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Harnessing digital issue in adopting metaverse technology in higher education institutions: Evidence from the United Arab Emirates

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C H R O N I C L E

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A B S T R A C T

This study delves into the intricate landscape of metaverse technology adoption within higher education institutions in the UAE, investigating the multifaceted interplay of accessibility, technology adaptability, and policies and regulations. Using a cross-sectional research design, data was meticulously collected through a multistage sampling approach, combining probability and non-probability methods. A pretested questionnaire underwent rigorous evaluation, ensuring unbiased item formulation and adherence to best practices. The investigation challenges and extends the Technology Acceptance Model (TAM) by revealing unexpected findings. The absence of a significant relationship between accessibility and metaverse adoption prompts a call for an expanded TAM framework. Surprisingly, a negative correlation between technology adaptability and adoption is highlighted, emphasizing the need for a cautious assimilation approach. Moreover, the research underscores the influential role of policies and regulations in metaverse adoption, advocating for a comprehensive TAM framework that encompasses regulatory dynamics. Findings offer practical implications for stakeholders, policymakers, and institutions, emphasizing diverse adoption facets beyond accessibility. The study contributes to the discourse on metaverse adoption and advances theoretical frameworks for technology integration within educational contexts. The methodology's meticulous design underscores the study's rigor, ensuring the robustness of the insights gleaned from the investigation.

1. Introduction

The advancement in technology has reshaped the education industry, thus, causing it to recent years have witnessed a significant transformation in the teaching and learning processes, prompting higher education institutions to embrace technology to enhance education quality and keep up with the demands of a rapidly evolving digital world (Amiel & Reeves, 2008; Habes et al., 2022; Núñez-Canal et al., 2022). The United Arab Emirates (UAE) stands at the forefront of technology adoption in higher education, making it an attractive destination for international students seeking quality education, vacation experiences, or employment prospects after their studies (Rubin, 2002; Akyeampong, 2000; Alwaely et al., 2022; Crawford et al., 2020; El Nokiti et al., 2022; Zainal & Salloum, 2021; Alghizzawi et al., 2019; Salloum et al., 2016). However, despite these advancements, several issues and prospects demand consideration when implementing technology in higher education in the UAE. One prominent issue concerns the digital divide among higher education institutions' students, faculty, and staff (Crawford et al., 2020; Eze et al., 2020). Although digital technologies have become increasingly available, disparities in technology access and usage persist, particularly for students from disadvantaged backgrounds (Becker, 2007; DiMaggio et al., 2004; Robinson et al., 2020; Tawfik et al., 2016). This digital divide may result in unequal access to educational resources and opportunities, hampering the overall effectiveness of technology adoption in higher education (Dewan & Riggins, 2005;

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Lembani et al., 2020; Reddick et al., 2020). Another significant issue in previous studies is the challenge of keeping pace with rapid technological change (Brynjolfsson & McAfee, 2012; Zhu et al., 2022). As technology evolves, higher education institutions must continuously update their infrastructure and systems, which can pose a substantial financial burden, particularly for smaller institutions with limited resources (Shahin et al., 2021; Dagiene et al., 2022; Potter et al., 2022).

Despite these challenges, adopting technology in higher education in the UAE offers several prospects. It can enhance student engagement, improve learning outcomes, and foster collaboration and communication among students and faculty (Divjak et al., 2022; Jain et al., 2022). Furthermore, technology can facilitate personalized learning and grant access to various educational resources and tools (Al et al., 2023; Nan et al., 2022). Considering these prospects and issues surrounding educational technology adoption, higher education institutions in the UAE are on the verge of adopting an interactive technology known as the metaverse (Aburayya et al., 2023; Al et al., 2023; Chengoden et al., 2023). The metaverse, a virtual world where users can interact with each other and digital objects, has garnered attention as a potential tool for enhancing teaching and learning in higher education in the UAE. One of the critical benefits of metaverse adoption in higher education lies in its ability to improve student engagement and learning outcomes. Within the metaverse, students can immerse themselves in interactive learning environments, participate in simulations and role-playing activities, and collaborate with peers from diverse backgrounds and cultures. This immersive experience promotes deeper learning, critical thinking skills and better prepares students for the demands of the digital age workforce. However, adopting the metaverse in higher education also presents challenges, particularly regarding accessibility and adaptability. Not all students can access the hardware and software required to engage with the metaverse. Not all faculty members possess the skills and knowledge to design and facilitate learning activities within this environment. Additionally, the rapid pace of technological change in the metaverse necessitates constant updates and infrastructure upgrades, which can impose financial constraints on institutions with limited resources.

