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Novel machine learning based approach for analysing the adoption of metaverse in medical training: A UAE case study

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ABSTRACT

The outbreak of the COVID-19 pandemic led to disruptions in the delivery of medical training across borders, posing challenges in observing and practicing advanced surgical techniques with cutting-edge medical equipment from foreign countries. However, the utilization of educational approaches centred on the “Metaverse” concept has emerged as a promising solution to address the escalating demand for virtual medical education. Traditional technologies like Zoom video conferencing were found insufficient for comprehensive medical instruction, prompting the emergence of innovative digital teaching methodologies within the medical community of the United Arab Emirates (UAE). This study aims to investigate how students perceive the effectiveness of the Metaverse system in achieving medical training objectives in the UAE. The research employs a unique conceptual framework that links individual attributes with technological factors. By employing a blend of structural equation modelling (SEM) and machine learning (ML) methodologies, along with the analysis of importance-performance maps (IPMA), the research evaluates the factors that contribute to measuring the viability of the Metaverse system for medical training. This evaluation is conducted using data gathered from a cohort of 879 university students. The findings indicated that the OneR classifier demonstrates the highest accuracy among classifiers in forecasting users’ inclination to embrace the Metaverse system for medical training, achieving an 80.7% accuracy rate. Furthermore, the study reveals a strong positive association between perceived usefulness and perceived usability, highlighting the significant impact of personal attributes and technological elements on students’ decisions. Notably, individuals with a greater willingness to embrace uncertainty and innovative technologies are more inclined to use the Metaverse system for medical education. In conclusion, this multi-analytical investigation sheds light on the potential of the Metaverse system to enhance medical training and addresses the challenges posed by the COVID-19 pandemic. The findings carry important implications for the field of information systems and provide valuable insights for medical educators seeking effective solutions during times of disruption.

1. Introduction

Some fields in virtual worlds need to be expanded swiftly, according to researchers and computer experts. Because social media and the Internet are so widely used, it is now possible to build (3D) virtual settings with ease and at a low cost [1,2]. The term *Metaverse* was invented by [3] As in a science fiction book, an engrossing 3D virtual environment was shown. The growth of Metaverse allows for regular human

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connection and communication. Consequently, Metaverse can be presented as a world which is practical–enhance physicality and spatial realism. It combines the physical and real universes; allowing users to picture the real world that DO NOT EXIST in real [1,4–6].

Numerous research endeavours have been conducted across various universities and educational institutions, focusing on the utilization of the Metaverse as a central element of their investigations. These studies have implemented the Metaverse within a learning environment, emphasizing the integration of a problem-based approach. By leveraging avatars and three-dimensional classrooms, both professors and students engage in describing and exploring complex issues within this simulated environment [7–10]. The work of Jeon and Jung [11] underscores the pivotal role of the Metaverse system in enhancing learners' enthusiasm and active participation. This platform fosters genuine engagement with innovative learning methods and the cultivation of self-directed learning opportunities. Similarly, other research endeavours [7,12], such as the study by Kanematsu et al. [8], have centred on the diverse application of the Metaverse across academic disciplines worldwide. These investigations have predominantly focused on the practical implementation of these concepts. In fact, the model can investigate the effectiveness of the Metaverse system where the focus is on the students' insight from a different viewpoint. Since the Metaverse system has been developed recently to solve problems in online learning environments, few studies have focused on its adoption and acceptance by users in developed countries, therefore, the present research represents the strong potential of the Metaverse adoption, attempting to investigate the impact of the innovative three dimensions' technology. In fact, according to recent research on the Metaverse system, it seems that Metaverse has been appreciated by users as a tool to manage the learning environment [13,14].

A thorough grasp of how people viewed the benefits of technology, according to previous studies [15]. Some studies have focused on the innovativeness of the technology as an external factor, not as a moderator factor [16,17]. Although past research has cited the importance of the Metaverse system, they failed to yield desirable results that are based on a comprehensive model incorporating all crucial factors. A major issue for the shortage of comprehensive awareness of its effectiveness is the fact that Metaverse is a recently developed system. The study aims at inhibiting effective methodology and a strong model to deeply explain the effect of the Metaverse system. To that end, this research captures two key elements; learners' satisfaction and innovativeness. The element of satisfaction is escorted by a variety of dynamics as well as perceived trialability, observability, and compatibility. The degree of satisfaction increases as perceived trialability, observability, and compatibility increase. When it comes to personal innovation, perceived utility, and simplicity of usage affect how effective personal innovation is [18,19].

The primary objective of this study was to explore the factors that influence the adoption of the Metaverse system in the UAE, specifically examining the impact of perceived utility, usability, and value on its uptake. Additionally, the study sought to investigate how individual innovations' perceived pleasure influences perceived utility and ease of use. Another key goal was to establish a connection between perceived value, focusing on aspects like observability, ubiquity, and trialability, and the implementation of the Metaverse system. Central to this study is the examination of ML models, which are essential for analysing the collected data. The data for the study was collected through online surveys distributed to university students in the UAE within a defined time frame. Various extracted features, including trialability, visibility, perceived enjoyment, perceived ubiquity, perceived worth, entrepreneurial orientation, and representations from the Technology Acceptance Model (TAM), play a crucial role in understanding students' perspectives on the Metaverse system. To evaluate the effectiveness of the ML models, several assessment metrics, including accuracy, precision, recall, and F1-score, are employed. These metrics are used to measure the models' predictive capabilities and their accuracy in classifying students' intentions to adopt the Metaverse system. The methodology of this study employs a comprehensive multi-analytical approach, combining SEM and ML techniques. This approach aims to provide a holistic understanding of the factors that influence students' behavior. By leveraging advanced ML algorithms, this research aims to uncover intricate relationships and patterns that drive students' intentions toward the adoption of the Metaverse system. The incorporation of ML in this study has the potential to offer significant contributions to the field of information systems. It provides practical, data-driven recommendations to enhance medical education and training, particularly in the face of the challenges posed by the COVID-19 pandemic.

2. Literature review

2.1. Metaverse: definition and features

The term "Metaverse" was created to describe fictitious scenarios in which individuals communicate with one another using avatars or pseudonyms in real-time situations. In the immersive, three-dimensional virtual world known as Metaverse, users interact socially and economically, regardless of their location. The interaction is computationally-base [4–6,20]. "Interactivity, Corporeity, and Persistence" are three distinctive qualities of Metaverse that distinguish it from other teaching tools. The interactivity component of the Metaverse system facilitates both independent and collaborative learning, as well as providing accessibility to all learning materials. This dynamic feature contributes to the creation of a distinctive educational environment. In both the virtual setting and the virtual learning platform, users can interact and communicate with each other. This allows users to remain engaged with technology while staying within their physical surroundings in the real world. Within the digital realm, the incorporation of corporeity results in the creation of avatars that are not constrained by physical limitations, closely resembling the visual quality seen in 3D video games. The persistence attribute holds significant importance as it enables the retention of conversations, data, and objects even after individuals have exited the virtual environment. This characteristic ensures continuity and coherence within the virtual world, a concept observed in various studies [4,21–23].

