAUT2 (Al-Adwan & Al-Debei, 2023) and Information System Success model (ISSM) (Al-Adwan & Al-Debei, 2023).

A careful examination of these theories and models reveals that it is crucial to consider a theoretical foundation tailored to Metaverse intention to use. To address this, the study adopted the TAM due to its simplicity and suitability for application in academic settings (Landry et al., 2006). As emphasized by Shachak et al. (2019) the simple structure of TAM makes it a valuable tool for directly assessing user acceptance of new technologies and distinguishes it from other models such as the UTAUT.

TAM includes three key constructs: perceived usefulness, perceived ease of use and intention to use. Therefore, it is imperative to investigate the potential impact of perceived usefulness and ease of use on Metaverse adoption in educational settings. In particular, a review of previous studies underscores the need to investigate intention to use Metaverse in education (Akour et al., 2022; Almarzouqi et al., 2022; Handoko et al., 2023).

Figure 1 shows research model current study. The current study explores the influence of Personal Innovativeness (PI) and User Satisfaction (US) on users' intention to use the Metaverse system (INT) in learning and education settings. US is contingent on User Compatibility (UC), Perceived Traibility (PTR), and Perceived Observability (POB) (Wu & Wang, 2005). Specifically, heightened levels of POB, PTR, and UC are associated with increased US. On the other hand, PI is dependent on Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) of the technological innovation (Chang & Tung, 2008).

The personal innovativeness

Personal innovativeness is an individual's willingness to try a new information technology (Agarwal & Prasad, 1998). Some individuals in society can adapt to new technologies more quickly, while some of them may lag behind in this regard. The ability of individuals to adapt to technology and innovations is called personal innovativeness (Agarwal &

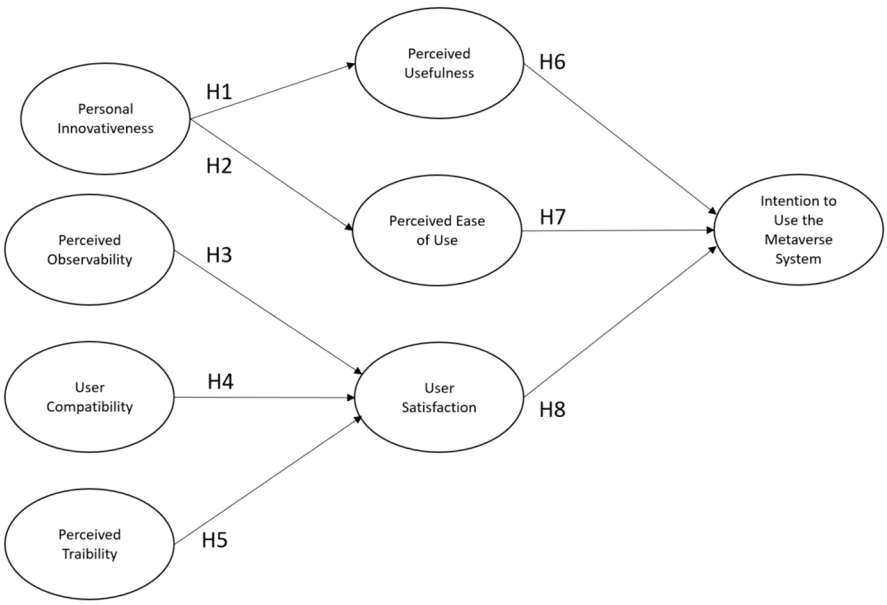

Fig. 1 Proposed research model

Prasad, 1998). Personal innovativeness encourages individuals to adopt a positive attitude towards technological innovations (Rogers, 1995). According to Rogers (1995), personal innovativeness is the tendency to assume technical risks generated and affected by perceived usefulness and perceived ease of use. The reason for using this variable in this study is that innovative individuals are more inclined to use software-based technologies. Some studies in the literature (Lu et al., 2005; Xu & Gupta, 2009) have shown that personal innovativeness affects the use of software-based products.

