Heliyon 10 (2024) e38741

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Understanding metaverse adoption in education: The extended UTAUMT model

Anh Hoai Duc Nguyen, Tung Thanh Le, Tri-Quan Dang, Luan-Thanh Nguyen *

Ho Chi Minh City University of Foreign Languages-Information Technology, HUFLIT, 828 Su Van Hanh, Ward 13, District 10, Ho Chi Minh City, Viet Nam

A R T I C L E I N F O

Keywords:
Metaverse
Education
UTAUMT
PLS-SEM
Modified UTAUT

A B S T R A C T

The metaverse, an immersive virtual environment enabling users to engage with digital experiences, has the potential to revolutionize education. However, research pertaining to this area is still in its early stages. This study investigates the variables that influence the acceptance of educational metaverses and the intention to use them. It also presents an expanded model called the Unified Theory of Acceptance and Use of Metaverse Technology (UTAUMT) to provide guidance to educators and decision-makers. The study involved 253 Vietnamese teachers and students who had experience with metaverse, selected through purposive sampling. The UTAUMT provides a comprehensive framework that encompasses various factors, including metaverse performance expectancy (MPE), metaverse effort expectancy (MEE), metaverse social influence (MSI), metaverse hedonic motivation (MHM), metaverse price value (MPC), metaverse self-efficacy (MSE), and metaverse facilitating conditions (MFC). These factors were assessed using a self-administered questionnaire. The findings indicate that MEE, MSI, MFC, MSE, and MBI have a considerable impact on the educational metaverse MUB. The extended UTAUMT model makes a theoretical contribution by including metaverse-specific elements into the technology acceptance framework. The managerial implications focus on the integration of the metaverse, training of users, and providing support to enhance the adoption rate. This study explores the elements that contribute to the adoption of metaverse technology in education and contributes to the existing literature on the acceptance of metaverse technology.

1. Introduction

Users (human or otherwise) have a “Metaverse” experience if they view the real world as a parallel digitally-created universe rather than as it actually is [1,2]. This universe can be a digital duplicate of our current reality called a “Digital Twin” [3], an entirely new digital realm called “Virtual Reality” (VR), or an augmented version of our universe called “Augmented Reality” (AR) or “Mixed Reality” (MR). An expansive, immersive, self-consistent, and massive persistent universe is where the idea of the metaverse originates [4]. Its name is a reference to everything in the cosmos. It is important for a metaverse, or “meta,” to have features like high realism, ease of use, pervasiveness, and decentralization. Persistent virtual reality is a more specific definition of the metaverse than the broader definition [5]. However, the metaverse stands for the final phase and far-reaching goal of Digital Transformation [6]. The metaverse

* Corresponding author.
E-mail addresses: anhndh@huflit.edu.vn (A.H.D. Nguyen), tunglt@huflit.edu.vn (T.T. Le), tridq@huflit.edu.vn (T.-Q. Dang), luannt@huflit.edu.vn (L.-T. Nguyen).

https://doi.org/10.1016/j.heliyon.2024.e38741
Received 20 June 2024; Received in revised form 27 September 2024; Accepted 29 September 2024
Available online 30 September 2024
2405-8440/

has the potential to revolutionize education by enhancing learning environments through immersion and interactivity [7]. Students have access to a vast array of educational resources from around the globe and can take advantage of personalized and adaptive learning opportunities [4]. Collaborative learning communities facilitate global connections and cultural exchange, while virtual labs and simulations facilitate experiential and skill-based learning [8]. Virtual workshops and training programs support lifelong learning and professional development. In addition, the metaverse promotes inclusion and accessibility by removing educational barriers and bridging geographical and socioeconomic gaps [9]. The metaverse has the potential to transform education into a dynamic and interconnected realm of personalized, collaborative, and experiential learning, despite its challenges.

The utilization of the metaverse in education was still in its early stages, with ongoing investigation and testing in different educational environments [10]. At that time, the adoption of the metaverse in education was mainly limited to pilot projects, research initiatives, and progressive institutions [4,8]. Virtual reality (VR) and augmented reality (AR) technologies were utilized to develop immersive learning environments [11]. The spectrum of experiences included interactive 3D models, collaborative problem-solving activities, virtual field trips, and simulations. Several educational institutions have incorporated virtual reality (VR) and augmented reality (AR) technologies to enhance STEAM education, medical training, and vocational skill development [7]. However, it should be emphasized that the integration of the metaverse into education has not yet become widespread in all grade levels and subject areas [9]. Widespread acceptance was hindered by technical barriers, high costs, and a lack of easily accessible hardware and software solutions [12,13]. It is crucial to examine the variables that are causing the integration of the metaverse into the educational process as the globe moves towards new methods of training and education [5,14]. By elucidating these driving factors, we can acquire a more profound comprehension of the metaverse's prospective educational advantages and possibilities. Gaining a thorough understanding of the main factors that influence the metaverse is crucial for comprehending the possible effects it may have on education, directing the allocation of resources, and promoting the creation of strategies for its acceptance [15]. To achieve more successful and game-changing metaverse applications in classroom settings, it is crucial to promptly address the ever-changing technology and education landscape.

The existing literature on metaverse adoption, particularly in the educational context, has extensively utilized well-established technology acceptance theories such as TAM and UTAUT/UTAUT2 [16]. However, scholars have noted that these theories may not be sufficient in explaining the widespread adoption of new advanced technologies by consumers and may not be appropriate for conducting such an investigation [16]. The Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and UTAUT2 are highly regarded models in the IT/IS area. They are employed to comprehend the process of adopting and utilizing novel technology. However, there are specific constraints to take into account when using these models to clarify the consumer adoption of cutting-edge technologies such as the metaverse. The original design of TAM focused on the perceived usefulness and ease of use in business environments, without considering the importance of personal context and the decision-making process for adoption. Additionally, the use of UTAUT in metaverse research and individual consumer adoption is limited because it primarily focuses on the adoption of workplace technology [2,16]. Although academics, especially in the field of Information Systems/Information Technology, have made serious efforts, these models still lack the ability to fully explain the spread of new technologies. Metaverse users have distinct perspectives and experiences compared to physical or e-learning users due to differences in immersive and interactive experiences, virtual surroundings, and immediate feedback and assessment. Therefore, these theories are not appropriate for metaverse study. This paper introduces the Unified Theory of Acceptance and Use of Metaverse Technology (UTAUMT) as a new fundamental model to fill this void. The advent of the metaverse carries substantial real-world implications, as it has the capacity to disrupt established markets, namely the education sector [2,17–19]. Metaverse technology facilitates students' participation in immersive simulations and fosters collaboration on group tasks. The COVID-19 pandemic has generated an increased need for alternate educational approaches, rendering Metaverse education particularly pertinent [20,21]. Educational institutions that use metaverse technology will get a substantial edge over their competitors confined to conventional settings. It is important to highlight that the educational use of the metaverse is still in its early stages, and its full powers have not been fully realized yet [22]. Thus, the objective of this study's aim to find out factor influence the Metaverse adoption in education context with the research question: What are factors influencing the Metaverse adoption in education?

Our research framework and the hypotheses that informed it are presented here. Next, the study provides an overview of the research approach taken and the data analysis that was performed. Our results are then discussed, and the managerial and theoretical implications of our study are investigated. We also note the limitations of our research and suggest potential future avenues of inquiry. This paper significantly contributes in two areas. To begin, we present the Unified Theory of Acceptance and Use of Metaverse Technology (UTAUMT), a model developed specifically for the metaverse space that accounts for the particularities of metaverse users. This model fills a void in the literature on IT/IS by providing a systematic approach to investigating metaverse environment.

2. Literature review and hypotheses development

2.1. Metaverse in education

Medical, nursing, healthcare, science, military, manufacturing, and language learning are just some of the fields that could benefit from using the metaverse in teaching and learning [4,7,8,23]. When compared to more conventional methods, the use of the metaverse in education stands out as significantly different due to its distinctive features.

For example, virtual reality (VR) has been shown to help EFL (English as a Foreign Language) students by simulating real-world situations [24]. On the other hand, the metaverse introduces a more holistic goal for language learning than just a single class or activity. The program's goal is to give students of English as a foreign language (EFL) an environment where they can live, work, study, and have fun entirely in English, just as native English speakers do. As a result, virtual reality (VR) and the metaverse (MV) provide very different opportunities for education. Additionally, the Metaverse provides a unified environment that bridges the gap between the physical and digital worlds, letting users experience both realistic simulations and fantastical alternatives. Using their senses of sight, touch, hearing, taste, and smell, users can become completely submerged in a digital world. Active learning has been shown to be most effective for many students, and the Metaverse's alluring 3D graphics are sure to appeal to the many gamers who also attend its classes [25]. Therefore, it is important for Metaverse learning applications to be relevant, socially interactive, and interesting [7]. Users can have fun and be captivated by the Metaverse's virtual reality tools [8]. Second Life is one example of a popular 3D learning application that has been used in classrooms and gamer-inspired virtual worlds. Opportunities for socialization and interactive communication between educators and students in digital domains like virtual schools, colleges, and campuses are substantial. Virtual campus tours are available online so that students can explore their schools from anywhere in the world. In fact, some schools have already created digital versions of their campuses [26]. Student services, content sharing, learning outcomes, and audience size are all areas where virtual campuses can be improved through careful design. Previous studies have shown that students enjoy learning academic subjects in a digital environment [7].