In addition to the challenges above and the prospects of adopting technology in higher education in the UAE, the role of policies and guidelines emerges as a crucial moderating factor. Given the rapid advancement of technology and the potential impact of the metaverse in higher education (Koohang et al., 2023; Salloum et al., 2023) because well-defined policies and guidelines can help address the issues of accessibility and adaptability (Armitage, 2005; Grenon et al., 2023). Such policies can ensure equitable access to necessary hardware and software, bridging the digital divide among students, faculty, and staff. Furthermore, guidelines can promote faculty development programs to enhance their skills and knowledge in designing and facilitating practical learning activities within the metaverse (Lasica et al., 2020; Lee & Hwang, 2022; Ravikumar et al., 2022). Hence, this investigation aims to achieve the following objectives:

i. To investigate the perceived role of the digital divide on the effectiveness of metaverse adoption among higher education institutions.
ii. To examine the significant influence of metaverse technology accessibility on its adoption effectiveness among higher education institutions.
iii. To examine the perception of students on the relationship between technology adaptability and effectiveness of metaverse adoption among higher education institutions.
iv. To understand the moderating role of policies and guidelines on the relationship between the digital divide, technology accessibility, and adaptability on effective metaverse technology adoption among higher education institutions in the UAE.

Based on these objectives, the research framework is given below.

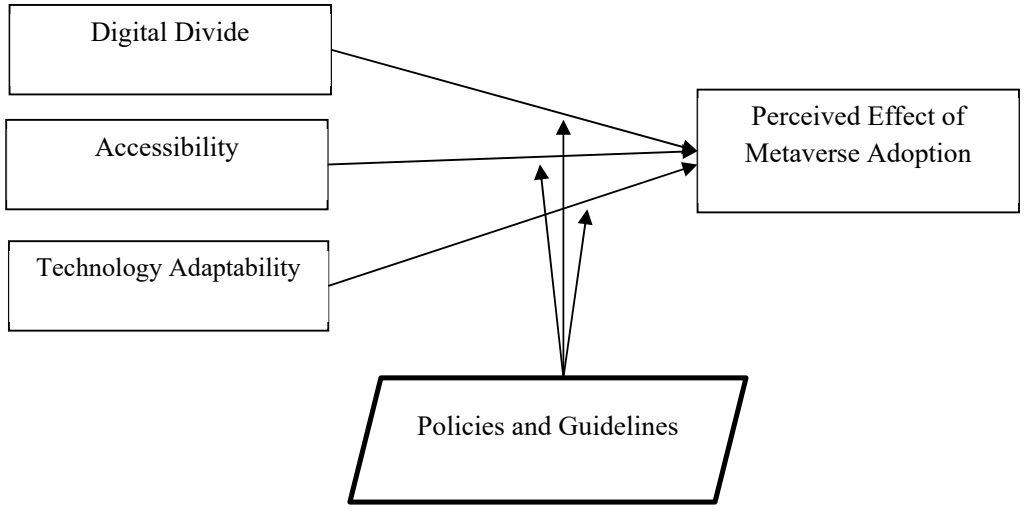

Fig. 1. The proposed study

2. Review of Relevant Literature

2.1 The Role of Technology in Education and Learning

Technology advancement has brought about the revolution, specifically to the education sector. It has revolutionized teaching and learning (Collins & Halverson, 2018; Green & Gilbert, 1995; Kaddoura & Al Husseiny, 2023). From online classes to digital textbooks, technology has created new opportunities for students to access and interact with educational content (Bogner & Menz, 2009; Jacob & Furgerson, 2012; Gustafsson & Ollila, 2003). According to Green and Gilbert (1995), technology has enhanced learning skills and allowed students to learn at their own pace. Likewise, with the advent of technology, educational resources not limited to podcasts, videos, virtual environments, and audio allows them to tailor their studies to their needs and schedule (Díaz et al., 2020; Tugtekin, 2023; Vermesan & Friess, 2013). In addition, adopting technology into the education system creates opportunities for collaborative learning, encourages teamwork, and enhances student communication skills (Divjak et al., 2022; Jain et al., 2022). Likewise, with digital tools such as Google Docs and collaborative whiteboards, students can work together on projects and assignments, regardless of their physical location (Sánchez & Hueros, 2010; Suki & Suki, 2011; Wang et al., 2022). Furthermore, technology adoption into the educational system creates immersive learning experiences that are more engaging in students' atmosphere via educational games simulations. Virtual reality platforms provide students with a unique and interactive way of learning complex concepts (Alwaely et al., 2022; Crawford et al., 2020). This approach to learning has been found to improve students' understanding and retention of material, as well as their motivation to learn (Kaddoura & Al Husseiny, 2023; Wang et al., 2022).

2.2 Overview of the Metaverse Concept and its Adoption in Higher Education Institutions

Metaverse technology is among the latest advancements in this area. It is a collective virtual shared space created by combining physical and virtual reality (Shwedeh et al., 2021; Mystakidis, 2022; Kye et al., 2021; Spajić et al., 2022). It is a fully immersive and interactive environment accessed through various devices such as computers, smartphones, and virtual reality headsets (Vermesan & Friess, 2013; Díaz et al., 2020). The metaverse concept has gained increasing attention in higher education in recent years due to its potential benefits, including immersive learning experiences that simulate real-world scenarios (Akour et al., 2022; Dincelli & Yayla, 2022; Tan et al., 2022) and increasing student engagement and motivation (Chen & Zhang, 2022; Díaz et al., 2020; Joshi et al., 2023; Tugtekin, 2023). According to Dincelli and Yayla (2022), Joshi and Pramod (2023), and Jovanović and Milosavljević (2022), metaverse technology also offers collaborative learning and knowledge-sharing opportunities among students and educators. A typical example of metaverse adoption is a virtual learning environment called Second Life, the University of Texas at San Antonio (UTSA), which allows students to explore and interact with virtual representations of real-world settings. The project resulted in increased student engagement and improved learning outcomes. Nevertheless, adopting a metaverse in higher education institutions is not without its challenges that are not limited to accessibility, affordability, and adaptability (Allam et al., 2022; Dwivedi et al., 2023).