Davis (1989) stated that perceived usefulness and perceived ease of use are the most critical factors in TAM. Perceived usefulness refers to the degree to which users of the technology believe it will be useful, while perceived ease of use is the user's belief that a particular technological innovation will require little effort to operate. The conceptual model of this study argues that personal innovativeness significantly affects perceived usefulness and perceived ease of use (Akour et al., 2022; Almarzouqi et al., 2022; Celik & Sokmen, 2018; Gor, 2015; Handoko et al., 2023; Lee et al., 2011). In this context, the following hypotheses are proposed:

H1 Personal Innovativeness would predict the Perceived Usefulness.

H2 Personal Innovativeness would predict the Perceived Ease of Use.

The perceived traibility, observability, and compatibility

Traibility is the degree to which an innovation can be tested on a limited basis (Rogers, 1995). Innovative early adopters may make traibility more remarkable than late adopters (Fliegel & Kivlin, 1966). Fliegel and Kivlin (1966) stated that the traibility feature of an innovation has a positive and serious effect on the adoption and acceptance of that innovation. Agarwal and Prasad (1998) argued that if those who want to adopt an innovation have an experience with it before using it, their degree of adoption will increase.

Observability is the degree to which the results of an innovation are visible to others. The adoption of an innovation by other members is one of the critical factors in observability because it is pretty easy and practical to see and embody the results of the innovation in those who have adopted it before them. For this reason, information about the innovation is obtained from the immediate environment using the innovation. Those who analyze and observe the innovation well will know more about it. Thus, they will perceive and adopt the benefits of innovation in a short time. The easier the innovation results appear, the faster they will be adopted (Rogers, 1995).

Tornatzky and Klein (1982) defined compatibility as conforming to the values of potential adopters. Compatibility is the degree to which an innovation is perceived as consistent with its current values and experiences. The rate of adoption of an idea incompatible with the basic behaviors and rules in the social system is quite low. Adopting an incompatible innovation often requires prior adoption of a new value system. Innovation compatible with the system's values will be adopted more quickly (Rogers, 1995). If users think that innovation is suitable for their lifestyle, they adapt more easily to innovation.

This study will evaluate the effects of testability, observability, and compatibility factors on metaverse user satisfaction in software education. Many studies have shown that these variables significantly affect user satisfaction (Akour et al., 2022; Almarzouqi et al., 2022; Handoko et al., 2023). Considering these features, innovations with high

compatibility, traibility, and observability rate will be adopted by system users faster. In this context, the following hypotheses are proposed:

H3 Perceived Observability would predict the User Satisfaction.

H4 User Compatibility would predict the User Satisfaction.

H5 Perceived Traibility would predict the User Satisfaction.

Perceived usefulness, perceived ease of use and user's satisfaction

Perceived ease of use and perceived usefulness are the critical criteria of the TAM. Perceived ease of use refers to a person's perception of the effortlessness of using a system. Perceived usefulness, on the other hand, is the individual's personal belief about the benefit the system will bring to him/her and the increase in performance when he/she uses it (Davis, 1989). Perceived usefulness and perceived ease of use in the TAM affect one's attitude towards new technology. If the user understands that a technology will improve its performance, he/she is much more likely to adapt to that system (Davis, 1989). In other words, if the system is useful, users develop a positive attitude towards it, and as a result, they intend to use it (Elwalda et al., 2016). Perceived ease of use, unlike perceived usefulness, is more related to the intrinsic motivations of the user. Intrinsic motivation is performing an activity on its own without any reinforcement (Davis & Kay, 1990).

Satisfaction is individuals' perception of their needs and general views about a technology (Wang & Wang, 2009). In addition, satisfaction means that the user's needs, goals, and wishes can be fully met (Mohammadi, 2015). It has been demonstrated in many studies in the literature that satisfaction significantly affects use (Akour et al., 2022; Almarzouqi et al., 2022; Celik & Orhan, 2021; Handoko et al., 2023). In this context, the following hypotheses are proposed.

H6 Perceived Usefulness would predict User Intention to Use the Metaverse System.

H7 Perceived Ease of Use would predict User Intention to Use the Metaverse System.