The educational sector has shown considerable interest in the metaverse, leading to multiple scientific inquiries. Al-Kfairy et al. (2024) investigate the variables that impact the adoption and acceptability of Metaverse technologies in educational environments [20]. The important determinants they identify include effort expectancy, behavioral intention, self-efficacy, enjoyment, and immersion. The study emphasizes that the implementation of Metaverse in education is contingent on the context, with different aspects demonstrating moderating influences. The assessment provides significant insights for educators, politicians, and technology developers that seek to effectively incorporate Metaverse technologies into educational frameworks. Al-Adwan et al. (2024) conducted a study that examines how students' views, social influence, and perceived behavioral control influence their intention to adopt meta-education [15]. Researchers discover that students' perspectives are influenced by the congruence between meta-education and their learning styles, as well as the level of user-friendliness, utility, and enjoyment. Social influence, encompassing peer pressure and herd behavior, exerts a notable impact, however superior influence does not significantly affect students' decisions to adopt. In a separate investigation conducted by Al-Kfairy, Alomari et al. (2024), they propose the adoption of comprehensive, ergonomically focused designs and the implementation of standardized procedures to guarantee smooth interactions across different Metaverse platforms [22]. This study highlights the significance of usability, interoperability, and social influence in molding user experiences and perceptions in the Metaverse. Al-Adwan et al. (2023) have also identified perceived utility, personal innovativeness in IT, and perceived fun as important factors that influence students' behavioral intents to adopt the Metaverse [21]. On the other hand, the perception of cyber danger is identified as a major obstacle to the adoption of these objectives, while the perception of ease of use is determined to have no significant impact. The study conducted by Nguyen et al. (2024) adds to the existing research by examining how Metaverse environments affect collaborative learning and student engagement [2]. Their research investigates the impact of immersive virtual environments on students' collaboration, interaction with course content, and attainment of learning objectives. The authors identify certain crucial aspects that impact the efficacy of teaching based on the Metaverse. These factors encompass virtual presence, the quality of engagement, and the compatibility of Metaverse tools with educational goals. Researchers have discovered that virtual presence, which refers to the feeling of being physically present in a virtual environment, greatly improves students' level of engagement and motivation. Effective collaborative learning relies on high-quality interactions within Metaverse platforms, which are assisted by enhanced virtual reality (VR) and augmented reality (AR) technology. Furthermore, the study emphasizes the significance of creating Metaverse experiences that closely correspond to teaching objectives. Integrating Metaverse tools into the curriculum in a smart manner can offer valuable educational experiences that enhance collaborative learning and problem-solving abilities. Dang et al. (2023) also discussed certain obstacles, such as the disparity in access to digital resources and the requirement for a strong and reliable technical framework [17]. They propose that ensuring fair and equal access to Metaverse technologies, along with enough technical assistance, is crucial for enabling all students to take advantage of these advancements.

2.2. The extended unified theory of acceptance and use of metaverse technology (UTAUMT)

2.2.1. The extended unified theory of acceptance and use of technology 2 (UTAUT2)

UTAUT2 is the second iteration of the highly influential and widely embraced Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT2 model, developed by Venkatesh, Morris, and Davis in 2003, offers a comprehensive understanding of individuals' objectives and behaviors when it comes to adopting and utilizing technology [16,27]. The UTAUT2 model incorporates several fundamental elements to elucidate the acceptance and utilization of technology. One concept that is relevant in this context is "performance expectancy," which refers to the users' expectations regarding the usefulness and practicality of the technology (Nguyen et al., 2023). The concept of "effort expectancy" considers individuals' perceptions of the time and effort required to learn and adopt a new technology [28,29]. The availability of support, resources, and infrastructure can significantly enhance the probability of individuals adopting and utilizing a new technology [30]. Hedonic motivation, as defined by Dao et al. (2023) [31], pertains to the enjoyment and contentment derived from utilizing technology for its intrinsic value. The term "price value" denotes an evaluation of the perceived worth of a technology in relation to its purchase price [30]. By regularly using technology, individuals form deeply ingrained habits and engage in actions that are based on established routines [32]. Self-efficacy examines individuals' level of confidence in their capacity to acquire and utilize technology proficiently [33].

UTAUT2 incorporates several moderators, which are factors that influence the intensity of the relationships between different concepts. Demographic factors, such as gender and age, and user characteristics, such as experience and volitional use, are examples of moderators. The UTAUT2 model acknowledges the subtle contextual factors that affect individuals' willingness to accept and utilize technology by considering these moderators [34]. Demographic factors, such as gender and age, along with user characteristics, such as experience and voluntary use, may not be appropriate as moderators when studying the adoption of Metaverse in education. The Metaverse is an emerging technology that surpasses conventional demographic limitations and is progressing at a fast pace. Gender and age have less influence than individual interests, familiarity with virtual environments, and specific educational needs when it comes to determining the adoption of virtual environments. Furthermore, proficiency in alternative technologies may not completely transfer to the distinctive characteristics and user interfaces of the Metaverse. Moreover, the integration of the Metaverse in education is not solely determined by personal preferences, but is also influenced by institutional factors, pedagogical considerations, and educational policies. Consequently, this study will not consider these moderators.

2.2.2. The extended unified theory of acceptance and use of metaverse technology (UTAUMT)

This study investigates the implementation of education in the Metaverse and suggests that the extended Unified Theory of Acceptance and Use of Technology is a valuable framework for comprehending the factors that influence the acceptance and utilization of this new technology by educators and students [35]. The Unified Theory of Acceptance and Use of Technology (UTAUT) is highly applicable to the examination of metaverse adoption in education due to its inclusive framework that incorporates crucial factors influencing technology acceptance, including performance expectancy, effort expectancy, social influence, and facilitating conditions [16]. Understanding the complex nature of embracing the metaverse, a novel and immersive technology that combines virtual reality (VR) with augmented reality (AR), is particularly vital [2]. The UTAUT model is highly suitable for investigating the effective integration of the metaverse into educational contexts due to its comprehensive consideration of several elements, such as user engagement, experience, resource availability, and institutional support [2,17]. Moreover, the model's established ability to accurately anticipate outcomes in different situations guarantees a dependable basis for studying technology adoption behaviors. Additionally, its adaptability enables the inclusion of metaverse-specific characteristics like user immersion and presence. UTAUT is a strong framework for studying user acceptance in the metaverse in education due to its versatility and comprehensive approach. This study presents the Extended Unified Theory of Acceptance and Use of Metaverse Technology (UTAUMT), which defines concepts within the metaverse environment, as proposed by Tamilmani et al. (2021) [36]. The UTAUMT offers a comprehensive structure that includes several factors, such as metaverse performance expectancy (MPE), metaverse effort expectancy (MEE), metaverse social influence (MSI), metaverse hedonic motivation (MHM), metaverse price value (MPC), metaverse self-efficacy (MSE), and metaverse facilitating conditions (MFC). These characteristics are extremely important when considering the implementation of the Metaverse in education. By employing UTAUMT, this study can systematically analyze these factors, collect empirical data, and uncover the relationships between them, resulting in a more thorough understanding of the adoption process and offering valuable insights for developing efficient strategies to promote the successful incorporation of the Metaverse in educational settings. The proposed model is presented in Fig. 1.

2.2.3. Hypotheses development

Metaverse Performance Expectancy (MPE) is the extent to which an individual believes that utilizing the metaverse will improve their performance in a certain setting, such as education [27]. The concept revolves around the belief that interacting with the metaverse will enhance the effectiveness, efficiency, or enjoyment of tasks. Within the context of education, MPE encompasses the anticipation that the metaverse will offer a heightened level of engagement in the learning process, enhance comprehension of intricate ideas, and facilitate easier and more captivating collaborative learning. The study conducted by Nguyen et al. (2024) validates the correlation between MPE (Media Presence Experience) and the behavioral intention to use livestreaming on the metaverse. Al-kfairy et al. (2024) investigated the role of MPE as a significant driver for the utilization of metaverse in the field of education [18]. Al-kfairy, Alomari et al. (2024) also examined the direct correlation between performance expectancy and the way younger participants perceive users [22]. Consequently, the study indicates that having higher expectations of success in educational settings inside the metaverse can have a favorable influence on the intention to use and participate in these platforms for learning. We propose the hypothesis as follow:

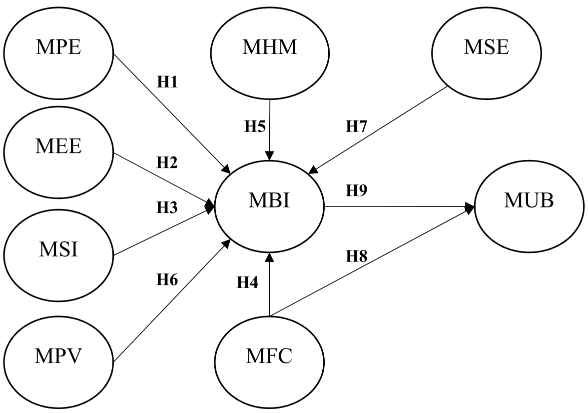

Fig. 1. Proposed model.