With an academic perspective, businesses and industries need educated workers who can handle the new challenges presented by the Metaverse environment. This calls for innovative organizational forms of leadership and methodological approaches. Additionally, these environments will allow for a better explanation of human activity in educational settings as well as an examination of how it differs from or is similar to conduct in the actual world. Institutions of higher education can benefit from a variety of strategies by creating a system that enables professors, staff, and students to interact in an environment that is completely adaptable with classes that are free of restrictions. With just the click of a mouse, students can interact digitally with their instructors. The Metaverse aims to adopt this scenario by transforming a real university or institution into a virtual one where instructors, students, and learning models can communicate and collaborate in hybrid and cooperative classes [22,23].

The built prediction base is evaluated in this study using two different approaches; the SmartPLS tool [24] and the conceptual framework using ML techniques using Weka and SPSS [25]. To anticipate the correlations in the suggested theoretical model, this study employs a variety of methodologies for ML different classifiers, and deep learning [25].

2.2. Metaverse system and previous studies

The attainment of learning objectives within the educational setting depends on the effectiveness of the teaching and learning strategies employed. Utilizing strategies like the Metaverse proves to be instrumental in achieving these goals. By transcending the limitations of time and space, the Metaverse platform offers a solution to the challenge of meeting learning objectives. This makes problem-based education particularly beneficial in the virtual realm, rendering it as impactful as traditional education [7,8,12].

Various domains of education, including engineering, technology, and materials science, have effectively embraced the Metaverse as a means to achieve their teaching and learning goals. Through the incorporation of problem-based learning within the Metaverse environment, learners are exposed to challenges that demand creative solutions. Operating within a virtual space where avatars can carry out daily tasks, learners are required to apply their knowledge to solve problems. Educators create scenarios within the Metaverse that mirror real-world challenges, allowing learners to approach these issues as avatars. The efficacy of the proposed solutions is evaluated through questionnaires or interactions between students and teachers. In certain instances, students are provided with introductory explanations in traditional classes, followed by in-depth consideration and problem-solving discussions in the Metaverse environment. This approach results in a comprehensive understanding and a strong determination to address the problem. Research has consistently shown that students' familiarity with Metaverse technology and their readiness for its utilization significantly impact the effectiveness of the problem-based learning approach within the Metaverse, as demonstrated in studies conducted across several nations, including Malaysia, Japan, and Germany [7–10].

In a study by [2], the research's primary goal was to determine the importance of AR. To create mobile Functionality utilizing the Metaverse AR platform, instructors must integrate augmented reality into the class. The findings indicate that teachers are more encouraged by the material than the AR tool itself. The outcome raises concerns about whether the significance of a Metaverse in the daily classroom was adequately conveyed to both educators and learners, as well as how AR fits into it. One more study by [4] investigated how a virtual or Metaverse system may be used in a classroom, paying particular attention to how easily synchronous and asynchronous information can be accessed. The study opens the door to practical educational situations where pupils and instructors can interact while utilizing library services, going to a museum, holding a meeting, etc. For a group of pupils, they used a quasi-experiment study design. A questionnaire was used as the method to determine how satisfied students were with the virtual environment. Although the study's main objective was to develop pedagogical strategies using new technology, it was only able to focus on math instruction at the University of Cundinamarca.

The interactive elements and customized customer experience of the Metaverse make it efficient. Therefore, scientists are using these two truths to their benefit in the classroom [26,27]. Ng et al. [26], have offered a virtual educational case study to solve the issue of the integrated revenue allocation plan. Thus, Metaverse educational settings can offer a variety of advantages in a variety of academic subjects, including STEM education, math and engineering, and teaching and training for airplanes. There are a ton of options for virtual airplane engagement in the context of aviation maintenance and training. Metaverse, enhancing options for learning and training that improves the ability to engage with virtual items in mixed reality STEM education leverages the potential of the Metaverse by establishing connections, thereby enhancing the applicability of educational concepts [28,29]. The Metaverse's efficacy across diverse domains has led to the prevailing notion that there exists a strong correlation between the Metaverse and motivation. Engaging with the Metaverse platform positively influences the motivation levels of team members. In practice, this mode of communication aligns well with the expectations of all involved parties, making it a highly favoured means of interaction [11].

2.3. Metaverse for medical training: UAE's innovative approach

The utilization of the Metaverse for medical training within the educational landscape of the UAE introduces an innovative and ground breaking approach. With conventional teaching methods encountering limitations, the incorporation of the Metaverse offers potential solutions to the growing demand for virtual education. In contrast to passive technologies like Zoom, the medical community in the UAE is embracing digital teaching techniques that harness the capabilities of the Metaverse. This technology immerses medical professionals and students into interactive virtual environments, facilitating impactful learning experiences [30]. This pioneering research is dedicated to comprehending students' perceptions of the Metaverse system for medical training. Employing a multidimensional approach, it integrates adoption patterns and factors such as triability, visibility, perceived enjoyment, and perceived ubiquity. The application of ML methods aids in predicting the intent to adopt Metaverse services, culminating in a distinctive and comprehensive conceptual framework that bridges individual characteristics with technological dimensions. This hybrid analytical approach, amalgamating SEM and ML, furnishes valuable insights into the acceptance and utilization of the Metaverse among students. By identifying perceived usefulness as a pivotal indicator, this study offers guidance to medical institutions in harnessing the full potential of the Metaverse for medical education, contributing novel insights to the realm of information systems.

In comparison to other systems, the selected Metaverse system exhibits advantageous features that are particularly suitable for medical training. Its remarkable realism and immersive nature provide lifelike and interactive environments, facilitating the efficient development of critical skills. The collaborative learning opportunities foster knowledge exchange among medical practitioners on a global scale. However, this chosen system may also entail certain drawbacks, including technical intricacies, higher implementation costs, and potential compatibility challenges. Addressing concerns related to data security and privacy is paramount to ensure the protection of sensitive patient information. A comprehensive evaluation of the merits and limitations of the system will offer valuable guidance to researchers and educators seeking effective virtual training solutions.

The Metaverse environment employed in this study is characterized by sophistication and immersion, leveraging cutting-edge technology to simulate realistic medical scenarios and replicate medical training settings. Participants, predominantly comprising medical professionals and students, engage with scenarios spanning surgical simulations, emergency room scenarios, patient interactions, medical technology demonstrations, and collaborative learning experiences. Visual aids and graphical representations enhance comprehension and engagement. The research endeavours to capture participants' insights and encounters with the Metaverse system, evaluating various factors through the conceptual framework established in the study. Through meticulously crafted and lifelike scenarios, the research yields reliable and meaningful findings, contributing to the advancement of medical education in the UAE and beyond.