H8 User Satisfaction would predict User Intention to Use the Metaverse System.

User's intention to use the metaverse system

Many studies describing the future of technology use have extensively investigated the intention factor as a dependent variable (Ajzen, 1991; Davis, 1989; Venkatesh et al., 2003, 2012). In this study, a research model is proposed by considering various features as possible determinants of the intention to use Metaverse in order to investigate the perceptions of the students of Management Information Systems in Türkiye towards using Metaverse for software education. Figure 1 shows the proposed research model.

Research methodology

This research aims to measure the intentions of Management Information Systems students in Türkiye to use Metaverse in software education through the variables of perceived traibility, perceived observability, user compatibility, personal innovativeness, user satisfaction, perceived usefulness, and perceived ease of use. This section gives information about the data collection technique and scales.

Data collection and analysis technique

A questionnaire was used as the data collection tool. For this purpose, a literature review was conducted first. As a result of the review, a new research model was proposed. The scales of this model were determined. The original forms of the scales were translated from English to Turkish in two stages. First, two academicians and two translation experts, fluent in English in their field, independently translated all the scales into Turkish. In the next step, a researcher and a translation expert compared the obtained translations, and the translations with the best expression were accepted. Then, two expert academicians rechecked the scales, and the scale took its final form. The online version of the questionnaire was created via Google Forms. The link obtained was delivered to the Management Information Systems Department students through various social media accounts, forums, and blogs between 1 and 15 June 2022. As a result, 877 usable data were obtained.

In the study, the R program was used to create demographic information and to perform confirmatory factor analysis and structural equation model analysis. SPSS 18 program was used to determine the reliability of the scales used in the study and to create the correlation matrix.

Scales used in the research and creating the questionnaire

The data used to test the research model were obtained by applying an online questionnaire to the students of the Management Information Systems department. The introductory part of the questionnaire explains the brief description of the Metaverse, the purpose of the study, and by whom it was conducted. The first part of the questionnaire includes questions to determine the demographic characteristics of the participants. The second part consists of a comprehensive questionnaire consisting of scales of intention to use Metaverse for software education, perceived traibility, perceived observability, user compatibility, personal innovativeness, user satisfaction, perceived usefulness, and perceived ease of use. These statements were presented to the participants using a 5-point Likert scale. The options are between "Strongly Disagree" and "Strongly Agree," and respondents were asked to mark the appropriate option according to their level of agreement. The Perceived Traibility scale was adapted from (Jon et al., 2001; Martins et al., 2004; Rogers, 1995), the Perceived Observability scale from (Bennett & Bennett, 2003; Martins et al., 2004), the Perceived Compatibility scale from (Chang & Tung, 2008), the Personal Innovativeness scale from (Agarwal & Prasad, 1998), the Perceived Ease of Use and Perceived Usefulness scales from (Doll et al., 1998), and the scale of Intention to use Metaverse from (Barclay et al., 1995; Teo et al., 2008).

Results

The results section begins with an initial review of demographic statistics, followed by a two-stage Structural Equation Modeling (SEM) approach used to validate the conceptual model and test the relevant hypotheses. Sect. "Confirmatory factor analysis" summarizes the results of the Confirmatory Factor Analysis (CFA) conducted in the first stage, while Sect. "Structural model" describes the results of the second stage focusing on the structural model within the SEM framework.

Demographic statistics

First, demographic data were analyzed. Table 1 shows the demographic findings of the study participants. Accordingly, 56% (n = 491) of the participants were male and 44% (n = 386) were female. 9% (n = 83) of the participants were 1st year students, 23% (n = 198) 2nd year students, 41% (n = 362) 3rd year students, 27% (n = 234) 4th year students. Participants were asked how long ago they had heard the term Metaverse. 46.8% (n = 410) of the participants heard it less than 1 year ago, 35.6% (n = 312) 1–2 years ago, 10.7% (n = 94) 2–3 years ago, and 7% (n = 61) answered that they heard it more than 3 years ago.