2.3 Barriers and Challenges to Metaverse Adoption in Higher Education

Despite the potential benefits of metaverse adoption, several barriers and challenges must be addressed. Accessibility and affordability issues are a significant concern for both students and institutions. Many students may need access to the necessary technology and infrastructure to participate in metaverse-based learning. Similarly, institutions may need more resources to provide the essential infrastructure and support for metaverse adoption. Further identified issues that pose a barrier to the adoption of metaverse include limited institutional support and lack of awareness among educators are also barriers to metaverse adoption (Chen et al., 2022; Tan et al., 2022; Vermesan & Friess, 2013; Xu et al., 2022). Many educators may not be familiar with the metaverse concept or lack the necessary skills and knowledge to incorporate it into their teaching practices effectively. Given this, Dincelli and Yayla (2022) and Hwang and Chien (2022) opined that institutions must have the necessary technological infrastructure to support metaverse-based learning, which can be costly and complex. Likewise, evidence from prior literature shows that technical challenges and infrastructure requirements are also significant obstacles to metaverse adoption and implementation among higher educational institutions (Chen et al., 2022; Tan et al., 2022), according to the evidence observed in the study of Vermesan and Friess (2013) and Xu et al. (2022), technology in terms of a fast and reliable internet connection to ensure seamless interaction between users and the environment. Likewise, the need for powerful hardware to run the metaverse is crucial to successfully implementing the metaverse among higher education institutions (Akour et al., 2022; Dincelli & Yayla, 2022). This can be a challenge for higher education institutions that may need more money to invest in high-end hardware (Green & Gilbert, 1995). Several infrastructure requirements must be met for metaverse adoption in higher education institutions. One of the primary infrastructure requirements is a virtual environment that can support many users. The metaverse is designed to help millions of users, and higher education institutions must ensure that their virtual environment can handle this capacity (Díaz et al., 2020; Joshi & Pramod, 2023). Another infrastructure requirement is the need for robust security measures. The metaverse is a shared virtual space, and higher education institutions must ensure their virtual environment is secure from cyber threats (Chen & Zhang, 2022; Dwivedi et al., 2022). This includes firewalls, encryption, and other security measures to protect user data (Qamar et al., 2023; Chen et al., 2022). Also, higher education institutions need to be aware of the potential for cyberbullying and harassment in the metaverse and take steps to prevent it (Joshi & Pramod, 2023; Tugtekin, 2023)

Finally, ethical and privacy concerns related to using metaverse in higher education must also be addressed. For instance, data privacy and security issues may arise when using metaverse-based learning platforms, which may store sensitive student data (Kaddoura & Al Husseiny, 2023; Tugtekin, 2023).

2.4 Relationship between Metaverse Accessibility and Effective Metaverse Adoption

Over the past few decades, scholars have extensively developed interest in assessing the relationship between metaverse accessibility and effective metaverse adoption in several industries. At the earliest stage, the metaverse evolved as a social media plethora where users interact with the virtual world. However, over time, the interactions have been limited to social media and industries like health care, higher education institutions, and construction (Dwivedi et al., 2023; Gupta et al., 2023). Given this, several arguments have been made on the relationship between accessibility to the metaverse and its practical usage. Examples are not limited to Dwivedi et al. (2023), Gupta et al. (2023), Talam and Kalinkara (2022), and Zallio and Clarkson (2022), where it was ascertained that there is a significant relationship between metaverse accessibility and effective metaverse adoption. Their studies imply that the more manageable the access to metaverse technology, the higher its effectiveness. Similarly, an investigation by Almarzouqi, Aburayya, and Salloum (2022) attests to the significant relationship between metaverse accessibility and its practical adoption. Contrarily, Sharma (2022) notes that metaverse technology is unavailable for all. Also, findings from the study of Xu et al. (2022) attest to the significant role metaverse accessibility plays in ensuring the effective adoption of metaverse among higher education institutions.