H1. Metaverse performance expectancy (MPE) positively affect behavioral intention to adopt (MBI) education in metaverse

Metaverse Effort Expectancy (MEE) pertains to the level of simplicity connected with the utilization of metaverse technology [37]. It denotes the users' subjective assessment of the level of ease or difficulty associated with utilizing the metaverse for particular tasks or activities. In an educational setting, MEE refers to the ease with which learners and educators may navigate virtual environments, access materials, and employ tools within the metaverse for educational purposes. Having high expectations of effort required may discourage usage, whilst having low expectations of effort required could increase the possibility of adoption. Al-kfairy, Alomari et al. (2024) highlight that MEE is a crucial determinant for the adoption of the metaverse [22]. In their study, Al-Adwan et al. (2024) discovered that MEE plays a crucial role in students' adoption of meta-education [18,20,22]. Hence, the research indicates that when persons view the metaverse as user-friendly and easy to traverse, their inclination to embrace and utilize it for educational purposes is enhanced. We propose the hypothesis as follow:

H2. Metaverse effort expectancy (MEE) positively affect behavioral intention to adopt (MBI) education in metaverse

Metaverse Social Influence (MSI) is the extent to which an individual's choice to embrace and utilize the metaverse is impacted by the viewpoints, actions, or expectations of others, including peers, instructors, colleagues, or influencers [37]. Within the realm of education, MSI refers to the influence of social networks, endorsements from influential individuals, or peer trends that promote the utilization of the metaverse as an educational platform. There is a positive correlation between the intensity of social influence and the likelihood of an individual embracing the metaverse for educational reasons. The study conducted by L.-T. Nguyen et al. in 2023 established a correlation between MSI and the intention to embrace metaverse in the context of banking services [16]. Al-Adwan et al. (2024) discovered a positive correlation between meta-education and the intention to adopt [15]. The study suggests that when individuals believe that influential people, such as peers, instructors, or influencers, believe they should use the metaverse for educational purposes, their propensity to adopt and use it for learning activities increases. We provide the hypothesis as follows:

H3. Metaverse social influence (MSI) positively affect behavioral intention to adopt (MBI) education in metaverse

Metaverse Facilitating Conditions (MFC) encompass the various resources and support systems that empower humans to efficiently utilize the metaverse [37]. These conditions encompass the availability of necessary technology, software, internet connection, and technical assistance that enable the integration and utilization of the metaverse for specific objectives, such as education. Lu et al. (2005) shown that FC is a significant determinant of the behavioral intention to embrace a particular technology [38]. Once the necessary tools and assistance for utilizing the metaverse, including technological infrastructure, user guides, and customer service, are in place, it will significantly increase individuals' inclination to utilize and embrace the metaverse for educational objectives [39,40]. We provide the hypothesis as follows:

H4. Metaverse facilitating conditions (MFC) positively affect behavioral intention to adopt (MBI) education in metaverse

H8. Metaverse facilitating conditions (MFC) positively affect use behavior (MUB) of education in metaverse.

Metaverse Hedonic Motivation (MHM) refers to the level of satisfaction or pleasure that individuals derive from their use of the metaverse. In the realm of education, it pertains to the enjoyable and captivating elements of acquiring knowledge in a digital setting, which might inspire users to embrace the metaverse. Alalwan et al. (2015) highlighted that hedonic motivation has an impact on behavioral intention [41]. The studies conducted by H.-B. Nguyen & Nguyen (2021) [42] and Nguyen et al. (2023) [28] have established that the pleasure derived from utilizing a technology can significantly influence the inclination to embrace that particular technology in different settings. Hence, in the field of education, if users observe the amusement and pleasure received from utilizing the metaverse, it will enhance their inclination to embrace it for educational purposes. We provide the hypothesis as follows:

H5. Metaverse hedonic motivation (MHM) positively affect behavioral intention to adopt (MBI) education in metaverse

The Metaverse Price Value (MPV) denotes the subjective worth that a user attributes to utilizing the metaverse in relation to its associated expenses [29,43]. When people perceive that the advantages of utilizing the metaverse for educational purposes are greater than the associated expenses, their inclination to embrace it grows. The study conducted by Nguyen et al. in 2023 established a correlation between MPV and the intention to use metaverse technology [2]. Al-Adwan et al. (2024) discovered a positive correlation between MPV and the intention to adopt in the field of meta-education. Consequently, when users consider the expense of utilizing the metaverse for education to be affordable in comparison to the advantages, their inclination to embrace it grows. We suggest the following hypothesis:

H6. Metaverse price value (MPV) positively affect behavioral intention to adopt (MBI) education in metaverse

Metaverse Self-Efficacy (MSE) refers to an individual's confidence in their capability to effectively utilize the metaverse in order to accomplish desired goals [29]. In an educational context, high self-efficacy refers to the learners or educators' strong belief in their ability to effectively navigate and utilize the metaverse for learning and teaching. The study conducted by Al-Adwan et al. (2023) discovered a direct correlation between Mean Squared Error (MSE) and the inclination to utilize Metaverse-Based Learning Platforms. Alruwaie et al. (2020) and Oh et al. (2023) discovered a direct correlation between MSE and the behavioral intention of adopting technology [44,45]. Hence, the research indicates that an individual's confidence in their capacity to utilize the metaverse proficiently has an impact on their inclination to embrace it for educational objectives. We suggest the following hypothesis:

H7. Metaverse self-efficacy (MSE) positively affect behavioral intention to adopt (MBI) education in metaverse

Metaverse Behavioral Intention to Adopt (MBI) generally pertains to the probability of humans adopting a new behavior or technology based on their intentions and attitudes. Metaverse Behavioral Intention to Adopt in education pertains to the probability of educators, students, and institutions embracing and using Metaverse technologies into their educational processes. Research on technology adoption consistently demonstrates that a stronger inclination to engage in an activity is associated with a higher likelihood of actually performing that action. Research has shown that users who have a favorable intention to adopt new technologies are more inclined to include those technologies into their normal routines [1,17,46]. If educators and students possess a firm desire to utilize Metaverse technology, it is probable that they will actively engage with and utilize these resources. We provide the hypothesis as follows:

H9. Behavioral intention to adopt (MBI) education in metaverse positively affect use behavior (MUB) of education in metaverse.

3. Methodology

3.1. Instrument development and validation

According to Nunnally (1978), the content domain of each construct must be included in order to ensure the development of an effective instrument [47]. Internal consistency refers to the degree to which the items used to measure a particular construct converge and demonstrate a high degree of correlation with one another [48]. They also need to be easily distinguishable from components of other frameworks. Each component of the instrument must have high levels of reliability and validity. First, construct definitions and item selection are made, which are the first steps of the instrument development process. In the first stage, we evaluate the initial effectiveness of the instrument through item selection, pre-testing, and pilot testing. The next step involves a massive field study to establish the instrument's psychometric properties and fine-tune its reliability and validity for the proposed model.

3.2. Measurement scale

The researchers used 7-point Likert scales to determine how much participants agreed or disagreed with various statements. Seven-point Likert scales were used because they produce a wider variety of responses, allowing for greater variation in participants' ratings. With a more nuanced range of agreement options provided by a 7-point scale, the frequency of neutral or indifferent responses is reduced. The agreement scale used for this research allowed for a range of responses from 1 (strongly disagree) to 7 (strongly agree). The original measurement scale adopted from Tew et al. [50]; Venkatesh et al. [49] and Karjaluoto et al. (2020) [34], [51], [52], [53] presented in Appendix A.

3.3. Target population and sample

According to Statista (2023), the population of university lecturers and students as of 2020 was approximately 76,000 and 1,900,000, respectively (Nguyen et al., 2024; [54]). Vietnamese academics and students who are familiar with the metaverse are the target population. Vietnam was chosen as the study's location because of the country's active participation in metaverse and blockchain conferences and its population's familiarity with modern technology [55]. The study aims to collect data from people who are familiar with the concept of the metaverse and have first-hand experience using it, and so it focuses on lecturers and students in Vietnam. Purposive sampling was used to recruit people for this study due to their specialized knowledge of the metaverse [56]. This method of sampling was opted for to guarantee that only people with pertinent knowledge and first-hand experience in the metaverse would be included. The study seeks to gather data that accurately reflects the particular setting under investigation by specifically targeting participants who are professors and students from both public and private educational institutions in Ho Chi Minh City, Vietnam, and who have also had firsthand contact with the metaverse. Purposive sampling improves the quality and generalizability of a study by selecting only those participants most likely to contribute useful and relevant information [57].

3.4. Data collection procedures

The researchers in this study used Google Forms to send out questionnaires to the technology and blockchain programs in Ho Chi Minh City's academic institutions. The purpose of the survey was to learn about people's thoughts, feelings, and experiences with the metaverse as it relates to technology education. The survey link was distributed via email and other channels after approval was granted by the appropriate departments or faculty heads. The questionnaire allowed respondents to elaborate on their responses using both 7-point Likert scales and free-form text boxes. The time frame for data collection was limited, and reminders were sent to encourage higher response rates.

This study uses Gpower version 3.1 to compute the required sample size using the following criteria: effect size 0.15, err probability 0.05, 1-err probability 0.95, and number of predictors 7 [1,20]. The sample size required is 153. Following the data collection phase, 253 responses met the inclusion criteria and were included in the analysis. At all points during data collection, privacy and discretion were strictly maintained. The final measurement scale is in Appendix A.

3.5. Pretest

During the pre-testing phase of the research project, measurement scales for the instrument were developed in accordance with both its face validity and its content validity. The concept of face validity refers to the process of determining whether or not the items on the scale appear to measure what they are designed to measure and whether or not the participants can comprehend the items. On the other hand, content validity is concerned with whether or not the items being measured are relevant to the construct being measured and whether or not they are representative of that construct.

3.6. Scale development and expert panel

The measurement scales that were implemented into the instrument were derived from previously conducted research after an exhaustive review of the relevant literature. An expert panel with six members was assembled to evaluate both the outward appearance of their validity and the internal consistency of their content validity. There were three Vietnamese professors on the panel, and their areas of expertise included Information Systems (IS) and education. Between them, they had a significant number of publications in journals that were ranked by either ISI or Scopus. Because of their extensive experience in the field, they were able to conduct an in-depth analysis of the scales and offer insightful commentary on the relevance and clarity of their results. The remaining three members of the expert panel were all experienced practitioners, with one of them being a teacher of blockchain technology, another being a coordinator, and the third being a master teacher.

3.7. Face validity

Measurement validity is comprised of two separate but related concepts: face validity and content validity. While “face validity” refers to the extent to which items appear to measure what they are intended to measure, “content validity” refers to the representation of an appropriate sample of the construct’s domain [58]. Face validity and content validity are both aspects of test validity. An expert panel was assembled, and its members were given the responsibility of examining the measurement scales to determine whether or not they accurately measured the intended constructs. This was done so that the face validity could be ensured. The feedback received from the expert panel indicated that, on the whole, they believed the instrument to have face validity that was satisfactory. In response to their suggestions and recommendations, a few insignificant changes and formatting adjustments were suggested and incorporated.