Confirmatory factor analysis

The initial phase of the analysis entailed evaluating the model's adequacy through Confirmatory Factor Analysis (CFA). Various fit indices were considered for this purpose, encompassing the Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Comparative Fit Index (CFI), Normed Chi-Square (CMIN/DF), Normed-Fit Index (NFI), and Root Mean Square Error of Approximation (RMSEA) (Hair et al., 2010). The outcomes of these assessments are presented in Table 2.

As seen in Table 2, six of the goodness of fit values for the first version of the measurement model had acceptable and five has good fit values.

Table 3 shows the Cronbach Alpha Reliability Coefficient, AVE (Average Variance Extracted), CR (Composite Reliability) values, and correlation matrix for all scales. Accordingly, only the Cronbach Alpha coefficient of the Perceived Traibility scale is

Table 1 Demographic data of the respondents

Criterion	Factor	Frequency	Percentage
Gender	Male	491	56
	Female	386	44
What grade are you in?	1st class	83	9
	2nd class	198	23
	3rd class	362	41
	4th class	234	27
How long ago did you hear the term metaverse?	Less than 1 year	410	46.8
	Between 1–2 years	312	35.6
	Between 2–3 years	94	10.7
	3 years and above	61	7
Total		877	100

Table 2 Values of the goodness of fit

Fit index	Value	Good fit values	Acceptable fit values	Result
Chi square/df	744.704/224 = 3.32	< 3	< 5	Acceptable
CFI	0.963	> 0.95	> 0.90	Good fit
RMSEA	0.051	< 0.050	< 0.080	Acceptable
TLI	0.954	> 0.95	> 0.90	Good fit
RNI	0.963	> 0.95	> 0.90	Good fit
NNFI	0.954	> 0.95	> 0.90	Good fit
IFI	0.963	> 0.95	> 0.90	Good fit
RFI	0.936	> 0.95	> 0.90	Acceptable
NFI	0.948	> 0.95	> 0.90	Acceptable
GFI	0.930	> 0.95	> 0.90	Acceptable
AGFI	0.906	> 0.95	> 0.90	Acceptable

Table 3 Cronbach's alpha, AVE, CR values, and correlation matrix

	α	AVE	CR	1	2	3	4	5	6	7	8
PI	.772	.452	.711	1							
POB	.797	.562	.794	.607**	1						
UC	.831	.626	.834	.644**	.748**	1					
PTR	.550	.388	.607	.484**	.650**	.624**	1				
PU	.867	.686	.868	.630**	.711**	.695**	.563**	1			
PEU	.852	.656	.851	.684**	.632**	.686**	.487**	.687**	1		
US	.826	.615	.827	.678**	.739**	.731**	.599**	.762**	.714**	1	
INT	.879	.709	.880	.609**	.653**	.712**	.557**	.757**	.676**	.725**	1

α: cronbach alpha coefficient, *AVE*: average variance extracted, *CR* construct reliability, *PI*: personal innovativeness, *POB* perceived observability, *UC* user compatibility, *PTR* perceived traibility, *PU* perceived usefulness, *PEU* perceived ease of use, *US* user satisfaction, *INT* intention to use the metaverse

**p < .01

0.550, and the Cronbach Alpha coefficient of the other scales is between 0.772 and 0.879. This finding shows that the Perceived Traibility scale has medium reliability, while the other scales have high reliability (Iacobucci & Duhachek, 2003; Nunnally, 1978). For convergent validity, Construct Reliability (CR) must be greater than the Average Variance Extracted (AVE) (Fornell & Larcker, 1981; Hair et al., 2010).

Table 3 shows that the AVE value of the Perceived Traibility scale is 0.388, and the AVE value of the Personal Innovativeness scale is 0.452. AVE values of other scales range from 0.562 to 0.709. The CR values of all structures are higher than the AVE values. This finding shows that the scales are valid. Correlation analysis was performed to show the relationships between the variables. The analysis revealed a significant ($p < .01$) positive relationship between all variables. The strongest relationship between structures is between perceived usefulness and user satisfaction ($r = .762$, $p < .01$), and the weakest relationship is between personal innovativeness and perceived traibility ($r = .484$, $p < .01$).