2.4. Meta Platforms, Inc.: our preferred virtual realm

For this study, we selected Meta Platforms, Inc [31]. (formerly known as Facebook [32]) as the Metaverse system. Our decision was based on a multifaceted rationale. Firstly, from a technical standpoint, Meta's advanced infrastructure, rooted in its Oculus virtual reality and augmented reality technologies, offers unparalleled immersive experiences. The platform's high-resolution virtual environments, real-time interaction capabilities, and expansive user base are critical features pertinent to our research objectives. Furthermore, Meta's commitment to building a comprehensive Metaverse ecosystem is evident from its strategic shift and investments, positioning it at the forefront of Metaverse evolution. Compared to other available Metaverse systems, Meta provides a unique blend of social media integration, widespread accessibility, and advanced technological prowess, making it an optimal choice for an in-depth study of user behavior and interaction in virtual realms.

Meta Platforms, Inc., formerly Facebook, is ambitiously steering towards creating an interconnected virtual universe, emphasizing social connectivity and leveraging its vast user base [33,34]. In contrast, Epic Games' Fortnite not only functions as a game but also as a digital space hosting virtual concerts and events, bridging entertainment sectors and showcasing the potential of interactive digital platforms [35]. Roblox's strength lies in its democratization of content creation, enabling users to craft and monetize their virtual experiences, underscoring a more decentralized approach to virtual world-building [36]. On the blockchain front, Decentraland and The Sandbox are pioneering the concept of tokenized digital real estate and assets, providing users with true ownership and introducing a fresh economic dimension to virtual spaces [37].

In medical training, Meta Platforms Inc. presents a meticulously crafted and deeply immersive experience. As illustrated in Fig. 1, it mirrors a virtual hospital or clinic setting with high-fidelity simulations. Trainees, embodied as avatars, navigate these spaces, engaging with virtual patients and utilizing simulated medical tools. Fig. 2 showcases their immersion in modules for surgical exercises, diagnostic tasks, and global collaborative research. The ambiance captures the subtle layers of a real medical backdrop, from the familiar hum of monitors to the bustling energy of a hospital corridor. This virtual environment not only amplifies hands-on learning but also reduces real-world training risks. The positioning of avatars, as shown in Fig. 3, is thoughtfully arranged: trainee avatars may be positioned by a virtual patient, whereas instructor avatars are strategically placed for oversight and immediate feedback. Additional scenarios feature avatars gathering in virtual conference spaces for collaborative discussions, mirroring the dynamics inherent to traditional medical training. The metaverse's communication is rich and varied; avatars converse in real-time through voice channels, fostering prompt exchanges and mentorship. Non-verbal cues, such as gestures and expressions, add depth to interactions. For detailed medical discourse or feedback, text-based communication offers a platform. Advanced modules, as demonstrated in Fig. 4, may even simulate touch feedback, giving avatars a realistic feel during certain

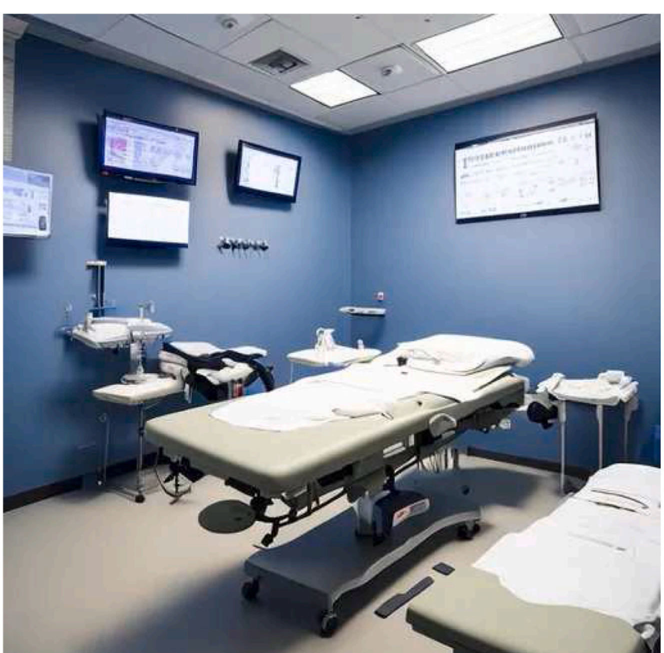

Fig. 1. Virtual clinic.

Fig. 2. Medical training: Inside the metaverse environment.

Fig. 3. Avatars.

Fig. 4. Virtual training dynamics.

tasks. Collaborative tools, like shared virtual screens or interactive 3D models, further amplify the depth of their collaborative experiences.

3. Conceptual model and hypotheses

3.1. The personal innovativeness (INN)

In the context of innovation theory, technology users are classified as highly innovative individuals who actively seek out information about novel concepts. They represent a specific user category that is capable of managing significant uncertainties and developing more favourable inclinations towards accepting new innovations. Personal innovativeness is expected to cultivate more positive attitudes towards innovative technologies. This notion is closely associated with one's own inclination for innovation, which embodies a propensity to take risks in adopting new technologies and is considered to exert the most significant impact on an individual's cognitive interpretations of information technology [30].

The TAM directly influences the individual's creative use of technology, a process that is often influenced by perceptions of technology's value and usability [38]. Within this model, two paramount constructs are perceived utility and ease of use. The former signifies the extent to which a user believes that employing a specific technology can enhance their performance for a given task. The latter pertains to how effortless an individual perceives it will be to utilize a particular technology. Studies conducted by [18,19] affirm a clear association between perceptions of effectiveness, usability, and intentional planning. Consequently, the proposed conceptual model posits that an individual's level of innovativeness significantly impacts the key relevant factors influencing the acceptance of the Metaverse platform [39,40]. On the basis of the preceding supposition, it is believed that:

H1. INN and the PU prediction.

H2. INN and the PEOU prediction.

3.2. Perceived observability (OBS)

The perceived observability presents the level at which many other people begin to notice and value the technology's innovation. The opinions of the peers and neighbours could impact how technology is adopted [15,41,42]. Accordingly, it can be assumed that:

H3. OBS would predict the PV.

3.3. Perceived ubiquity (UBI)

Research conducted by Kim & Garrison has demonstrated that ubiquity strongly influences individuals' intentions to adopt technology. Notably, ubiquity offers essential advantages encompassing elements such as consistency, promptness, speed, adaptability, flexibility, and availability. The capability of both individuals and the wider population to access new services affects their perceptions, expectations, and the perceived value, facilitated through the mobile component of accessibility that eliminates constraints of time and distance [43]. Consequently, perceived ubiquity exerts a positive and significant impact that notably influences the perceived value (PV) [44,45]. Therefore, it is posited that:

H4. UBI would predict the PV.

3.4. Perceived triability (TRA)

The motivation to employ technology is strongly related to the perceived trialability. Numerous investigations have suggested the concept of trialability. Researchers have verified how trialability has a favourable effect on system acceptance. Trialability describes how easy it is to handle innovation. It encompasses additional ideas such as the difficulty and risk of utilizing digital innovations for exploration, in addition to the ease of redoing and recovery actions [39,46–48]. The perceived trialability has a close relation with perceived value (PV). The results of the earlier premise formulated the following hypotheses:

3.5. Perceived enjoyment (ENJ)

The perceived enjoyment is characterized as the level of satisfaction people experience when working on a task. It may also refer to the level of satisfaction consumers have with the virtual environment since perceived enjoyment has been found to be a qualitative indicator of users' feelings of happiness, sadness, disgust, or hatred. which appear as a consequence of using technology, enabling users to act in a particular way [49–51]. The perceived enjoyment of technology users can influence the intention and intensity of using the technology because convenience and enjoyment in using technology will enable the users' to develop a positive perception towards the application; thus resulting in initial comfort [51,52]. The preceding supposition results in the following premise:

H6. ENJ would predict the PU.