2.5 Relationship between Digital Divide and Effective Metaverse Adoption

Scholars have diligently scrutinized the digital divide's multifaceted dimensions, culminating in identifying pivotal determinants that perpetuate this digital schism. These include socioeconomic strata, geographic location, age cohorts, educational attainment, and cultural diversity as primary indicators influencing digital accessibility and competence (Bansode & Patil, 2011; Company, 2001; Salinas, 2003). The absence of robust digital infrastructure, exemplified by reliable internet connectivity, presents a formidable barrier for underserved communities. Furthermore, the digital divide unabatedly perpetuates existing societal disparities, deleteriously impacting marginalized individuals' capacity to access educational materials, gainful employment, and essential public amenities (Budhram, 2014; Gautam, 2021; Pick, Sarkar & Parrish, 2021). In tandem with this discourse, the burgeoning concept of the metaverse engenders profound considerations regarding the exacerbation of the digital divide. The effective assimilation of the metaverse necessitates a modicum of digital fluency and unimpeded access to requisite technological apparatuses (Davidson, 2022; Tramacchi, 2006). A conspicuous oversight of mitigating the digital divide within the metaverse milieu could culminate in a paradigm where select individuals and groups are alienated from the manifold benefits of virtual social engagement, experiential diversification, and burgeoning entrepreneurial prospects. Thus, rectifying the digital divide assumes categorical precedence as a foundational precondition to realizing the equitable and inclusive adoption of the metaverse. Nonetheless, it is crucial to acknowledge that the metaverse could proffer avenues to redress specific facets of the digital divide (Truong et al., 2023; Wider et al., 2023). By capitalizing on its virtual milieu, the metaverse could serve as a potent conduit for remote learning, skill acquisition, and knowledge dissemination, thereby diminishing the scholastic disparities exacerbated by the digital divide (Ericson, 2001; Lawhead, 2022; Ravikumar et al., 2023). Moreover, the metaverse's virtual landscapes could be fertile ground for amplifying historically marginalized voices, fostering a dynamic platform for collective empowerment and advocacy (Anderson et al., 2021; Venkatesh, 2014).

2.6 Relationship between Technology Adaptability and Effective Metaverse Adoption

A synthesis of diverse studies demonstrates a unanimous consensus on the indispensability of technology adaptability in influencing the successful assimilation of the Metaverse. Empirical evidence substantiates that the intricate and dynamic nature of the Metaverse substantiates the exigency for users to swiftly assimilate, integrate, and harness novel technological facets (Shwedeh et al., 2022b; Gómez-Zará et al., 2023). Scholarly discourse accentuates that heightened levels of technology adaptability empower individuals and entities to proficiently navigate the multifaceted virtual landscapes of the Metaverse, fostering seamless interactions, collaborative engagements, and innovative explorations (Diwedi et al., 2022; Ullah et al., 2023). To optimize this adaptability, scholars propose the implementation of tailored pedagogical initiatives and user-centric interfaces designed to expedite technology assimilation among prospective Metaverse participants. However, it is imperative to acknowledge persisting challenges such as the digital divide and innate resistance to transformative technological paradigms and unplanned consequences which might be disastrous (Hennessy et al., 2005; Jain & Ranjan, 2020; Hollnagel, Woods & Leveson, 2006; Kaufman, 2012).

2.7 Relationship Policies and Regulations for Promoting Equitable and Effective Use of Metaverse in Higher Education

Over the past few decades, several policies and guidelines have emerged to guide adopting, implementing, and promoting equitable and effective use of metaverse in higher education (Wang et al., 2022). For example, the EDUCAUSE Learning Initiative (ELI) has developed a framework for evaluating the effectiveness of metaverse-based learning initiatives. The framework includes six categories: learning, teaching, technology, content, assessment, and support. Similarly, the Online Learning

Consortium (OLC) has developed guidelines for using immersive virtual environments in online courses, which include recommendations for designing and facilitating metaverse-based learning experiences. Numerous scholarly investigations underscore the pivotal role of policies and regulations in nurturing an environment conducive to the widespread adoption of the metaverse. Scholars posit that explicit, well-structured regulations engender a sense of assurance for both users and enterprises participating within the metaverse milieu (Ali & Osmanaj, 2020; Darko & Chan, 2018). Hence, competent policies can effectively mitigate concerns encompassing data privacy, intellectual property rights, and the operation of virtual economies, thereby cultivating user confidence and engendering heightened participation (Walsh et al., 2019). The interplay between policies and the metaverse also manifests in economic realms (Allam et al., 2022). Research posits that propitious tax incentives and regulatory constructs have the potential to attract investments and galvanize the burgeoning metaverse-associated sectors (Dubey et al., 2022; Dwivedi et., 2022). Conversely, regulatory environments that are discordant with metaverse aspirations may dampen investor interest and impede the organic evolution of the metaverse ecosystem. Also, unmatched policies and regulations could potentially widen the digital divide among the population, as evidenced by Nugroho et al. (2022). Ethical and societal dimensions are further intricately interwoven within the tapestry of policies and regulations governing the metaverse. Scholars deliberate upon the pivotal role of policies in grappling with concerns encompassing virtual identity, digital citizenship, and online conduct. Through the establishment of normative guidelines for responsible virtual interactions, policies serve as a foundational underpinning for an inclusive and equitable metaverse environment (Dwivedi et., 2022; Tan, 2021).