Structural model

The conceptual model's research hypotheses underwent testing in the second stage through Structural Equation Modeling (SEM). Initially, the fit indices of the structural model were assessed and found to be consistent with their recommended levels, indicating a favorable model fit: CMIN/DF = 3.77; GFI = 0.916; AGFI = 0.894; NFI = 0.937; CFI = 0.953; and RMSEA = 0.056. These fit indices affirm the overall adequacy of the fit obtained for the structural model, aligning with the guidelines proposed by (Hair et al., 2010). Moreover, the conceptual model demonstrated predictive validity, as a substantial proportion of variance (0.78) was explained in the context of Metaverse use intention.

Regarding the examination of research hypotheses (Table 4), the outcomes of the path coefficient analyses revealed that Intention to Use the Metaverse System was significantly influenced by various factors: Perceived Usefulness (PE) ($\gamma = .487$, $p < .000$), Perceived Ease of Use (PEU) ($\gamma = .121$, $p = .046$) and User Satisfaction (US) ($\gamma = .319$, $p = .009$). Additionally, the effect of Personal Innovativeness ($\gamma = .902$, $p < .000$/$\gamma = .896$, $p < .000$) on both perceived usefulness and perceived ease of use was statistically supported. However, the impact of Perceived Observability (PO) ($\gamma = 4.725$, $p = .075$), User Compatibility ($\gamma = -.375$, $p = .586$) and Perceived Traibility (PT) ($\gamma = -3.482$, $p = .093$) on User satisfaction was not statistically supported (Fig. 2).

Discussion

The empirical findings substantiate the predictive validity of the majority of the proposed factors. Results from the Confirmatory Factor Analysis (CFA) predominantly underscore the favorable fit of the measurement model to the observed data. Additionally, all factors satisfactorily meet the key criteria for the reliability and validity of constructs. Furthermore, the current study's model successfully elucidates approximately 0.78 of the variance in User Intention to Use the Metaverse System. This validation underscores the robust theoretical foundation of the current model.

The findings show that the personal innovativeness factor significantly affects perceived usefulness and perceived ease of use. Therefore, the H1 and H2 hypotheses were supported. This study's findings were compatible with many studies (Akour et al., 2022; Almarzouqi et al., 2022; Lai, 2017). The higher the innovativeness of individuals, the higher their perceived usefulness and perceived ease of use. Individuals with high innovativeness follow new technologies closely, are eager to use new technological devices as soon as possible, and can easily adopt them. When the significant relationship between personal innovativeness and perceived usefulness is examined, it is expected that students interested in new technologies will positively perceive the use of Metaverse in software education. College students are likely to respond more positively to uncertain situations if they use innovative technology. In terms of the significant relationship between personal innovativeness and perceived ease of use, students with strong innovative aspects are expected to find using Metaverse in software education effortless. Personal characteristics, including personal innovation, significantly affect adopting the metaverse system. A student willing to use a new technology positively perceives adopting the Metaverse system. In other words, a student willing to use a new technology has positive feelings towards uncertain situations and may develop a

Table 4 Structural equation model analysis

Hypothesis	Std. β	p	Supported/not supported
H1: personal innovativeness would predict the perceived usefulness	.902	.000	Supported
H2: personal innovativeness would predict the perceived ease of use	0.896	.000	Supported
H3: perceived observability would predict the user satisfaction	4.725	.075	Not supported
H4: user compatibility would predict the user satisfaction	− .375	.586	Not supported
H5: perceived traibility would predict the User satisfaction	− 3.482	.093	Not supported
H6: perceived usefulness would predict user intention to use the metaverse system	.487	.000	Supported
H7: perceived ease of use would predict user intention to use the metaverse system	.121	.046	Supported
H8: user satisfaction would predict user intention to use the metaverse system	.319	.009	Supported