3.8. Content validity index (CVI)

Ensuring good and reliable measurement requires meeting the fundamental requirement of content validity. Content validity refers to the degree to which the measurement items accurately reflect the construct being measured in a study. Measurement items previously published for the construct were utilized, and professionals and specialists conducted a thorough review of each item during both the pre-test and pilot test phases. This was done in order to attain content validity. The Content Validity Index (CVI) is the predominant metric for evaluating the validity of content, as proposed by Mary R. Lynn in 1986 [59]. There are two types of this index: the item-level CVI (I-CVI) and the scale-level CVI (S-CVI). A four-point ordinal scale was employed to eliminate any potential for ambiguity or neutral responses falling in the middle. The scale ranged from (1) irrelevant to (2) moderately relevant to (3) significantly relevant to (4) extremely relevant. Items rated 3 or 4 were considered relevant to the construct, while items rated 1 or 2 were considered irrelevant.

3.8.1. Item-level CVI

The Item-Level Content Validity Index (I-CVI) is computed as the proportion of panel experts who rated an item with either a 3 or 4 on the ordinal scale. This dichotomizes the responses into categories that are either relevant or not relevant to the question being asked. According to the recommendation that was provided by Lynn (1986) [60], the I-CVI should be equal to or higher than 0.83 for a panel that consists of six different experts. In this study, the I-CVIs for each item on the instrument were calculated based on the reviews provided by the six panel experts. These results can be found in Table 1, which summarizes the findings of the study. The fact that every I-CVI in the instrument is either equal to or greater than 0.94 leads one to the conclusion that every item in the instrument possesses adequate content validity. As a result, based on the findings of the content validity assessment, none of the items needed to be

Table 1
I-CVI and S-CVI results.

Constructs	S-CVI/Ave	Mean I-CVI
MEE	1.00	1.00
MPE	1.00	1.00
MSI	1.00	0.94
MFC	1.00	1.00
MHM	1.00	1.00
MPV	1.00	1.00
MBI	1.00	1.00
MUB	1.00	1.00

eliminated from the instrument.

3.8.2. Scale-level CVI

Calculating the ratio of items that received ratings of 3 or 4 from all raters involved in the assessment is how the Scale-Level Content Validity Index (S-CVI) is arrived at. S-CVI can be broken down into two categories: S-CVI/UA, which stands for "universal agreement," and S-CVI/Ave, which stands for "average value." S-CVI/UA indicates the proportion of items that were rated a 3 or 4 by all of the panel experts, whereas S-CVI/Ave indicates the average proportion of items that were rated a 3 or 4 by the panel experts. When there are a large number of experts involved, the S-CVI/UA can be overly demanding because reaching 100 % agreement might be overly cautious. As a result, the S-CVI/Ave combination is frequently chosen [61]. For the purpose of this research, it was decided that the S-CVI/Ave would serve as the criteria for determining the acceptance of scale content validity.

The recommendation that was made by Lynn (1986) stated that the minimum value for S-CVI/Ave should be 0.90 [60]. It is clear from looking at Table 1 that every S-CVI is at least 0.94, which indicates that every scale possesses sufficient levels of content validity. As a direct consequence of this, the content validity evaluation did not lead to the removal of any scales from the instrument.

3.9. Pilot test

The instrument underwent a pilot test with the involvement of educators from a single primary and secondary school. These teachers were excluded from the primary survey. The pilot test had a fluctuating number of participants ranging from 25 to 100. From this group of 100 participants, we selected our respondents for this specific study. Consequently, we concluded that 75 out of the responses could be utilized. During the pilot test, the instrument's construct reliability and clarity were assessed. Wilcox et al. (1985) suggest that conducting a pilot test with a sample size of 20–50 respondents is adequate for detecting errors in questionnaires [62]. The larger sample size was chosen in order to ensure more dependable feedback and insights [62].

As per the study conducted by Leong et al. (2021), "construct reliability" is defined as the degree to which a scale effectively represents the intended construct it is meant to measure [63]. We calculated Cronbach's alpha values for each construct in the reliability test using SPSS version 25. This enabled us to assess the extent to which the constructs exhibited coherence with each other. Items that had a negligible impact on the alpha value were removed through a process that included several rounds of revision. Table 2 presents the initial alpha values acquired from the pilot test. As per the findings of Hair et al. (2010), all the alpha values were above the threshold of 0.70 and ranged from 0.713 to 0.976 [64]. All of the alpha values were contained within this range. Based on these findings, we have determined that the instrument exhibits a significant degree of construct validity. The reason for this is that the instrument precisely captures the constructs being measured.

3.10. Fieldwork

Following the validation of the preliminary version of the instrument through a pilot test, the final version of the instrument was validated through a fieldwork study. During this phase, data was collected from individuals who were a part of the population that was being studied. The fieldwork investigation resulted in the collection of a total of 253 useable samples, which could be used in subsequent statistical data analyses. These samples constitute valuable data that can be analyzed in order to derive meaningful insights regarding the implementation and application of the metaverse in educational settings. The information that was gathered will be put through rigorous statistical analysis in order to investigate the connections between the various variables, put hypotheses to the test, and draw conclusions based on the results. The substantial size of the study's sample population not only improves the reliability and generalizability of the findings, but also makes a contribution to a more in-depth comprehension of the use of the metaverse in educational settings.

3.11. Ethical approval

The procedures conducted in this study with human subjects adhered to the ethical standards set by the institutional review board at the University of Foreign Languages-Information Technology, HUFLIT (Reference number 784/QDEA). Prior to data collection, each participant provided written informed permission and verbally confirmed their agreement after receiving a thorough explanation of

Table 2
Construct reliability (Cronbach's alpha).

Construct	Number of Items	Cronbach's Alpha
MEE	3	0.725
MPE	3	0.877
MSI	3	0.910
MFC	4	0.738
MHM	3	0.797
MPV	3	0.856
MSE	3	0.877
MBI	3	0.923
MUB	3	0.741

the study protocol.

4. Data analysis and results

4.1. The demographic characteristics of the sample

Table 3 shows how the sample is made up in terms of its demographics. More than half of the people who took part were women. About 46.25 percent of the participants had their K12 certificate, which in Vietnam means they had finished their basic education. Also, 48.22 % had degrees beyond the bachelor's level, while only 5.53 % had bachelor's degrees. In terms of age, the majority of respondents were between the ages of 18 and 22. After that, those between the ages of 30 and 35 and 36 to 40 made up 32 % of the sample each. Also, 5.93 % of the people who answered were over the age of 40, and 4.35 % were between the ages of 23 and 30.

4.2. Common method bias (CMB) and non-response bias

To address the issue of Common Method Bias (CMB), we employed a two-step data collection methodology. However, we employed both procedural and statistical techniques, as recommended by Podsakoff et al. (2003), to gather additional support for this assertion [65]. We ensured the anonymity of the respondents and emphasized that there were no objectively correct or incorrect responses, in order to promote candid and truthful answers. The Single Factor test conducted by Harman was approached from a statistical perspective [39]. The test results indicated that a solitary factor accounted for less than 50 % of the overall variation, implying that CMB was not significant. We conducted independent t-tests, as also performed by Wong et al. (2022), to further investigate the disparities among core constructs [66]. Non-response bias can be ruled out as a factor in our study due to the absence of any significant differences in the results. Through the implementation of these systematic and mathematical techniques, we aimed to guarantee the strength and accuracy of our results, enabling us to effectively tackle any possible concerns associated with CMB and non-response bias.

4.3. Measurement model assessment

Convergent validity in Table 4 was assessed by examining the Average Variance Extracted (AVE), which should exceed 0.50 [67], as well as the significance and magnitude of indicator loadings, which should exceed 0.70. The Fornell-Larcker criterion, which assesses discriminant validity, compares the square roots of Average Variance Extracted (AVE) with correlation coefficients [68]. The Fornell-Larcker ratio in Table 6, which should be less than one, and the HTMT <0.90 in Table 5 indicated strong discriminant validity. The construct reliability was assessed using Cronbach's alpha coefficient and the Composite Reliability (CR). Both values should exceed 0.70. In Table 4, it is evident that all CR values exceeded their AVE values, indicating the reliability of the constructs.

4.4. Structural model assessment

Prior to examining the internal structural model, a collinearity test was conducted to determine if any components exhibited significant similarity. The variance inflation factors (VIF) were computed and determined to range from 1.00 to 4.26. The values fell below the widely accepted threshold of 5.0, indicating a low likelihood of multicollinearity issues [19]. Collinearity was not a significant concern in the analysis.

The findings from the experimentation were presented in Table 7 and Fig. 2. The data indicated that 6 out of the 9 hypotheses were confirmed. The findings revealed the interrelationships and associations among the objects under investigation. These findings provide valuable insights into the variables that influence the adoption of metaverses in educational settings, while also corroborating the theoretical framework that informed the research. Contrary to previous predictions, the variables MEE, MHM, and MPV had a negligible impact on MBI. Therefore, hypotheses H2, H5, and H6 were largely unsupported. The findings indicate that MPE, MSI, MFC,

Table 3
Demographic profiles of respondents.

	Description	Frequency	Percent
Gender	Male	120	47.43
	Female	133	52.57
Age	18–22	117	46.25
	23–30	11	4.35
	31–35	69	27.27
	36–40	41	16.21
	Above 40	15	5.93
Highest education level	K12	117	46.25
	Bachelor degree	14	5.53
	Master degree	75	29.64
	PhD or Doctoral degree	47	18.58
Position in education	Students	117	46.25
	Lecturers	136	53.75

Table 4
Loading, composite reliability, and average variance extracted.