H7. ENJ would predict the PEOU.

3.6. Perceived value (PV)

Users' perceptions of perceived quality involve assessing the balance between costs and benefits. Individuals commonly perceive perceived value as paramount, assuming that the benefits outweigh the costs. The concept of utility, utilized as a predictor of adoption and usage, relies on the notion of perceived value [15]. Previous studies have indicated that perceived value positively influences intentions for technology adoption and usage [15,41,42]. Based on the prior assumption, it is possible to hypothesize that:

H9. PV would predict the META

3.7. TAM contracts

Numerous prior studies have investigated the influence of individual characteristics such as personal innovativeness, enjoyment, ubiquity, trialability, observability, and perceived value on the adoption of technology on a large scale. These attributes have been identified to significantly impact perceived usefulness and perceived ease of use [53–55]. However, the specific relationship between perceived usefulness and perceived ease of use, especially concerning the Metaverse system, remains understudied in this field. This study seeks to address this gap by examining how these factors contribute to perceived usefulness, perceived ease of use, and user adoption. Based on the aforementioned insights, the following assumptions are built:

H8. PU would predict the META.

H10. PEOU would predict the MATA.

3.8. The conceptual framework

As displayed in Fig. 5, these presumptions serve as the cornerstone of the suggested research methodology. To elucidate the prediction premise at first, a structural equation model is used; thereafter, it is assessed using ML methods.

4. Methodology

4.1. Data collection

Data collection for this study took place between January 15 and June 30, 2022, during the winter semester of 2021–2022. Online

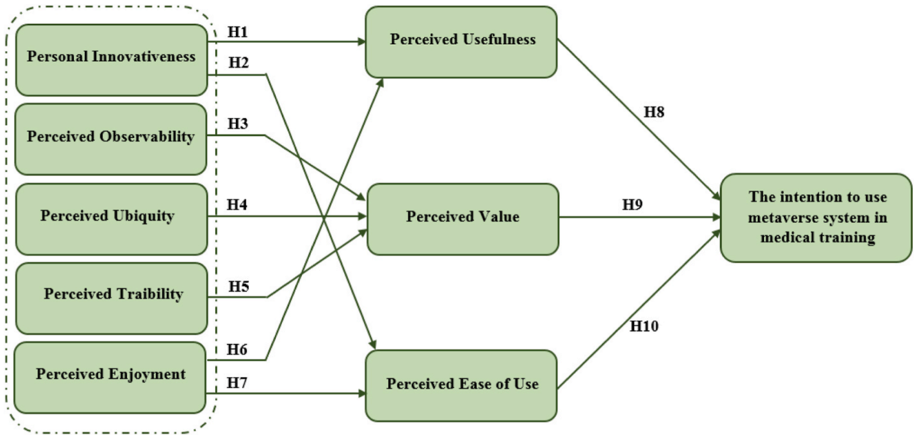

Fig. 5. Research model.

surveys were distributed to university students in the United Arab Emirates. A total of 1000 questionnaires were sent randomly to potential participants, and 879 respondents completed the surveys, resulting in a response rate of 88%. However, 121 of the completed questionnaires had to be excluded due to insufficient answers. Consequently, the analysis was conducted on 879 valid and fully completed questionnaires. The decision to focus solely on students was made because they are likely to have the most significant impact on the study outcomes. Following the suggestion of [56], considering a predicted sample size of 306 participants for a population of 1500, the final sample of 879 valid responses was considered appropriate for the study, surpassing the necessary minimum sample size criteria.

Given the sample size of 879, the use of Structural Equation Modelling (SEM) for analysis is appropriate [57]. SEM was employed to validate the theoretical constructs in the context of the Metaverse system's integration into medical training. While adaptations were made to tailor the model to the specific context, the underlying assumptions were grounded in established theories. The research team utilized the SmartPLS Version of SEM to test the measurement model (3.2.7), and the resulting path model was further analysed for insights.

4.2. Personal and demographic information

The male student population accounted for 51% of the respondents, slightly outnumbering female students at 49%. Respondents aged between 18 and 29 represented 65% of the participants, while those above the age of 29 comprised the remaining 35%. A significant portion of the participants possessed educational and professional qualifications, with 68% holding bachelor's degrees, 23% having master's degrees, and 9% holding PhD degrees. According to [58], the "purposive sampling approach" is used whenever participants are simple to reach and ready to volunteer. Students from different universities who ranged in age and were enrolled in a variety of programs at different levels made up the research sample. Using IBM SPSS Statistics version 23, the statistical profile was further evaluated.

4.3. Study instrument

As a tool for argument validation, a survey was created comprising 2 items. It assisted in evaluating the nine categories the questionnaire contained. Table 1 gives an account of the sources from where the 9 constructs were obtained. To improve the validity of the findings, the items being used in previous research were adjusted and adapted to fit the requirements of the current study.

4.4. Pilot study of the questionnaire

To establish the validity of the questionnaire's questions, a pilot study was conducted involving approximately 100 randomly selected students from the predetermined group. The sample size for the pilot study was determined as 10% of the overall sample size for the analysis, following rigorous research criteria. Internal reliability was assessed using the Cronbach's alpha test with the help of SPSS, and the results of the pilot study demonstrated satisfactory outcomes for the measurement items. In line with the common practice in social science research, a reliability coefficient of 0.70 is considered acceptable [71]. The Cronbach's alpha values for the five measurement items are presented in Table 2.

4.5. Common method bias (CMB)

Seven factors have been used in the Harman's single-factor analysis to ensure that the gathered data do not contain CMB [72]. Then, these ten components were combined into one parameter. The study reveals that the newly formed component accounts for 27.32% of the variation, which is below the required amount of 50% [72]. Therefore, there were no issues with the CMB in the gaathered data.

4.6. Survey structure

The questionnaire survey based on the below 3 sections was handed out to the students who participated in it [73].

- The first segment included information about the participants' private information.
- The purpose of using the Metaverse system in medical education was the subject of two elements in the second part.
- A total of 21 items in the final segment were based on "triability, observability, perceived enjoyment, perceived ubiquity, perceived value, personal innovativeness, perceived ease of use, and perceived usefulness."

After the surveys were completed, a five-point Likert Scale was used to evaluate the 23 elements.

5. Findings

5.1. Convergent validity

To assess the measurement model, incorporating both convergent and discriminant validity, various reliability measures were recommended by [74], including composite reliability (CR), Dijkstra's

Table 1
Measurement items.