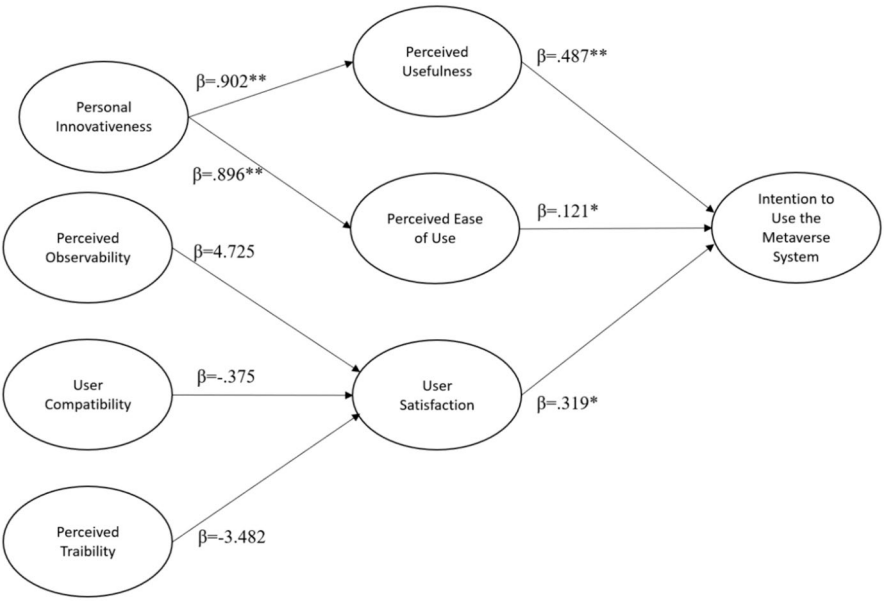

Fig. 2 Path analysis (*P < .05, **P < .001)

positive intention to adopt this technology. Today, it would be appropriate to develop the innovative characteristics of students. Students should be informed about new technologies and should be allowed to use them as much as possible. For this purpose, all educational institutions, especially universities, should constantly improve their curricula and ensure that students follow new technologies closely. Using the opportunities provided by the Internet, the technologies produced and used by students studying at universities in different parts of the world should be introduced to students. Doing this will contribute to the development of students' innovative aspects.

Interestingly, the perceived traibility, observability, and compatibility factors suggested in the study have no significant effect on user satisfaction. Therefore, hypotheses H3, H4, and H5 were rejected. Handoko et al. (2023) reported that perceived observability had no effect on user satisfaction. This is because students consider observability in the real world, some of the participants have never made virtual observations in the metaverse world. H4 and H5 hypotheses is contrary to the findings of other studies (Akour et al., 2022; Almarzouqi et al., 2022; Al-Rahmi et al., 2021). This finding shows that using Metaverse in software education by observability, traibility, and compatibility factors do not affect students' satisfaction. It is possible that this finding stems from the participant students not actually using metaverse technology in software education and that no students around them use it. It results from the high cost of using Metaverse and being a relatively new technology. In addition, the perception of satisfaction is affected by many factors and can vary from person to person. The satisfaction levels of individuals who receive the same service can be very different from each other. In this context, factors other than traibility, observability, and compatibility may affect students' satisfaction. Different studies stated that students who perceive the factors of traibility, observability and compatibility as important and effective will have a high level of satisfaction (Al-hawari & Mouakket, 2010; Ho et al., 2019).

According to the findings, H6, H7, and H8 were supported. Perceived usefulness is the most decisive factor in students' intention to use Metaverse in software education. This is followed by user satisfaction and perceived ease of use, respectively. These findings are consistent with those of other studies (Akour et al., 2022; Almarzouqi et al., 2022; Davis, 1989).

The perceived usefulness factor is the most decisive factor affecting Metaverse usage intention in software training. This finding shows that when students think that using Metaverse in software education increases their productivity and performance, this thought will positively affect their usage intentions. Metaverse can be helpful in increasing learning efficiency, as it allows students to participate in simulated real-life situations mentally and emotionally. Marks and Thomas (2022) found that 71.5% of the subjects participating in their study increased their learning performance when they used virtual reality and augmented reality for the first time. Their finding supports the findings of this study. As Jeon and Jung (2021) mentioned, the Metaverse is an essential tool in increasing students' motivation and participation. Metaverse can enable students to develop real feelings about the existence of innovative learning approaches, and students can gain self-learning experience.