	Items	Outer loading	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
MBI	MBI1	0.944	0.926	0.928	0.953	0.872
	MBI2	0.943				
	MBI3	0.913				
MEE	MEE1	0.846	0.829	0.831	0.898	0.745
	MEE2	0.864				
	MEE3	0.879				
MFC	MFC1	0.919	0.917	0.917	0.942	0.801
	MFC2	0.915				
	MFC3	0.886				
	MFC4	0.859				
MHM	MHM1	0.889	0.854	0.861	0.911	0.773
	MHM2	0.877				
	MHM3	0.871				
MPE	MPE1	0.898	0.884	0.885	0.928	0.811
	MPE2	0.909				
	MPE3	0.895				
MPV	MPV1	0.843	0.831	0.832	0.899	0.748
	MPV2	0.887				
	MPV3	0.863				
MSE	MSE1	0.875	0.805	0.822	0.885	0.721
	MSE2	0.896				
	MSE3	0.771				
MSI	MSI1	0.874	0.819	0.828	0.893	0.735
	MSI2	0.808				
	MSI3	0.887				
MUB	MUB1	0.926	0.899	0.905	0.937	0.832
	MUB2	0.895				
	MUB3	0.915				

Table 5
Hetero-trait-mono-trait assessment (0.90).

	MBI	MEE	MFC	MHM	MPE	MPV	MSE	MSI	MUB
MBI									
MEE	0.390								
MFC	0.813	0.518							
MHM	0.566	0.561	0.588						
MPE	0.698	0.523	0.705	0.684					
MPV	0.772	0.474	0.866	0.642	0.783				
MSE	0.875	0.478	0.874	0.631	0.747	0.861			
MSI	0.746	0.46	0.755	0.642	0.709	0.813	0.808		
MUB	0.785	0.509	0.867	0.759	0.842	0.773	0.863	0.757	

Table 6
The Fornell-Larcker ratio.

	MBI	MEE	MFC	MHM	MPE	MPV	MSE	MSI	MUB
MBI	**0.934**								
MEE	0.343	**0.863**							
MFC	0.750	0.451	**0.895**						
MHM	0.508	0.472	0.523	**0.879**					
MPE	0.633	0.447	0.635	0.595	**0.901**				
MPV	0.678	0.394	0.756	0.545	0.672	**0.865**			
MSE	0.760	0.393	0.757	0.532	0.635	0.712	**0.849**		
MSI	0.652	0.372	0.656	0.538	0.600	0.667	0.662	**0.857**	
MUB	0.721	0.438	0.790	0.666	0.752	0.672	0.741	0.650	**0.912**

and MSE have significant impacts on MBI, thereby confirming hypotheses H1, H3, H4, and H7. Ultimately, the findings indicate that both MFC and MBI have a favorable impact on MUB, thereby confirming the validity of hypotheses H8 and H9. In addition, Fig. 2 demonstrates that the research model explains 67.6 % and 66.2 % of the variation in MBI and MUB, respectively, indicating a strong ability to predict outcomes within the sample. Table 8 revealed that the Q2 values for both MBI and MUB in the field of education in the metaverse were all above 0. These results indicate that the model exhibited a satisfactory level of accuracy in its predictions. Furthermore, all of the root mean squared error (RMSE) indices in the Partial Least Squares Structural Equation Modeling (PLS-SEM)

Table 7
Hypothesis test results.

Hypotheses	Paths	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	2.50 %	97.50 %	Remark
H1	MPE - > MBI	0.129	0.126	0.054	2.397	0.017	0.026	0.237	Supported
H2	**MEE - > MBI**	**−0.066**	**−0.064**	**0.041**	**1.619**	**0.105**	**−0.143**	**0.018**	**Not Supported**
H3	MSI - > MBI	0.128	0.128	0.059	2.176	0.030	0.017	0.247	Supported
H4	MFC - > MBI	0.314	0.317	0.073	4.327	0.000	0.182	0.465	Supported
H5	**MHM - > MBI**	**0.028**	**0.032**	**0.059**	**0.477**	**0.634**	**−0.087**	**0.147**	**Not Supported**
H6	**MPV - > MBI**	**0.036**	**0.034**	**0.071**	**0.514**	**0.608**	**−0.098**	**0.176**	**Not Supported**
H7	MSE - > MBI	0.341	0.340	0.069	4.935	0.000	0.201	0.472	Supported
H8	MFC - > MUB	0.571	0.569	0.077	7.458	0.000	0.413	0.711	Supported
H9	MBI - > MUB	0.292	0.294	0.078	3.770	0.000	0.149	0.452	Supported

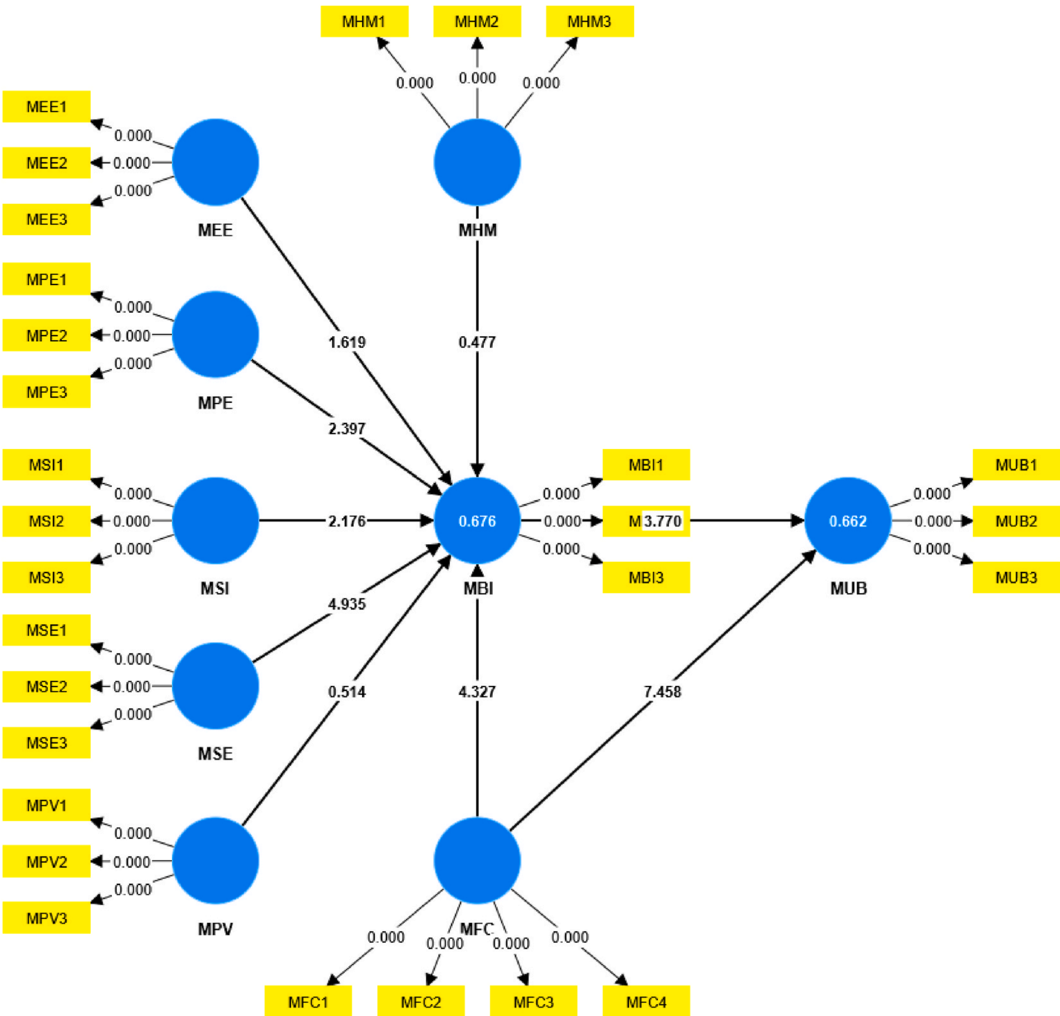

Fig. 2. Hypothesis testing results.

Table 8
PLS predict.

	Q^2predict	PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE
MBI1	0.598	**0.690**	0.445	**0.712**	0.464
MBI2	0.578	**0.698**	0.470	**0.736**	0.501
MBI3	0.525	**0.791**	0.516	**0.839**	0.544
MUB1	0.556	**0.606**	0.413	**0.620**	0.401
MUB2	0.467	**0.714**	0.515	**0.760**	0.480
MUB3	0.627	**0.564**	0.406	**0.582**	0.379

model were smaller than those in the linear model benchmark. Consequently, the PLS-SEM model demonstrated exceptional predictive capabilities, thereby affirming its reliability and accuracy in elucidating and forecasting the interdependencies among crucial variables within the educational framework of the metaverse [69].

5. Discussions

The current study introduced the extended Unified Theory of Acceptance and Use of Metaverse Technology (UTAUMT) and uncovered significant insights into metaverse technology behavioral intention and adoption in education. MPE (Metaverse performance expectancy), MSI (Metaverse Social Influence), MFC (Metaverse Facilitating Conditions), and MSE (Metaverse Self-Efficacy) were found to be positively associated with MBI (Metaverse Behavioral Intention). Furthermore, MFC was discovered to be a determining factor for educational use behavior in the metaverse.