Constructs	Term	Definition	Tool	Sources
Actual Trialability	TRA1	"Trialability refers to how effectively consumers of technologies could adapt to technological advancement" [59–61].	I want to test out the MS prior starting classes.	[59–61]
	TRA2		Getting acclimated to MS takes some time.	
	TRA3		The MS is helpful to me after my trial.	
Perceived Observability	OBS1	"How well the technology may be explained, observed, and imagined" is how observability is characterized. It is regarded as being essential to the acceptance of technology in the educational environment [59, 62].	I believe the MS can be applied to my regular classes.	[59,62]
	OBS2		The MS has a good value, in my opinion.	
	OBS3		All educational systems can benefit from my experiences with MS.	
Perceived Enjoyment	ENJ1	Perceived enjoyment refers to the extent where users feel that technology is pleasurable as a system apart from any performance consequences. Enjoyment causes people to feel comfortable.	MS offers a fun environment.	[63]
	ENJ2		MS offers an entertaining educational setting.	
	ENJ3		I am ready to use MS because it provides me with a comfortable atmosphere.	
Perceived Value	PV1	Perceived value refers to the users' perception towards the value of the technology by comparing it with attained against the cost and the benefits. It is used as indicator to the behavior intention to use technology.	MS offers great benefits in comparison with its cost.	[64]
	PV2		MS helps in doing different task with cheap price.	
Personal Innovativeness	INN1	The level of openness that consumers might have to technology is how personal innovativeness is characterized. In other words, it describes how ready users are to adopt new technologies. Personal innovativeness includes the idea of preparedness as an outside aspect to gauge how well consumers are accepting of technology [65].	I believe I'll use MS for my research.	[65]
	INN2		I think I'm equipped to handle cutting-edge technology like the MS.	
Perceived Ubiquity	UBI1	Perceived Ubiquity reveals a person's attitude about time and space flexibility [66], pp. 98). It implies that there is a kind of adaptability in both time and space, which are connected factors [67].	The MS, in my opinion, has a lot of value in a learning environment.	[66,67]
	UBI2		In my daily lessons, I assert that the MS has several benefits.	
	UBI3		I believe using the MS is worthwhile.	
Perceived Ease of Use	PEOU1	It relates to the extent to which the user perceives the invention as being simple [68].	I think the MS is effortless.	[68]
	PEOU2		Because it is simple, I believe I can utilize the MS for a variety of instructional purposes.	
	PEOU3		MS will likely be challenging to employ in several situations, in my opinion.	
Perceived Usefulness	PU1	It speaks of "the extent to which the user believes that the invention has material advantages." [68].	For live lectures and forums, I believe the MS is helpful.	[68]
	PU2		I believe the MS gives my research several advantages.	
The intention to use Metaverse system in medical training	META1	Users' preference to accept or reject technology by using particular strategies to ensure the continued use of technology" is the definition of intention to utilize technology.	Without a doubt, I'll use the MS for my education.	[69,70]
	META2		I'll only utilize the MS for a small amount of education.	

Table 2
Cronbach's Alpha values for the pilot study (Cronbach's Alpha ≥0.70).

Constructs	Cronbach's Alpha.
TRA	0.783
OBS	0.872
ENJ	0.891
PV	0.836
INN	0.712
UBI	0.855
PEOU	0.821
PU	0.863
META	0.819

reliability coefficient (pA), Henseler's reliability coefficient (CA), and Cronbach's alpha (CA). As presented in Table 3, the computed Cronbach's alpha (CA) values for construct reliability ranged from 0.803 to 0.890, all surpassing the threshold of 0.7 [75]. Similarly, Table 3 indicates that the composite reliability (CR) values range from 0.800 to 0.886, consistently exceeding the recommended threshold of 0.7 [76]. Additionally, for evaluating construct reliability, the Dijkstra-rho Henseler's (pA) coefficient is advised [76], and in this study, the overall reliability ratio (A) should exhibit values exceeding 0.70, while exploratory values beyond 0.80 or 0.90 suggest more advanced stages of work [75,77,78].

From the data presented in Table 3 and it can be observed that the internal consistency (A) for each measuring construct surpasses 0.70, providing evidence of the reliability coefficient's effectiveness. Evaluating composite reliability requires testing the average variance

Table 3
Convergent validity results.

Constructs	Items	Factor Loading	Cronbach's Alpha	CR	PA	AVE
Perceived Trialability	TRA1	0.727	0.890	0.881	0.880	0.609
	TRA2	0.861				
	TRA3	0.860				
Perceived Observability	OBS1	0.871	0.876	0.883	0.889	0.732
	OBS2	0.858				
	OBS3	0.815				
Perceived Enjoyment	ENJ1	0.759	0.841	0.802	0.811	0.640
	ENJ2	0.819				
	ENJ3	0.873				
Perceived Value	PV1	0.827	0.831	0.888	0.853	0.599
	PV2	0.875				
Personal Innovativeness	INN1	0.823	0.867	0.822	0.812	0.613
	INN2	0.722				
Perceived Ubiquity	UBI1	0.801	0.853	0.882	0.891	0.781
	UBI2	0.887				
	UBI3	0.870				
Perceived Ease of Use	PEOU1	0.777	0.803	0.800	0.812	0.615
	PEOU2	0.727				
	PEOU3	0.761				
Perceived Usefulness	PU1	0.860	0.852	0.886	0.848	0.652
	PU2	0.871				
Using the Metaverse technology for medical education.	META1	0.858	0.826	0.862	0.820	0.734
	META2	0.815				

extracted (AVE) and factor loading [74]. However, according to the results shown in Table 3, all measurement items yielded values below the ideal threshold of 0.7. Additionally, Table 3 demonstrates that the AVE values, ranging from 0.599 to 0.781, surpass the threshold of "0.5," indicating adequate values for convergent validity. These findings collectively establish the convergent validity for all concepts.

5.2. Discriminant validity

For assessing the psychometric properties, it was recommended to evaluate two specific requirements, namely the HTMT ratio and the Fornell-Larker criterion [79]. The outcomes presented in Table 4 reveal that the square roots of the AVE values are consistently greater than their correlations with other variables. This finding demonstrates compliance with the Fornell-Larker criterion [80]. The results of the HTMT ratio are displayed in Table 5. As shown, the values for all constructs are below the threshold value of 0.85 [79], indicating conformity with the HTMT ratio requirement. This indicates the presence of discriminant validity among the constructs. Upon examining the outcomes of the model evaluation, no issues related to validity and reliability were identified. Consequently, the collected information is deemed suitable for evaluating and analysing the conceptual framework.