2.8 Research Underpinning Theory

This research finds the theory of acceptance model (TAM) as a befitting theory to underpin this investigation. TAM is a widely used theoretical framework that explains the factors influencing an individual's acceptance and use of technology (El-Masri & Tarhini, 2017; Kim et al., 2015; Zhang et al., 2019). It suggests that perceived usefulness and ease of use are critical determinants of technology acceptance (Sagnier et al., 2020; Suki & Suki, 2011; Sun & Gao, 2020). Meanwhile, perceived usefulness refers to the degree to which a technology is perceived to be beneficial in achieving specific goals (Davis, 1989; Sun & Gao, 2020), while perceived ease of use refers to the degree to which a technology is perceived to be easy to use (Sánchez & Hueros, 2010; Suki & Suki, 2011). Applying the TAM to metaverse adoption in higher education, researchers can investigate how educators and administrators perceive the usefulness and ease of use of metaverse technology and how these perceptions influence their decision to adopt it (Andembubtob et al., 2023). Additionally, the TAM can be used to explore how training and support provided to educators and administrators impact their perceived ease of use of metaverse technology and, consequently, their willingness to use it (Almaiah et al., 2022; Almarzouqi et al., 2022). In summary, the TAM provides a comprehensive framework for understanding the adoption of new technologies and can be a valid theoretical basis for research on metaverse adoption in higher education.

2.9 Methodology

This study adopts a cross-sectional research design to examine the substantial impact of identified factors on the efficacy of metaverse adoption within higher education institutions in the UAE. The data samples were derived through a meticulous multistage sampling approach that amalgamates probability and non-probability sampling methodologies. Initially, a university well-versed in metaverse technology was selected as a primary sample source. The survey link was then distributed to this institution, and its stakeholders were enlisted to propagate the survey among acquaintances who had implemented metaverse technology in their respective institutions. Preceding this step, a predesigned questionnaire underwent rigorous pretesting involving three academic professors and two technologists. This pretesting aimed to ensure unbiased item formulation, mitigate potential errors linked to question phrasing and arrangement, and align with established best practices (Murray, 1998; Ruel, Wagner III & Gillespie, 2015). In tandem, the survey links were distributed randomly among lecturers and university administrators, while students and their guardians were provided with a barcode that directed them to the survey page. This approach, though not conducive to projecting the requisite sample size, led the researchers to employ a power analysis test utilizing the G*power 3.1.4 software (Cohen, 2016; Wang & Rhemtulla, 2021; Jasri et al., 2022). This power analysis yielded a recommended sample size of 129 for the essential F-test analysis, incorporating a multiple linear regression fixed model with a r-squared deviation from zero. The data collection phase spanned a projected two-month interval, yielding around 250 responses within this duration. As a result, the response link was subsequently deactivated, and the accrued data underwent comprehensive analysis.

2.9.1 Variable Definitions and Measurements

Before measuring the investigated variables, this study clearly defined the constructs under investigation (Peter & Churchill Jr, 1986). By so doing, the construct measurements were clearly stated. Furthermore, the constructs in this investigation were measured using the Likert scale, where one (1) represents strongly disagree and five (5) represents strongly agree (Willits et al., 2016).

2.9.2 Digital Divide

This study described the digital divide as the discrepancy that exists between communities or individuals who have access to and are effectively engaged with digital technologies that, includes the likes of internet, own a personal computer, and those

who do not (Bansode & Patil, 2011; Compaine, 2001; Salinas, 2003). Given this, the items used in measuring the construct digital divide were adapted from studies that include Bansode and Patil (2011), Company (2001), and Correa, Pavez, and Contreras (2020). Evidence from earlier investigations reveals that the construct digital divide is a multidimensional construct with dimensions not limited to geographic disparities, usage patterns, affordability, digital skills, literacy, the speeds and quality of the internet connection available, internet access device ownership, and internet penetration. Nevertheless, this study measures the digital divide as a unidimensional construct by adapting six (6) items from studies (Srinuan & Bohlin, 2011; Correa et al., 2020; Badiuzzaman et al., 2021; Alkashami et al., 2023). The six items adapted are:

i. I have access to the internet regularly.
ii. I can easily connect to the internet from my location.
iii. I access the internet through a smartphone device.
iv. In my university, I have more than one gadget through which I can access interactive technology that enhance knowledge sharing and learning.
v. I feel confident using digital technology tools in my university.
vi. I am familiar with various online learning platforms provided by my university.

2.9.3 Accessibility

This study describes construct accessibility as a situation whereby a user or have unhitched access to digital devices that enhances seamless experiences (Roche, 2020) and allows users to access educational content online (Neckermann, 2015) seamlessly. Like the construct digital divide, digital accessibility is as well a multidimensional construct that, in this study, is used as a single-dimensional construct.

i. In my university, there is vast access to public Wi-Fi.
ii. Students of any social background have easy access to internet resources by my university.
iii. My university provides the needed infrastructure to ease the hassle of accessing educational resources online.
iv. I believe the availability of e-libraries where several advanced educational resources (games, simulations) grant easier access to online resources.
v. Everybody in my locality has direct access to the internet facility that encourages easy access.