Metaverse Effort Expectation (MEE), Metaverse Hedonic Motivation (MHM), and Metaverse Price Value (MPV) have not been found to significantly affect Metaverse Behavioral Intention (MBI) in the context of metaverse-based learning. The findings are in line with the research of Dang et al. (2022); Nguyen & Nguyen (2021); Al-Adwan & Al-Debei (2024); Al-kfairy et al. (2024); and Nguyen et al. (2024) [18], [19], [20], [70]. The insignificant relationship between MEE and behavioral intention to use metaverse in education can be explained as Users may prioritize other factors, such as the perceived usefulness of Metaverse technologies, over the ease of use. In educational settings, if students and educators perceive that the Metaverse significantly enhances learning outcomes, engagement, or collaboration, these benefits might outweigh concerns about the effort required to use the technology. This focus on utility over ease of use can lead to a situation where effort expectancy does not play a significant role in influencing behavioral intention. common misconception about the educational potential of the metaverse is that it is an extremely difficult and time-consuming environment for users to master. Users may be dissuaded from adopting the metaverse as a serious educational tool because of the impression of increased effort expectancy. Second, MHM did not significantly affect MBI because in an educational context, the primary motivation for adopting new technologies is often their perceived utility in enhancing learning outcomes rather than the enjoyment or pleasure derived from their use. If educators and students perceive Metaverse technologies as more of an educational tool rather than a source of entertainment or pleasure, then hedonic motivation may not significantly influence their intention to adopt. The focus tends to be on how these technologies can improve knowledge retention, engagement, and educational effectiveness rather than on how enjoyable or fun they are to use. The third factor that affects users' behavioral intention to adopt the metaverse for educational purposes is the MPV. If the costs associated with adopting Metaverse technologies are perceived to be high relative to the educational benefits they provide, users may not view the price as justifiable. For example, if educators and students believe that the Metaverse does not significantly enhance learning outcomes or provide unique educational advantages over existing methods, they might not be inclined to adopt it, even if it offers some benefits. In such cases, the perceived price value is low, reducing its positive impact on the intention to adopt. Uncertainty and perceived risks associated with adopting a novel technology may also discourage users from adopting the metaverse for educational purposes. Concerns about data security, privacy, and potential disruptions in learning experiences may prevent users from fully committing to the metaverse as an educational medium. Additionally, users' behavioral intention to use the metaverse for education can be significantly influenced by individual learning preferences, pedagogical approaches, and instructional styles. It's possible that some users will respond better to tried-and-true instructional methods, while others will be more receptive to the fresh perspectives and engaging environments of the metaverse. In order to effectively promote the metaverse's adoption in education, practitioners, designers, and stakeholders must understand and address these user-centric factors. Educators can improve the metaverse's appeal and efficacy as a transformative learning tool by allaying users' concerns and misgivings and providing compelling evidence of the metaverse's educational benefits.

Finally, the results show that Metaverse effort expectancy (MEE), Metaverse social influence (MSI), Metaverse facilitating conditions (MFC), Metaverse self-efficacy (MSE), and Metaverse Behavioral Intention (MBI) yield substantial effects on Metaverse Use Behavior (MUB). The findings are in line with Senyo & Osabutey (2020); Slade et al., 2015); Al-Adwan & Al-Debei (2024); and Al-kfairy et al. (2024) [20], [21], [71], [72]. This means that the user's expectation of the metaverse's ease of use, the influence of others, the availability of external support, and the user's own sense of competence in using the metaverse all play significant roles in shaping the user's intent to employ the metaverse for educational purposes. Users who have a favorable outlook on these aspects are more likely to indicate a robust behavioral intention to participate in metaverse-based pedagogical activities. Metaverse Use Behavior (MUB) was defined as the study's secondary outcome, and it shows that people do use the metaverse for learning. Users' metaverse education experiences and outcomes are significantly influenced by their intention to use the metaverse for education. These results highlight the importance of addressing and promoting positive perceptions of effort expectancy, social influence, facilitating conditions, and self-efficacy among users to encourage their behavioral intention to use the metaverse for education. Educational practitioners and designers can increase metaverse adoption and utilization for educational purposes, leading to better learning experiences and outcomes within the metaverse, by providing user-friendly interfaces, fostering a supportive social environment, ensuring adequate resources, and building users' confidence in utilizing the metaverse effectively.

6. Theoretical contributions and managerial contributions

6.1. Theoretical contributions

The comprehensive Unified Theory of Acceptance and Use of Metaverse Technology (UTAUMT) and the examination of behavioral intention and adoption in education within the metaverse environment result in numerous noteworthy theoretical advancements.

The UTAUT2 framework has been expanded to include distinct components pertaining to the metaverse, such as Metaverse Effort Expectancy (MEE), Metaverse Hedonic Motivation (MHM), and Metaverse Price Value (MPV). This expansion improves the framework's applicability to the emerging metaverse technology. The expanded model integrates these distinct elements to offer a comprehensive understanding of users' intentions and adoption behaviors within the metaverse. This addresses the lack of theoretical knowledge and drives the progress of technology acceptance models.

The field of research on behavioral intention and adoption in metaverse education investigates the factors that exert a substantial influence on metaverse behavioral intention (MBI) and metaverse use behavior (MUB). The factors encompass metaverse perceived enjoyment (MPE), metaverse social influence (MSI), metaverse facilitating conditions (MFC), and metaverse self-efficacy (MSE). The findings of this study provide valuable knowledge for designers, educators, and policymakers who want to improve the acceptance and use of the metaverse in education. They shed light on the pivotal factors that impact users' intentions to interact with it.

In addition, this study enhances the verification and implementation of technology adoption theories within the distinct metaverse context. It accomplishes this by conducting tests and validating the expanded UTAUMT model put forth by Upadhyay and Khandelwal (2022). This improves the resilience of technology acceptance models and enhances their ability to adjust to various technological contexts.

Moreover, the use of the metaverse for educational purposes has concrete consequences for educators, educational institutions, and policymakers. A thorough understanding of the factors that impact users' behavioral intentions and adoption behaviors can improve student engagement, learning opportunities, and overall educational outcomes in the metaverse. This comprehension can inform the development of educational programs and interventions.

The theoretical contributions and findings of this study establish a basis for future investigations into the adoption and utilization of the metaverse as the technology progresses and gains popularity (Hajjami & Park, 2023). Future research can build upon the identified factors and relationships to delve deeper into the complexities of technology adoption in the metaverse and its effects on various fields, including education.

6.2. Managerial contributions

Decision-makers in educational institutions looking to harness the potential of metaverse technology for educational purposes can benefit greatly from the research's managerial insights. Managers can decide how best to incorporate this cutting-edge technology into their educational platforms and programs by identifying and comprehending the critical variables that have a significant impact on users' behavioral intentions and adoption of the metaverse. Focusing on elements like Metaverse Perceived Enjoyment (MPE), Metaverse Social Influence (MSI), Metaverse Facilitating Conditions (MFC), and Metaverse Self-Efficacy (MSE) is necessary for the strategic integration of the metaverse. These insights can be used by managers to create and carry out programs that encourage favorable user perceptions and intentions regarding the adoption of the metaverse [10]. Educational institutions can improve user engagement and satisfaction, which will ultimately result in better learning outcomes and educational experiences, by developing a user-friendly and enjoyable learning environment within the metaverse. The study's results also shed light on important aspects of resource allocation, such as Metaverse Effort Expectancy (MEE), Metaverse Hedonic Motivation (MHM), and Metaverse Price Value (MPV). Managers can invest in measures that reduce perceived effort, improve hedonic appeal, and address cost concerns related to the adoption of the metaverse by addressing these factors. This focused resource distribution makes sure that educational institutions get the most out of their investments in metaverse technology, facilitating and speeding up adoption.

By prioritizing training programs and offering robust support services to improve Metaverse Self-Efficacy (MSE), managers can further empower their users. Enhancing user satisfaction as well as the overall success of educational initiatives within the metaverse environment depends on users' increased confidence and proficiency in navigating and using the metaverse for educational purposes. A distinct competitive advantage can be provided to educational institutions by utilizing the metaverse for educational purposes [10]. Institutions can establish themselves as leaders in offering cutting-edge and immersive learning experiences by actively integrating this cutting-edge technology into their teaching and learning methods. Students and stakeholders looking for cutting-edge learning environments may find this to be an appealing proposition.

The research has managerial benefits that go beyond initial adoption because it establishes the framework for ongoing improvement. These priceless insights can be used by decision-makers to regularly review and improve their metaverse integration strategies and approaches, ensuring that they stay abreast of new trends and user preferences. For decision-makers in educational institutions looking to embrace the metaverse for educational purposes, the managerial contributions of the study offer helpful advice and real-world implications [11]. Managers can strategically integrate the metaverse, optimize resource allocation, improve user training and support, gain a competitive edge, and promote continuous improvement in their educational offerings within the dynamic metaverse environment by making use of these insights.

7. Conclusion, limitation, and future researches

The present study examined the relationship between behavioral intention and adoption in the field of education in the metaverse environment. It also put forward the extended Unified Theory of Acceptance and Use of Metaverse Technology (UTAUMT). The findings indicate that there are robust correlations between expectations of metaverse effort (MEE), social influence in the metaverse (MSI), facilitating conditions for the metaverse (MFC), self-efficacy in the metaverse (MSE), and intentions to engage in metaverse behavior (MBI). These factors have a substantial influence on the behaviors related to metaverse use (MUB) in the context of metaverse education. These findings provide valuable information for practical applications in educational settings and contribute to the advancement of theoretical understanding of technology acceptance models.

Potential future research endeavors could explore various subjects in order to propel the advancement of metaverse adoption in the realm of education. Initially, research could concentrate on examining the impact of individual variations, such as personality traits and learning preferences, on users' behavioral intentions and actions within the metaverse. Furthermore, considering the ever-evolving nature of technology, conducting longitudinal studies can provide valuable insights into the evolution of users' perspectives and behaviors in the metaverse over time. For educational institutions seeking to maintain the adoption of metaverse technology in the long run, this could assist in recognizing possible obstacles and prospects. Conducting comparative research in different educational settings, such as primary, secondary, higher education, and professional training, can provide valuable insights into the intricate impacts of adopting metaverse technology. Considering the rapid progress of metaverse technology, future research could explore the impact of emerging elements and applications, such as augmented reality overlays, virtual reality simulations, and blockchain-based interactions, on learning outcomes and user experiences.

An ethics statement (including the committee approval number) for animal and human studies

University of Foreign Languages-Information Technology, HUFLIT (Reference number 784/QDEA).

CRediT authorship contribution statement

Anh Hoai Duc Nguyen: Investigation, Formal analysis. **Tung Thanh Le:** Software, Formal analysis. **Tri-Quan Dang:** Writing – original draft, Methodology. **Luan-Thanh Nguyen:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization.

Declaration of competing interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e38741.

References

[1] T. Dang Quan, G. Wei-Han Tan, E.C.X. Aw, T.H. Cham, S. Basu, K.B. Ooi, Can you resist the virtual temptations? Unveiling impulsive buying in metaverse retail, Asia Pac. J. Mark. Logist. (2024), https://doi.org/10.1108/APJML-09-2023-0911.