5.3. Model fit

The essential fit metrics are available from SmartPLS: The sample fit in PLS-SEM is shown by the standard root mean square residual (SRMR), precise fit criterion, d ULS, d G, Chi-Square, NFI, and RMS theta [81]. The discrepancy between both the model-implied correlation matrix and the measured correlations is implied by the SRMR [82] and scores below 0.08 are regarded as good model fit indicators [83]. NFI scores above 0.90 signify an excellent fit of the model [84]. The NFI is a comparison between the suggested model's Chi 2 value and that of the null model or benchmark model [85]. Because the NFI increases with increasing variable size, NPI is not advised as a model fit measure [82]. There is a difference between both the correlation matrix indicated by the composites factor structure and the experimental covariance according to the squared Eucledian distance, d ULS, and the geometric distance, d G [82,86]. RMS theta evaluates the degree of correlation in the outer model residuals and is primarily applicable for reflection in action [85]. In the context of the PLS-SEM model, a lower RMS theta value indicates better performance; values slightly below 0.12 are considered indicative of a good fit, while values significantly deviating from this threshold suggest a poor fit [87]. It's worth noting that Hair et al. [82] emphasized that the predictor evaluates the comprehensive effects and system models, while the cause of long-term assesses correlations among all variables.

RMS-theta was taken into consideration, and its value of 0.053 indicated a satisfactory goodness-of-fit for the PLS-SEM model, thereby supporting the reliability of the PLS model as a whole. The sum of the result is shown in Table 6.

5.4. Hypotheses testing using PLS-SEM

Smart PLS, which had the expectation - maximization estimate, was used to build the multiple linear regression model to analyse the relationship between different theoretical ideas in the structural model [58,

Table 4
Fornell-larcker scale.

	TRA	OBS	ENJ	PV	INN	UBI	PEOU	PU	META
TRA	**0.870**								
OBS	0.403	**0.857**							
ENJ	0.467	0.328	**0.086**						
PV	0.529	0.522	0.439	**0.876**					
INN	0.434	0.404	0.456	0.444	**0.875**				
UBI	0.404	0.531	0.553	0.547	0.515	**0.823**			
PEOU	0.553	0.455	0.428	0.488	0.521	0.318	**0.872**		
PU	0.539	0.438	0.464	0.466	0.431	0.299	0.437	**0.839**	
META	0.531	0.337	0.375	0.421	0.270	0.216	0.600	0.531	**0.837**

Table 5
Heterotrait-monotrait ratio (HTMT).

	TRA	OBS	ENJ	PV	INN	UBI	PEOU	PU	META
TRA									
OBS	0.675								
ENJ	0.561	0.730							
PV	0.650	0.791	0.116						
INN	0.667	0.728	0.281	0.635					
UBI	0.491	0.274	0.245	0.255	0.424				
PEOU	0.447	0.280	0.323	0.236	0.309	0.175			
PU	0.522	0.426	0.211	0.355	0.495	0.211	0.411		
META	0.519	0.401	0.459	0.302	0.310	0.264	0.367	0.519	

Table 6
Model fit metrics.

	Complete Model	
	Saturated Model	Estimated Mod
SRMR	0.054	0.054
d_ULS	0.637	1.448
d_G	0.693	0.693
Chi-Square	489.518	489.518
NFI	0.877	0.877
Rms Theta	0.053	

Table 7
R^2 of the endogenous latent variables.

Construct	R^2	Results
META	0.642	Moderate
PEOU	0.508	Moderate
PU	0.679	Moderate
PV	0.554	Moderate

88] to reports, the model's predictive ability was standard [46], implying that the proportion of variance within perceived usability, potential value, user satisfaction of use, and perceived utility is roughly 51%, 55%, 64%, and 68%, respectively. Table 7 and Fig. 6 present these findings.

Table 8 provides the beta (*β*), t, and p values for each of the established premises using the data generated by the PLS-SEM technique. Evidently, every academic has supported every theory. Based on data processing, the empirical findings reinforce hypotheses H1, H2, H3, H4, H5, H6, H7, H8, H9, and H10.

The relationships between Personal Innovativeness (INN) and (Perceived Usefulness (PU) & Perceived Ease of Use (PEOU)) (β = 0.536, P < 0.001), (β = 0.743, P < 0.001) were found to be statistically significant, and thus, the hypotheses H1 and H2 are generally supported. Perceived Observability (OBS), Perceived Ubiquity (UBI), and Perceived Trialability (TRA), has significant effects on Perceived Value (PV) (β = 0.646, P < 0.001), (β = 0.570, P < 0.001), and (β = 0.468, P < 0.001) respectively; hence H3, H4, and H5 are supported. The relationships between Perceived Enjoyment (ENJ) and (Perceived Usefulness (PU) & Perceived Ease of Use (PEOU)) (β = 0.272, P < 0.05), (β = 0.338, P < 0.001) were found to be statistically significant, and thus, the hypotheses H6 and H7 are generally supported. Finally, Perceived Usefulness (PU), Perceived Value (PV), and Perceived Ease of Use (PEOU) has significant effects on Users' H8, H9, and H10 are confirmed since the intention to use the MS (META) was (=0.783, P0.001), (=0.643, P0.001), and (=0.781, P0.001), correspondingly.

5.5. Testing hypotheses by using traditional algorithms of ML

To predict the relationships within the provided conceptual framework, this study employs a diverse set of methods including decision trees, Bayesian networks, neural networks, and if-then-else rules [25,

Table 8
Hypotheses-testing of the research model (significant at p** ≤ 0.01, p* < 0.05).

H	Relationship	Path	*t*-value	p-value	Direction	Decision
H1	INN - > PU	0.536	9.643	0.004	Positive	Supported**
H2	INN - > PEOU	0.743	10.167	0.002	Positive	Supported**
H3	OBS - > PV	0.646	19.708	0.000	Positive	Supported**
H4	UBI - > PV	0.570	7.312	0.003	Positive	Supported**
H5	TRA - > PV	0.468	5.087	0.008	Positive	Supported**
H6	ENJ - > PU	0.272	4.842	0.014	Positive	Supported*
H7	ENJ - > PEOU	0.338	20.468	0.000	Positive	Supported**
H8	PU - > META	0.783	21.834	0.000	Positive	Supported**
H9	PV - > META	0.643	18.229	0.000	Positive	Supported**
H10	PEOU - > META	0.781	19.579	0.000	Positive	Supported**

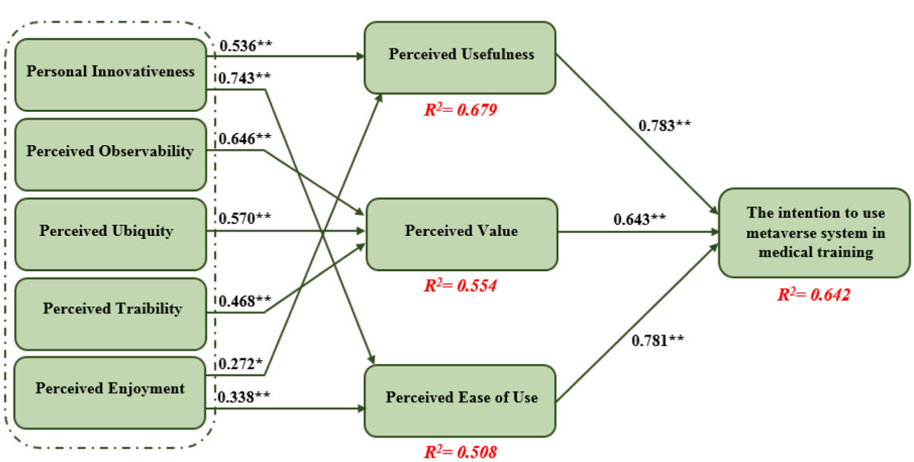

Fig. 6. Path coefficient of the model (significant at p** ≤ 0.01, p* < 0.05).