User satisfaction is the second most decisive factor affecting metaverse usage intention in software training. This finding shows that when students perceive a new technology as satisfactory, they develop positive perceptions of using this innovative technology. In addition, this finding shows that when students believe that the Metaverse has many advantages and is worth using in software education, student's intention to use it is positively affected.

Perceived ease of use is another factor affecting Metaverse usage intention in software education. This finding shows that when the Metaverse is user-friendly, easy to use, practical, and accessible, it will positively affect students' intention to use it. In addition, during the management process of the training platform, attention should be paid to platform maintenance, and user feedback should be addressed on time. Metaverse platform developers and operators should consider making the virtual environment clearer and instructions simpler in learning how to use the training platform.

Theoretical contribution

The study has theoretical contributions to the literature. The first of its theoretical contributions is that this study is a pioneering study investigating the adoption of the Metaverse from the students' point of view based on the TAM. Thanks to this feature, this study will be a basis for future studies and shed light on them. Secondly, there are studies based on the TAM on the factors affecting students' intention to use the Metaverse (Akour et al., 2022; Almarzouqi et al., 2022; Handoko et al., 2023). In particular, the perspectives of students in higher education regarding the intention to use metaverse in software education have not been investigated. This study, on the other hand, presents the factors that affect the intention of students studying in Management Information Systems, a department that closely follows technology, to use Metaverse for software education. Thus, this study expands the knowledge in the field of Metaverse adoption. It also supports the future exploration of the metaverse application in other fields such as the entertainment industry, tourism industry, government services, and agriculture sector. In conclusion, this study makes a significant and distinctive contribution by improving our understanding of the key factors vital to the successful implementation of the use of metaverse in the software education of students in higher education.

Practical implications

Metaverse is a new concept, and its implications for education will be much more observable in the long run. Metaverse, used mainly by the game industry today, attracts the attention of educators and increases their tendency to participate in this virtual world. Technological developments facilitate the realization of these tendencies of educators. The increase in the number of those interested in this field arouses the curiosity of the academic community. It paves the way for the development of a new academic field of study. Academic studies on the Metaverse have started in the last few years and are still insufficient, although increasing. Metaverse, a concept that can be handled from many different aspects, has also been researched by academics working in the field of business management in social sciences. Academic literature, which frequently covers topics such as ethics, marketing, human resources, finance, management, collaborations, and customers, still discusses the psychological and cultural effects of the Metaverse.

Education in modern societies should be conducted in enriched, interactive, inclusive, and exciting environments. In this context, it would be appropriate to give software training in the Metaverse system. Unlike education conducted over the Internet, students participate in holistic education activities such as communication and empathy during the software education process with Metaverse. This technology allows students to be in a virtual environment through avatars. Students in the Metaverse can feel the teacher's and other students' presence. They can interact instantly as if they were in a real classroom environment. This situation is likely to increase students' learning motivation and productivity. It is predicted that software training conducted through this system will be as effective as face-to-face training. In addition, this system does not have geographical restrictions as in face-to-face education. It has advantages such as the possibility of telepresence and providing more profound and permanent information opportunities. All these features can enable the system to get ahead of face-to-face education.

Findings regarding metaverse usage intention in the field of software education may have several practical implications for educators and policymakers. Determining metaverse usage intent allows educators to develop new strategies to reach students more effectively. These strategies may support students to gain greater benefits from metaverse-based education. Policymakers can strengthen technology-focused education policies by considering metaverse usage intent. This could encourage educational institutions to provide infrastructure and resources to offer metaverse-based educational opportunities to students. The findings may highlight the need for investments in educational technologies to include metaverse-focused solutions. Educators and policy makers can consider the potential of metaverse technology and invest more in this area. Metaverse usage intention can foster innovation in education and provide students with different learning experiences. Educators can integrate metaverse-based content by taking into account students' diverse learning styles and preferences. Metaverse has the potential to provide access to students without being bound by geographical limitations. By supporting metaverse-based education, policymakers can focus on the goal of achieving broader participation and access in education.