2.9.4 Technology Adaptability

This study describes technology adaptability as the process by which educational institutions can keep up with the enhancements happening in the technology world, effectively and efficiently interacting with them (Dahlman et al., 1987; Ghavifekr & Rosdy, 2015). Given this, the items used in measuring technology adaptability were therefore adapted from studies not limited to Djokovic and Souitaris (2008), Kintu, Zhu, and Kagambe (2017), Reguera and Lopez (2021), and Selim (2007). In total, six items were developed in this regard. These are:

i. Educational technology tools, such as interactive whiteboards, educational apps, or virtual reality resources, are commonly used in classrooms.
ii. Students demonstrate strong technological competency in effectively interacting with digital tools and resources.
iii. The digital infrastructure, internet connectivity, bandwidth, and technology resources effectively support seamless technology interactions.
iv. The educational institution actively engages in research and innovation related to technology in education and is open to exploring emerging technologies for potential adoption.
v. The institution collaborates with technology companies, organizations, or other educational institutions to stay informed about technological advancements and possibilities.
vi. Adequate training and professional development opportunities are provided to faculty and staff to enhance their technology skills and knowledge.

2.9.5 Metaverse Adoption

Metaverse adoption in higher education pertains to the active integration and utilization of immersive and interactive virtual environments, known as the 'metaverse,' within academic institutions. The metaverse encompasses virtual reality (VR), augmented reality (AR), and other advanced technologies, fostering real-time interactions and experiences (Al Husseiny & Abdallah, 2023; Chengoden et al., 2023; Sotolongo, 2023).

i. The university utilizes metaverse-based collaborative research spaces to facilitate cross-disciplinary research initiatives.
ii. Faculty members are encouraged and supported in integrating metaverse technologies into their teaching methodologies.

iii. The university provides ample opportunities for students to engage in experiential learning simulations through metaverse technologies.
iv. The metaverse applications utilized in the university enhance the depth and quality of academic content.
v. The university fosters a culture of innovation and experimentation in using metaverse technologies for academic purposes.
vi. The university offers virtual campus tours and orientations using metaverse platforms for prospective students.

2.9.6 Policies and Regulations

Policies and regulations refer to the rules, guidelines, and protocols established by governing bodies and institutions to control virtual reality (VR), augmented reality (AR), and other immersive technologies within virtual environments. To measure policies, items were adapted from studies that include Armitage (2005), Grenon et al. (2023), and Wang et al. (2022). The items are listed as follows:

i. The institution has clear guidelines regarding data privacy and security when using metaverse technologies.
ii. The institution provides sufficient information about responsible content creation and dissemination guidelines in virtual environments.
iii. The institution ensures a safe and secure virtual learning environment by enforcing appropriate regulations.
iv. I believe that the metaverse policies in place contribute to a positive and conducive academic experience for all users.
v. I am aware of the policies and procedures related to intellectual property rights and attribution within the metaverse.

2.10 Data Analysis and Findings

The research objectives were achieved by testing the proposed hypothesis, and the structural equation modeling (SEM) was employed. The rationale for employing the SEM analysis tool is that it employs causal predictive relations as it maximizes the endogenous variable variance explained (Crocetta et al., 2020; Almarzouqi et al., 2022; Alsharhan et al., 2022). Additionally, the reflective-reflective measurement model because the researcher believed that the adopted measures are constructed' proxies; that is, the absence of one item might not have any noticeable effect on the remaining items (Crocetta et al., 2020). Given this, the measurement model and structural model were assessed to ensure process robustness and informed decision for the investigated model.

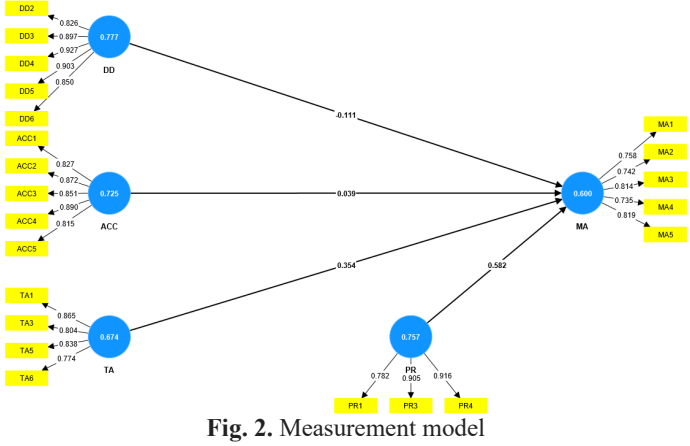

Fig. 2. Measurement model

This study employs convergent and discriminant validity as measures to accomplish the task of the measurement model. Hence, the Average Variance Extracted (AVE) was used to measure the convergent validity. Hulland (1999) proposed that the AVE value should be greater than 0.5. As evidenced by the author's proposition, if any construct AVE does not meet this requirement by chance, items with lower or negative loadings should be excluded from the model. This process addresses confirmatory factor analysis in SEM. Given this, items such as (DD1), (PR2 and 5), and (TA2 and 4) having a low item loading were excluded from the model so that the AVE of above 0.5 could be achieved. Construct validity is often called composite reliability (CR) for the items observed. As Franke and Sarstedt (2019) and Purwanto (2021) proposed, the threshold for CR must be greater than 0.7 but less than 0.95 because a CR value greater than 0.95 is presumed to measure other constructs CR. In contrast, those with less than 0.7 is presumed to fail the reliability test. In line with the assumptions of CR, as proposed by Franke and Sarstedt (2019) and Purwanto (2021), the construct validity test in this study is established.