89–91]. Weka version 3.8.3 was utilized to assess the prediction models, employing various classifications such as BayesNet, Logistic, LWL, AdaBoostM1, OneR, and J48 [91–94].

To evaluate the performance of the ML models, multiple evaluation metrics are taken into account, including accuracy, precision, recall, and F1-score. These metrics provide insights into the models' predictive abilities and their capacity to effectively categorize students' intentions regarding the utilization of the Metaverse system. The study's methodology adopts a complementary multi-analytical approach, combining both structural equation modelling (SEM) and ML techniques, in order to gain a comprehensive understanding of the factors influencing students' behavior.

Through the utilization of advanced ML algorithms, this research aims to uncover intricate relationships and patterns that drive students' intentions towards the Metaverse system. The integration of ML techniques in this study holds the promise of offering valuable contributions to the field of information systems, providing practical and data-driven recommendations to enhance medical education and training, especially in the challenging context of the COVID-19 pandemic.

Table 9 illustrates that the J48 classifier outperforms other classifiers when assessing the Perceived Usefulness (PU) of the Metaverse system. J48 achieved an accuracy of 87.31% with a 10-fold cross-validation, thus supporting hypotheses H1 and H6. This classifier exhibited better performance in terms of True Positive (TP) rate (0.873), recall (0.875), and precision (0.875) compared to other classifications (0.877).

The results also showed higher performance of the classifier by J48 in estimating the PV when contrasted to other classifiers, as illustrated in Table 10. Based on the characteristics of OBS, UBI, and TRA with 81.80% accuracy, J48 made a prediction of the PV. Therefore, there was assistance for H3, H4, H5.

Based on the results presented in Table 11, J48 performed better than other classifications in predicting the PEOU using the properties of INN and ENJ. J48 indicated Perceived Ease of Use (PEOU) with an accuracy of 83.49%. As a result, H2 and H7 received support.

The outcomes are displayed in Table 12, revealing that the OneR classifier exhibited superior performance compared to the alternative classifiers when forecasting META. Achieving an accuracy of 80.72%, the OneR classifier accurately predicted META by employing the variables PU, PV, and PEOU. This outcome lends support to hypotheses H8, H9, and H10.

5.6. Importance-Performance Map Analysis

Applying behavioural intention as the target attribute, this study has employed the Importance-Performance Map Analysis (IPMA) within the framework of advanced Partial Least Squares Structural Equation Modelling (PLS-SEM). Ringle and Sarstedt [95] emphasized that IPMA enhances the comprehension of analysis results in PLS-SEM. IPMA incorporates both the comprehensive standard of latent constructs and their associated components (i.e., performance measure), providing an alternative approach to solely assessing path coefficients (i.e., importance measure) [95]. According to IPMA, the effectiveness of latent variables is gauged by the overall average of these constructs, while the total effects showcase the relevance of preceding components for the desired factor. The IPMA findings are presented in Fig. 7. The study has evaluated the significance and efficacy of six criteria (i.e., TRA, OBS, ENJ, PV, INN, UBI, PEOU, and PU). The results indicate that PU exhibits the highest values in terms of both significance and efficiency measures. Furthermore, ENJ secures the second-highest scores in relevance and system performance, as depicted. On the other hand, OBS registers the lowest performance metric score while ranking third in significance measurement. PV, however, exerts the least impact on the significance measure.

Table 9
Predicting the PU by INN and ENJ.

Classifier	CCI[a] (%)	TP[b] Rate	FP[c] Rate	Precision	Recall	F-Measure
BayesNet	81.54	.815	.349	.816	.819	.820
Logistic	83.67	.836	.386	.835	.833	.835
LWL	83.39	.833	.371	.834	.835	.839
AdaBoostM1	84.35	.843	.383	.844	.848	.846
OneR	85.28	.852	.422	.856	.853	.853
J48	**87.31**	**.873**	**.651**	**.877**	**.875**	**.878**

[a] CCI: Correctly Classified Instances.
[b] TP: True Positive.
[c] FP: False Positive.

Table 10
Predicting the PV by OBS, UBI, and TRA.

Classifier	CCI1 (%)	TP[2] Rate	FP[3] Rate	Precision	Recall	F-Measure
BayesNet	76.36	.763	.220	.760	.769	.762
Logistic	77.25	.772	.362	.777	.775	.775
LWL	73.29	.732	.210	.739	.734	.742
AdaBoostM1	75.68	.756	.342	.757	.749	.766
OneR	76.75	.767	.399	.762	.757	.756
J48	**81.80**	**.818**	**.583**	**.811**	**.812**	**.820**

Table 11
Predicting the PEOU by INN and ENJ.

Classifier	CCI1 (%)	TP[2] Rate	FP[3] Rate	Precision	Recall	F-Measure
BayesNet	80.53	.805	.369	.807	.804	.810
Logistic	82.26	.822	.339	.825	.825	.830
LWL	82.58	.825	.392	.828	.828	.835
AdaBoostM1	81.26	.812	.336	.811	.814	.829
OneR	81.42	.814	.387	.815	.818	.815
J48	**83.49**	**.835**	**.742**	**.834**	**.842**	**.840**

Table 12
Predicting the META by PU, PV, and PEOU.

Classifier	CCI1 (%)	TP[2] Rate	FP[3] Rate	Precision	Recall	F-Measure
BayesNet	74.57	.745	.341	.750	.744	.746
Logistic	72.59	.725	.372	.745	.729	.724
LWL	74.80	.748	.355	.749	.749	.747
AdaBoostM1	74.30	.743	.472	.744	.747	.744
J48	75.54	.755	.409	.756	.758	.756
OneR	**80.72**	**.807**	**.646**	**.816**	**.812**	**.809**

6. Discussion

The study employed a hybrid model that integrated three distinct methodologies—SEM-PLS and traditional ML analyses—in an endeavour to yield findings. The primary outcomes of the research underscored that the ML approach significantly bolsters the variable of users' intention to adopt the Metaverse system. In comparison to SEM-PLS (R^2 = 64.2%), the ML analysis indicates a notably elucidated predictive capability (R^2 = 80.7%). The results highlighted a robust and positive correlation between perceived usefulness and perceived usability. This underscores the considerable influence of both personal attributes and technological factors on students. As per the findings, individuals who exhibit a greater inclination to engage with uncertainty and innovative technologies are more inclined to embrace the Metaverse system.