In online education, students often turn off their cameras, so they may not be in the classroom even if they seem connected. As a result, interaction is less in the online education system. In addition, synchronous online training on two-dimensional web-based applications such as Zoom, Google Meet, and Windows Teams can cause serious mental fatigue. On the other hand, online training given asynchronously can cause emotional

isolation that harms the motivation of the student. As a result, e-learning courses on synchronous or asynchronous online platforms result in high dropout rates. However, the presence of the student and their friends with the avatar in Metaverse allows the student to interact more. It is likely that the student's sense of being in the environment will also increase their readiness for the lesson. As a result, while students are outside the educational environment in the online education model, they are in the education environment in Metaverse. In this context, focusing on training in Metaverse may enable students to study on a more efficient education platform.

Using Metaverse in software education also has some disadvantages. Virtual reality technologies can cause health problems such as dizziness and nausea. In addition, information overload in the education process and possible traumatic experiences in the virtual reality environment can adversely affect the users' mental health. On the other hand, users' personal information and data, such as location, may be captured and used by others for commercial purposes. In these respects, it is recommended that students, families, and educators be careful. In addition, the barriers preventing students from adopting this system include the lack of content of Metaverse software education and the students' need for some hardware, such as high internet infrastructure, more technological computers, wearable technologies, and energy, to use this system. Therefore, students who do not have access to Metaverse technologies due to the lack of financial resources or other restrictions should not be ignored. Educational institutions and governments should provide these students with organizational and technological resources to reduce educational inequality.

Conclusions

The dizzying progress of technology leads to the emergence of new technologies every day. One of these technologies is the Metaverse. Metaverse is based on the interaction between the virtual world and the real world. This technology can change the world in many ways, including the economy, entertainment, and education. The Metaverse has the power to replace the internet and pave the way for innovative learning and teaching practices. Even in the future, people will be able to receive their education in the metaverse environment instead of face-to-face or over the internet. In this context, it is crucial to investigate the intentions of people to use this new educational environment. This study examines the factors affecting the Management Information Systems students' intention to use the Metaverse in software education in Türkiye. The investigation begins with a comprehensive literature review that reveals the paucity of studies addressing issues related to the use of Metaverse in software education. TAM was identified as a theoretical framework suitable for the proposed conceptual model. In this model, intention is predicted to be influenced by perceived usefulness, perceived ease of use, and user satisfaction. Besides TAM, four additional factors were introduced: Personal Innovativeness, Perceived Observability, User Compatibility, and Perceived Traibility. The data for this study were collected from management information systems students at a higher education institution in Türkiye, and subsequent analyzes using Structural Equation Modeling (SEM) largely confirmed the validity of the proposed model. The results confirmed the significant impact of the proposed factors on Metaverse usage intention. A comprehensive discussion of the results is presented, taking into account the features of the Metaverse, the virtual environment, and software training. Additionally, an in-depth review and discourse on the theoretical contributions and practical implications derived from this study are presented.

Limitations and future research directions

This study has some limitations. First, participant students have never used Metaverse in software education. They completed the survey in the light of brief information about Metaverse in the introduction part of the survey and the knowledge they had. Future studies may select students who have experience in Metaverse technologies as samples. Further, future studies may examine how or to what extent the Metaverse affects students' education. This issue can be examined with a longitudinal evaluation. For future research endeavors, incorporating diverse data collection techniques, including interviews and focus groups, could indeed provide a richer qualitative dimension to complement the quantitative findings. For example, experiments can be conducted using an experimental group trained through metaverse technology for a certain period and a control group trained through traditional educational technologies. Future studies may use larger sample sizes to increase the representativeness and reliability of the results. The findings obtained by using the research model of this study in different samples can be compared with the findings of this study, and this comparison may contribute to the literature. In addition, this research model can be developed by adding different variables. This study focused only on software education over the Metaverse. Future studies can expand the metaverse literature, which can be considered very new, by focusing on different educational processes.

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Data availability Data and data analysis scripts are available for review upon reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict interest.

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