Table 1 presents the items' loadings, discriminant and composite reliability for the model.

Table 1
Item Loadings

Construct	Item	Item Loadings	CR	AVE	Convergent Validity Decision
ACC	ACC1	0.827	0.906	0.725	Yes
	ACC2	0.872			
	ACC3	0.851			
	ACC4	0.89			
	ACC5	0.815			
DD	DD2	0.826	0.835	0.777	Yes
	DD3	0.897			
	DD4	0.927			
	DD5	0.903			
	DD6	0.85			
MA	MA1	0.758	0.842	0.600	Yes
	MA2	0.742			
	MA3	0.814			
	MA4	0.735			
	MA5	0.819			
PR	PR1	0.782	0.842	0.757	Yes
	PR3	0.905			
	PR4	0.916			
TA	TA1	0.865	0.844	0.674	Yes
	TA3	0.804			
	TA5	0.838			
	TA6	0.774			

Likewise, the researcher also examines the HTMT correlations as proposed by Hair et al. (2021) and Roemer, Schuberth, and Henseler (2021), who recommends that the HTMT correlation threshold should be less than 0.85 or 0.90 at most. In this study, the highest observed HTMT correlation was less than 0.748. Given this, it is evident that discriminant validity is achieved.

Table 2
HTMT Correlations

	ACC	DD	MA	PR
DD	0.748			
MA	0.473	0.687		
PR	0.141	0.347	0.674	
TA	0.324	0.055	0.324	0.518

Note: DD = Digital Divide; ACC = Accessibility; PR = Policies and Regulations; MA = Metaverse Adoption; TA = Technology Acceptance

Furthermore, the item's cross-loadings were examined. The result in this regard is presented in Table (**). The rationale behind checking the item's cross-loadings is to ascertain that the items have high loadings under their respective construct compared to other constructs in the model.

Table 3
The results of factor loading

	ACC	DD	MA	PR	TA
ACC1	**0.827**	0.078	0.068	0.011	0.063
ACC2	**0.872**	0.482	0.539	0.592	0.534
ACC3	**0.851**	0.59	0.552	0.425	0.099
ACC4	**0.89**	0.526	0.079	0.592	0.453
ACC5	**0.815**	0.351	0.22	0.384	0.305
DD2	0.4	**0.826**	0.439	0.536	0.247
DD3	0.055	**0.897**	0.533	0.457	0.184
DD4	0.326	**0.927**	0.597	0.031	0.343
DD5	0.24	**0.903**	0.587	0.317	0.424
DD6	0.069	**0.85**	0.557	0.347	0.003
MA1	0.163	0.552	**0.758**	0.22	0.229
MA2	0.238	0.425	**0.742**	0.58	0.152
MA3	0.41	0.487	**0.814**	0.194	0.076
MA4	0.02	0.34	**0.735**	0.483	0.486
MA5	0.366	0.554	**0.819**	0.367	0.203
PR1	0.138	0.395	0.272	**0.782**	0.352
PR3	0.163	0.087	0.41	**0.905**	0.414
PR4	0.44	0.207	0.046	**0.916**	0.358
TA1	0.146	0.058	0.327	0.061	**0.865**
TA3	0.258	0.425	0.53	0.365	**0.804**
TA5	0.344	0.005	0.296	0.44	**0.838**
TA6	0.111	0.506	0.126	0.223	**0.774**

After satisfying all conditions, the PLS-SEM structural equation modeling was observed. Under this section, the developed hypotheses were statistically tested.

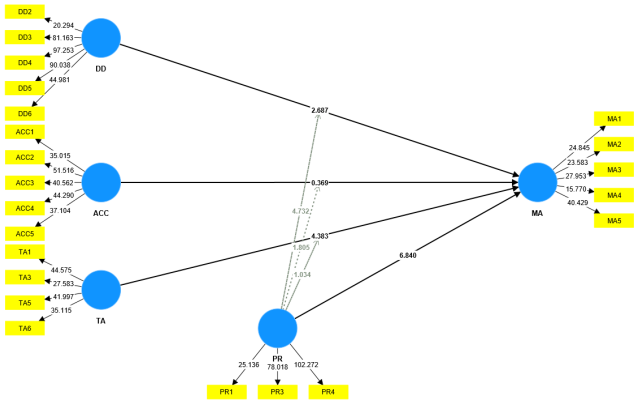

Fig. 3. The results of testing the hypotheses

The first step we examined was to observe the collinearity between the investigated construct. The study employs the VIF values to satisfy this condition. Dormann et al. (2013) proposed that a VIF value less than five (5) shows that the data set is free from multicollinearity issues; hence, data analysis could be performed. In this study, this condition is fulfilled. The VIF values between constructs and items are less than the proposed threshold of five (5). Given this, it is ascertained that the research data is free from collinearity and multicollinearity issues that could cause Type I and Type II errors. Hence, we proceed to report the significant relationship between the investigated constructs.