The study accentuated the characteristics linked to adoption, which were concurrently linked to perceived value. The acceptance of the Metaverse system is significantly shaped by its qualities of observability, ubiquity, and trialability. To foster an upsurge in the rate of Metaverse acceptance among students, these attributes must be emphasized and

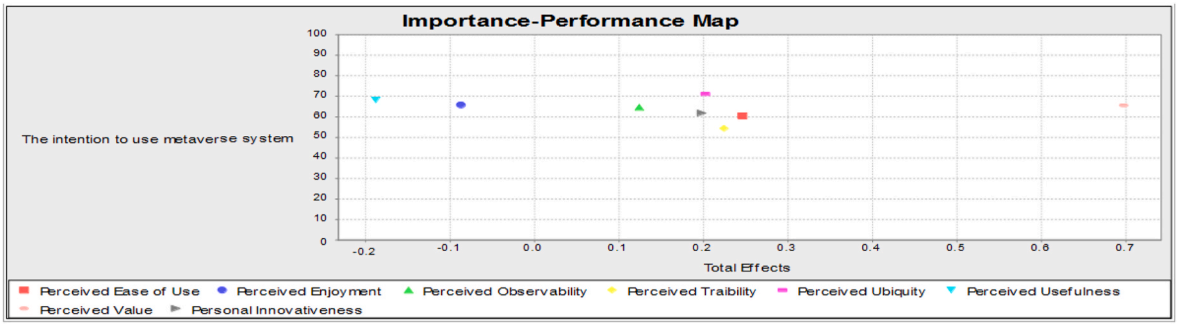

Fig. 7. IPMA results.

upheld. The current findings align with prior research, indicating that observability, ubiquity, and trialability collectively influence the pace at which individuals adopt new technologies. In simpler terms, the recent conceptual model substantiates the unanimous recognition of the importance and significance of observability, ubiquity, and trialability when making decisions to adopt a Metaverse system. This consistency with earlier research underscores the substantial impact of these attributes on students' preferences, decisions, and educational approaches [18,53,96].

Moreover, the findings of these investigations affirm that individuals harbour favourable attitudes toward adopting innovative technology when they perceive it as commendable and harmonious with their environment [97–99]. Students who acknowledge the significance and influence of observability, ubiquity, and trialability are more likely to hold positive perspectives on the integration of the Metaverse system and perceive a heightened level of value in its implementation.

Furthermore, students who exhibit a preference for adopting innovative technology tend to hold favourable attitudes even in unfamiliar circumstances, making them more inclined to have positive intentions toward such technologies. These present findings are consistent with prior research that established a direct link between students' perceptions and perceived usefulness, particularly considering that younger generations often have a penchant for novel technology, serving as an additional motivating factor [100,101]. Moreover, students' perceptions of technology's utility being highly effective significantly influence their behavioural intention to use it. However, other factors might also come into play and influence technology adoption, such as the enjoyment factor, which warrants further investigation. Hence, students' perspectives could vary accordingly [102–104].

Furthermore, the recent study supports the notion that perceived ease of use (PEOU) can impact students' perspectives. The premise that students are more inclined to embrace novel technology if it is user-friendly and easy to adapt to finds support in the evident correlation between personal innovativeness and PEOU [105,106]. This is grounded in the fact that students of different age groups aspire for technology that is novel and exceptional, while its features and functionalities remain uncomplicated. In alignment with previous studies, research by [107] also emphasized the significant influence of both PEOU and perceived usefulness (PU) on technology adoption [108].

However, due to variations in the communal value orientation, some earlier findings have demonstrated no direct relationship between innovativeness and technological adoption. This discrepancy in results can be attributed to the diverse nature of the population studied. Notably, individuals in the Gulf region exhibit a readiness to comprehend and incorporate technology into their daily lives. When the innovative features are effectively utilized and clearly highlighted, the adoption rate tends to be higher.

6.1. Theoretical and practical implications

This study evaluated the proposed model using a combination of PLS-SEM and ML classification approaches. Being a rare attempt to utilize ML algorithms in predicting the real-world usage of the Metaverse system, this study introduces a novel aspect to the realm of information literature (IS). Incorporating a parallel multi-analytical approach is believed to contribute a fresh perspective. PLS-SEM, renowned for its ability to anticipate variables and validate theoretical models rooted in existing theories, was harnessed [109]. Likewise, supervised ML techniques were employed to predict a dependent variable based on independent factors, where a predefined dependent variable was utilized [25]. The study's exploration of various classification techniques, such as decision trees, Bayesian networks, association rules, neural networks, and if-then-else guidelines, is particularly intriguing. Notably, J48, a decision tree algorithm, emerged as the top performer among traditional classifiers. Worth highlighting is the utilization of a clustering algorithm, which is nonparametric and capable of categorizing both continuous (numerical) and categorical variables. This segmentation of the community into homogeneous subgroups based on the most influential independent factor enhances the study's depth [25].

In contrast, the PLS-SEM technique was employed to randomly select multiple sub-samples and assess the significant coefficients, with replacements from the sample. Notably, the predictive prowess of ML surpasses that of the PLS-SEM model. This is attributed to the ML platform's capacity to discern non-linear relationships among the components within the theoretical model, ultimately contributing to its higher predictive capability compared to the PLS-SEM analysis.

6.2. Managerial implications

The recent study's results hold contemporary significance for reshaping educational and learning approaches. They suggest that students' perceptions of utilizing Metaverse technologies are significantly influenced by their personal inventiveness and character traits. Consequently, educators and technology enthusiasts should prioritize fostering both human attributes and technological qualities, enabling students to fully engage with the appeal of the Metaverse system. This emphasis has the potential to lead to an upward trend in students' positive assessments and an increased enthusiasm for utilizing the Metaverse system, contributing to further innovations in learning environments. Subsequent research should consider individual differences and the impact of gender on perceptions of education.

6.3. Study restrictions and future research

There are two notable limitations in the study. Firstly, the inclusion of only two variables—personal innovativeness and perceived value—can be considered a significant limitation. Secondly, the decision to restrict the TAM construct to the concepts of PEOU and PU was intentional, aimed at streamlining assessment and accentuating two crucial factors influencing life satisfaction and personal innovativeness. Additionally, the study's survey distribution through social media and the internet may have led to increased accessibility and participation among students [29,110]. Having said that, the outcome from this study can spawn further research comparing the use of the Metaverse between students from the Gulf regions with other regions worldwide.

7. Conclusion

The Metaverse system holds the potential to revolutionize various fields such as engineering, economics, and education. Its integration with modern technology has become integral to instructional approaches. Recently, Facebook's transformation into the Metaverse, now known as Meta World, has further underscored its significance. This study focused on understanding tGulf region university students' perceptions of the Metaverse and the factors influencing their decision to use it. The research explored the educational benefits offered by the Metaverse system. The results revealed a strong connection between students' perceptions of using the Metaverse and their evaluations of its utility and accessibility. These judgments were notably influenced by perceptions of innovation. The findings contribute to the existing body of knowledge on technology adoption theories, highlighting the substantial impact of adoption attributes like trialability, observability, ubiquity, and enjoyment. Moreover, the study sheds light on students' perspectives regarding the integration of cutting-edge technology in educational settings, aligning with previous research endeavours.

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Data availability statement

Not Applicable.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests

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