[2] B.-H.T. Nguyen, T.-Q. Dang, L.-T. Nguyen, T.-T.T. Tran, Are we ready for education in Metaverse? PLS-SEM analysis, Edelweiss Applied Science and Technology 8 (2) (Feb. 2024) 73–83, https://doi.org/10.55214/25768484.v8i2.693.

[3] A. Alnagrat, R. Che Ismail, S.Z. Syed Idrus, R.M. Abdulhafith Alfaqi, A review of extended reality (XR) technologies in the future of human education: current trend and future opportunity, Journal of Human Centered Technology 1 (2) (2022) 81–96, https://doi.org/10.11113/humentech.v1n2.27.

[4] I.A. Akour, R.S. Al-Maroof, R. Alfaisal, S.A. Salloum, A conceptual framework for determining metaverse adoption in higher institutions of gulf area: an empirical study using hybrid SEM-ANN approach, Comput. Educ.: Artif. Intell. 3 (Jan. 2022) 100052, https://doi.org/10.1016/j.caeai.2022.100052.

[5] E. Viardot, A. Brem, P.A. Nylund, Technological Forecasting & Social Change Post-pandemic implications for crisis innovation : a technological innovation view, Technol. Forecast. Soc. Change 194 (June) (2023) 122680, https://doi.org/10.1016/j.techfore.2023.122680.

[6] J. Leng, et al., Industry 5.0: prospect and retrospect, J. Manuf. Syst. 65 (August) (2022) 279–295, https://doi.org/10.1016/j.jmsy.2022.09.017.

[7] M.A. Camilleri, Metaverse applications in education: a systematic review and a cost-benefit analysis, Interact. Technol. Smart Educ. (2023), https://doi.org/10.1108/ITSE-01-2023-0017.

[8] P. Hines, T.H. Netland, Teaching a Lean masterclass in the metaverse, International Journal of Lean Six Sigma (2022), https://doi.org/10.1108/IJLSS-02-2022-0035.

[9] A.K. Upadhyay, K. Khandelwal, Metaverse: the future of immersive training, Strateg. HR Rev. 21 (3) (2022) 83–86, https://doi.org/10.1108/shr-02-2022-0009.

[10] M. Mehta, G. Pancholi, D.A. Saxena, Metaverse changing realm of the business world: a bibliometric snapshot, J. Manag. Dev. (2023), https://doi.org/10.1108/JMD-01-2023-0006.

[11] O. Hajjami, S. Park, Using the Metaverse in Training: Lessons from Real Cases, European Journal of Training and Development, 2023, https://doi.org/10.1108/EJTD-12-2022-0144.

[12] W. Batat, W. Hammedi, The extended reality technology (ERT) framework for designing customer and service experiences in phygital settings: a service research agenda, J. Serv. Manag. 34 (1) (2023) 10–33, https://doi.org/10.1108/JOSM-08-2022-0289.

[13] T.-Q. Dang, P.-T. Tran, L.-T. Nguyen, in: M.A. Al-Sharafi, M. Al-Emran, G.W.-H. Tan, K.-B. Ooi (Eds.), Are You Ready for Tapping into the Metaverse in Higher Education? Integrated by Dual PLS-SEM and ANN Approach BT - Current and Future Trends on Intelligent Technology Adoption, ume 1, Springer Nature Switzerland, Cham, 2023, pp. 63–84, https://doi.org/10.1007/978-3-031-48397-4_4.

[14] L.-T. Nguyen, T.-T.C. Phan, D.-V.T. Dang, T.-T.T. Tran, in: M.A. Al-Sharafi, M. Al-Emran, G.W.-H. Tan, K.-B. Ooi (Eds.), Mobile Payment Adoption in Vietnam: A Two-Staged SEM-ANN Approach BT - Current and Future Trends on Intelligent Technology Adoption, ume 1, Springer Nature Switzerland, Cham, 2023, pp. 209–228, https://doi.org/10.1007/978-3-031-48397-4_11.

[15] A.S. Al-Adwan, M. Alsoud, N. Li, T. Majali, J. Smedley, A. Habibi, Unlocking future learning: exploring higher education students' intention to adopt meta-education, Heliyon 10 (9) (May 2024) e29544, https://doi.org/10.1016/j.heliyon.2024.e29544.

[16] L.-T. Nguyen, D.T.V. Duc, T.-Q. Dang, D.P. Nguyen, Metaverse banking service: are we ready to adopt? A deep learning-based dual-stage SEM-ANN analysis, Hum Behav Emerg Technol 2023 (2023) 6617371, https://doi.org/10.1155/2023/6617371.

[17] T.-Q. Dang, P.-T. Tran, L.-T. Nguyen, Are you ready for tapping into the metaverse in higher education? Integrated by dual PLS-SEM and ANN approach BT - current and future trends on intelligent technology adoption: volume 1, in: M.A. Al-Sharafi, M. Al-Emran, G.W.-H. Tan, K.-B. Ooi (Eds.), Current and Future Trends on Intelligent Technology Adoption, Springer Nature Switzerland, Cham, 2023, pp. 63–84, https://doi.org/10.1007/978-3-031-48397-4_4.

[18] M. Al-kfairy, M. Alzaabi, B. Snoh, H. Almarzooqi, W. Alnaqbi, Metaverse-based classroom: the good and the bad, in: 2024 IEEE Global Engineering Education Conference (EDUCON), 2024, pp. 1–7, https://doi.org/10.1109/EDUCON60312.2024.10578570.

[19] A.S. Al-Adwan, M.M. Al-Debei, The determinants of Gen Z's metaverse adoption decisions in higher education: integrating UTAUT2 with personal innovativeness in IT, Educ. Inf. Technol. 29 (6) (2024) 7413–7445, https://doi.org/10.1007/s10639-023-12080-1.

[20] M. Al-kfairy, S. Ahmed, A. Khalil, Factors Impacting Users' Willingness to Adopt and Utilize the Metaverse in Education: A Systematic Review, Elsevier B.V., Aug. 01, 2024, https://doi.org/10.1016/j.chbr.2024.100459.

[21] A.S. Al-Adwan, N. Li, A. Al-Adwan, G.A. Abbasi, N.A. Albelbisi, A. Habibi, Extending the technology acceptance model (TAM) to predict university students' intentions to use metaverse-based learning platforms, Educ. Inf. Technol. 28 (11) (Nov. 2023) 15381–15413, https://doi.org/10.1007/s10639-023-11816-3.

[22] M. Al-kfairy, A. Alomari, M. Al-Bashayreh, O. Alfandi, M. Tubishat, Unveiling the Metaverse: A Survey of User Perceptions and the Impact of Usability, Social Influence and Interoperability, Elsevier Ltd, May 30, 2024, https://doi.org/10.1016/j.heliyon.2024.e31413.

[23] F. Yang, L. Ren, C. Gu, A study of college students' intention to use metaverse technology for basketball learning based on UTAUT2, Heliyon 8 (9) (2022) e10562, https://doi.org/10.1016/j.heliyon.2022.e10562.

[24] S.-Y. Chien, G.-J. Hwang, M.S.-Y. Jong, Effects of peer assessment within the context of spherical video-based virtual reality on EFL students' English-Speaking performance and learning perceptions, Comput. Educ. 146 (2020) 103751, https://doi.org/10.1016/j.compedu.2019.103751.

[25] A. Siyaev, G.S. Jo, Towards aircraft maintenance metaverse using speech interactions with virtual objects in mixed reality, Sensors 21 (6) (2021) 1–21, https://doi.org/10.3390/s21062066.

[26] J.E.M. Díaz, C.A.D. Saldaña, C.A.R. Avila, Virtual world as a resource for hybrid education, International Journal of Emerging Technologies in Learning 15 (15) (2020) 94–109, https://doi.org/10.3991/ijet.v15i15.13025.

[27] V. Venkatesh, M.G. Morris, G.B. Davis, F.D. Davis, User acceptance of information technology: toward a unified view, MIS Q. 27 (3) (2003) 425–478, https://doi.org/10.2307/30036540.

[28] B.-T.H. Nguyen, T.H. Le, T.Q. Dang, L.-T. Nguyen, What role does AI chatbot perform in the F&B industry? Perspective from loyalty and value Co-creation: integrated PLS-SEM and ANN techniques, Journal of Law and Sustainable Development 44 (4) (2023) 1–39, https://doi.org/10.55908/sdgs.v11i4.794.

[29] L.-T. Nguyen, T.-T.C. Phan, D.-V.T. Dang, T.-T.T. Tran, Mobile payment adoption in Vietnam: a two-staged SEM-ANN approach BT - current and future trends on intelligent technology adoption: volume 1, in: M.A. Al-Sharafi, M. Al-Emran, G.W.-H. Tan, K.-B. Ooi (Eds.), Current and Future Trends on Intelligent Technology Adoption, Springer Nature Switzerland, Cham, 2023, pp. 209–228, https://doi.org/10.1007/978-3-031-48397-4_11.

[30] P.K. Senyo, E.L.C. Osabutey, Unearthing antecedents to financial inclusion through FinTech innovations, Technovation 98 (June 2019) 102155, https://doi.org/10.1016/j.technovation.2020.102155. Dec. 2020.

[31] N.-Y. Dao, L.-T. Nguyen, V.-H. Dinh, Factors driving Vietnamese university students' adoption in a smart learning environment: the application of self-determination theory and technology acceptance model, in: Smart Learning for A Sustainable Society Lecture Notes in Educational Technology, 2023, pp. 185–190, https://doi.org/10.1007/978-981-99-5961-7_22.

[32] K. Owusu Kwateng, K.A. Osei Atiemo, C. Appiah, Acceptance and use of mobile banking: an application of UTAUT2, J. Enterprise Inf. Manag. (2019), https://doi.org/10.1108/JEIM-03-2018-0055.

[33] K.F. Yuen, L.Y. Koh, L.Y.H. Tan, X. Wang, The determinants of virtual reality adoption for marine conservation, Technol. Soc. 72 (Feb. 2023) 102170.

[34] V. Venkatesh, J.Y.L. Thong, X. Xu, Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology, MIS Q. (2012), https://doi.org/10.2307/41410412.

[35] D. Buhalis, M.S. Lin, D. Leung, Metaverse as a driver for customer experience and value co-creation: implications for hospitality and tourism management and marketing, Int. J. Contemp. Hospit. Manag. 35 (2) (2023) 701–716, https://doi.org/10.1108/IJCHM-05-2022-0631.

[36] K. Tamilmani, N.P. Rana, S.F. Wamba, R. Dwivedi, The extended Unified Theory of Acceptance and Use of Technology (UTAUT2): a systematic literature review and theory evaluation, Int. J. Inf. Manag. (2021), https://doi.org/10.1016/j.ijinfomgt.2020.102269.

[37] V. Venkatesh, M.G. Morris, G.B. Davis, F.D. Davis, User acceptance of information technology, MIS Q. 27 (3) (2003) 425–478. https://doi.org/10.2307/30036540.

[38] J. Lu, C.S. Yu, C. Liu, Facilitating conditions, wireless trust and adoption intention, J. Comput. Inf. Syst. 46 (1) (Sep. 2005) 17–24, https://doi.org/10.1080/08874417.2005.11645865.

[39] L.-T. Nguyen, T.-Q. Dang, D.T.V. Duc, The dark sides of AI advertising: the integration of cognitive appraisal theory and information quality theory, Soc. Sci. Comput. Rev. (Jun. 2024), https://doi.org/10.1177/08944393241258760.

[40] N.-Y. Dao, L.-T. Nguyen, V.-H. Dinh, Factors driving Vietnamese university students' adoption in a smart learning environment: the application of self-determination theory and technology acceptance model, in: Lecture Notes in Educational Technology, Springer Nature Singapore, 2023, pp. 185–190, https://doi.org/10.1007/978-981-99-5961-7_22.

[41] A.A. Alalwan, Y.K. Dwivedi, N.P. Rana, B. Lal, M.D. Williams, Consumer adoption of Internet banking in Jordan: examining the role of hedonic motivation, habit, self-efficacy and trust, J. Financ. Serv. Market. (2015), https://doi.org/10.1057/fsm.2015.5.

[42] H.-B. Nguyen, L.-T. Nguyen, Factors influence blockchain adoption in supply chain management among companies based in Ho Chi Minh city, in: Conference towards ASEAN Chairmanship 2023 (TAC 23 2021), Atlantis Press, Indonesia, 2021, pp. 1–13 [Online]. Available: https://www.atlantis-press.com/proceedings/t-a-c-23-21/125965535.

[43] L.-T. Nguyen, D. Nguyen, K.N.-N. Ngoc, D.T.V. Duc, Blockchain adoption in logistics companies in Ho Chi Minh city, Cogent Business & Management 10 (2) (2023) 1–24, https://doi.org/10.1080/23311975.2023.2216436.

[44] H.J. Oh, J. Kim, J.J.C. Chang, N. Park, S. Lee, Social benefits of living in the metaverse: the relationships among social presence, supportive interaction, social self-efficacy, and feelings of loneliness, Comput. Hum. Behav. 139 (November 2021) (2023) 107498, https://doi.org/10.1016/j.chb.2022.107498.

[45] M. Alruwaie, R. El-Haddadeh, V. Weerakkody, Citizens' continuous use of eGovernment services: the role of self-efficacy, outcome expectations and satisfaction, Govern. Inf. Q. 37 (3) (Jul. 2020), https://doi.org/10.1016/j.giq.2020.101485.

[46] T.Q. Dang, G.W.H. Tan, E.C.X. Aw, K.B. Ooi, B. Metri, Y.K. Dwivedi, How to generate loyalty in mobile payment services? An integrative dual SEM-ANN analysis, Int. J. Bank Market. (2023), https://doi.org/10.1108/IJBM-05-2022-0202.

[47] J.C. Nunnally, Psychometric theory, in: McGraw-Hill Series in Psychology, McGraw-Hill, New York, NY, US, 1978.

[48] R. Shanmugam, Understanding research methods: an overview of the essentials, J. Stat. Comput. Simulat. (2020), https://doi.org/10.1080/00949655.2019.1628904.

[49] V. Venkatesh, J.Y.L. Thong, X. Xu, Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology, MIS Q. (2012), https://doi.org/10.2307/41410412.

[50] H.-T. Tew, G.W.-H. Tan, X.-M. Loh, V.-H. Lee, W.-L. Lim, K.-B. Ooi, Tapping the next purchase: embracing the wave of mobile payment, J. Comput. Inf. Syst. (2021), https://doi.org/10.1080/08874417.2020.1858731.

[51] H. Karjaluoto, A.A. Shaikh, M. Leppäniemi, R. Luomala, Examining consumers' usage intention of contactless payment systems, Int. J. Bank Market. 38 (2) (2020) 332–351, https://doi.org/10.1108/IJBM-04-2019-0155.

[52] H.-T. Tew, G.W.-H. Tan, X.-M. Loh, V.-H. Lee, W.-L. Lim, K.-B. Ooi, Tapping the next purchase: embracing the wave of mobile payment, J. Comput. Inf. Syst. (2021), https://doi.org/10.1080/08874417.2020.1858731.

[53] H. Karjaluoto, A.A. Shaikh, H. Saarijärvi, S. Saraniemi, How perceived value drives the use of mobile financial services apps, Int. J. Inf. Manag. 47 (2019) 252–261, https://doi.org/10.1016/j.ijinfomgt.2018.08.014. September 2018.

[54] M.-N. Nguyen, "Vietnam: number of university teacher," Statista.com [Online]. Available: https://www.statista.com/statistics/815234/number-of-university-teachers-in-vietnam/. (Accessed 15 July 2023).

[55] Ngoc Lan, "Sound prospects for metaverse in Vietnam," VnEconomy.Accessed: June. 4, 2023. [Online]. Available: https://vneconomy.vn/sound-prospects-for-metaverse-in-vietnam.htm. 0(1)1-1.

[56] I. Etikan, Comparison of convenience sampling and purposive sampling, Am. J. Theor. Appl. Stat. (2016), https://doi.org/10.11648/j.ajtas.20160501.11.

[57] S. Lew, G.W.H. Tan, X.M. Loh, J.J. Hew, K.B. Ooi, The disruptive mobile wallet in the hospitality industry: an extended mobile technology acceptance model, Technol. Soc. 63 (2020), https://doi.org/10.1016/j.techsoc.2020.101430.

[58] D.M. Hardesty, W.O. Bearden, The use of expert judges in scale development. Implications for improving face validity of measures of unobservable constructs, J. Bus. Res. 57 (2) (Feb. 2004) 98–107, https://doi.org/10.1016/S0148-2963(01)00295-8.

[59] Mary R. Lynn, Determination and quantification of content validity [Online]. Available: http://ijoh.tums.ac.ir/index.php/ijoh/article/view/26, 1986.

[60] Mary R. Lynn, Determination and Quantification of Content Validity, 1986.

[61] D.F. Polit, C.T. Beck, The content validity index: are you sure you know what's being reported? Critique and recommendations, Res. Nurs. Health 29 (5) (2006) 489–497, https://doi.org/10.1002/nur.

[62] J.B. Wilcox, P.H. Rossi, J.D. Wright, A.B. Anderson, Handbook of survey research, J. Market. Res. 22 (1) (1985) 100, https://doi.org/10.2307/3151558.

[63] T.K. Leong, A.N. Chiek, C.W. Lim, A modified Utaut in the context of M-payment usage intention in Malaysia, Journal of Applied Structural Equation Modeling 5 (1) (2021) 39–60, https://doi.org/10.47263/jasem.5(1)05.

[64] Hair, Multivariate Data Analysis, seventh ed., Prentice Hall, 2010.

[65] P.M. Podsakoff, S.B. MacKenzie, J.Y. Lee, N.P. Podsakoff, Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies, 2003, https://doi.org/10.1037/0021-9010.88.5.879.

[66] L.W. Wong, G.W.H. Tan, K.B. Ooi, B. Lin, Y.K. Dwivedi, Artificial intelligence-driven risk management for enhancing supply chain agility: a deep-learning-based dual-stage PLS-SEM-ANN analysis, Int. J. Prod. Res. (May) (2022), https://doi.org/10.1080/00207543.2022.2063089.

[67] J.F. Hair, A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), 2017. Second edi.

[68] M.R. Ab Hamid, W. Sami, M.H. Mohmad Sidek, Discriminant validity assessment: use of Fornell & Larcker criterion versus HTMT criterion, in: Journal of Physics: Conference Series, 2017, https://doi.org/10.1088/1742-6596/890/1/012163.

[69] G. Shmueli, S. Ray, J.M. Velasquez Estrada, S. Chatla, The elephant in the room: evaluating the predictive performance of partial least squares (PLS) path models, SSRN Electron. J. (2015), https://doi.org/10.2139/ssrn.2659233.

[70] H.-B. Nguyen, L.-T. Nguyen, Factors influence blockchain adoption in supply chain management among companies based in Ho Chi Minh city, in: Conference towards ASEAN Chairmanship 2023 (TAC 23 2021), Atlantis Press, Indonesia, 2021, pp. 1–13.

[71] E. Slade, M. Williams, Y. Dwivedi, N. Piercy, Exploring consumer adoption of proximity mobile payments, J. Strat. Market. (2015), https://doi.org/10.1080/0965254X.2014.914075.

[72] P.K. Senyo, E.L.C. Osabutey, Unearthing antecedents to financial inclusion through FinTech innovations, Technovation 98 (June 2019) 102155, https://doi.org/10.1016/j.technovation.2020.102155. Dec. 2020.