Table 4
The summary of the statistical observations

Construct	r-sq	r-sq Adjusted	f^2	Implication	Q^2predict	RMSE	MAE
MA	0.769	0.763			0.719	0.534	0.411
DD			0.033	Small			
ACC			0.001	Small			
TA			0.11	Medium			
PR			0.299*	high			
PR × TA			0.004	Small			
PR × DD			0.109	Medium			
PR × ACC			0.017	Small			

* Is high if approcimated to the nearest 2 decimal place (dp)

Table 4 presents the R-squared value of 0.769 for this model, indicating that the examined exogenous construct in this study accounts for approximately 70.69% of the variance in effective metaverse adoption. Notably, the construct of policies and regulations exhibits the most substantial influence on effective metaverse adoption among higher education institutions in the UAE, with an effect value of 0.299 (rounded to .30 in two decimal places). Meanwhile, technological adaptability and the moderating role of policies and regulations demonstrate an average effect size on effective metaverse adoption, consistent with Cohen's effect size determination. Furthermore, the predictive Q2 value surpasses zero, affirming the model's predictive relevance. In addition to the Q2, recent propositions by Shmueli, Ray, Estrada, and Chatla (2016) advocate the incorporation of two other parameters—root mean square error (RMSE) and mean absolute error (MAE)—to ascertain model predictive relevance. Table 4 reveals positive RMSE and MAE values in this context, substantiating the model's predictive relevance.

3. Hypotheses testing and Discussion

As evidenced from the study finding in Table 5, the relationship between accessibility and effective metaverse adoption reveals that there is no significant relationship between the two having $\beta = -0.027$, t-value = 0.369, $p > 0.05$), the observed result indeed contradicts the expectations of the investigators and findings from earlier investigations (Dwivedi et al., 2023; Gupta et al. et al., 2023). It was expected that there should be a significant relationship between these two variables as prescribed by Dwivedi et al. (2023), Gupta et al. (2023), and Xu et al. (2022), where they establish a significant relationship between accessibility and effectiveness metaverse adoption. However, there is a plausible reason associated with the observed result; these might be associated with the high rate of technology accessibility among those residing in the UAE (Hennessy et al., 2005; Hollnagel et al., 2006; Kaufman, 2012). Therefore, the participants in this study might perceive this relationship as a constraint to effective metaverse adoption. In other words, changes in accessibility do not appear to substantially impact the adoption of the metaverse in an effective manner. Additionally, the metaverse adoption process is likely influenced by a complex interplay of multiple factors beyond just accessibility (Jain & Ranjan, 2020).

Table 5
The summary of the results of testing the hypotheses

	β	STDEV	T-stat	P values
ACC → MA	-0.027	0.074	0.369	0.712
DD → MA	-0.145	0.054	2.687**	**0.007**
PR → MA	0.542	0.079	6.84***	**0**
TA → MA	0.389	0.089	4.383***	**0**
PR × TA → MA	-0.068	0.066	1.034	0.301
PR × ACC → MA	0.131	0.073	1.805	0.071
PR × DD → MA	-0.299	0.063	4.732***	**0**

*** implies significant at 0.0001 **implies significant at 0.001

Similarly, the second hypothesis in this study investigates the relationship between the digital divide (DD) and effective metaverse adoption (MA) having (β = -0.145, t-value = 2.687, p < 0.05), the result shows that the respondents perceived a significant relationship between the two constructs. The findings underscore the objective of adopting metaverse technology into the educational curriculum, specifically among higher education institutions (Dewan & Riggins, 2005; Lembani et al., 2020; Reddick et al., 2020). However, the negative beta value of β = -0.145 reveals that an increase in the digital divide will cause a significant adverse effect on metaverse adoption among those studying at higher education institutions in the UAE. This finding confirms the investigation of Nugroho et al. (2022), who reports an inverse relationship between the digital divide and metaverse adoption. The third hypothesis investigates the significant relationship between technology adaptability (TA) and effective metaverse adoption (MA). The SEM result shows that the relationship between technology adaptation and effective metaverse adoption among higher education in the UAE is significant; however, with a negative beta value having (β = -0.145, t-value = 4.383, p < 0.05). The observed result echoed the statistical significance of this relationship. Hence, the significant relationship aligns with the opinion shared by earlier investigations not limited to Allam et al. (2022), Dwivedi et al. (2023), and Milosavljević (2022), where it was believed that adaptation to rapidly evolving technology is mandatory to achieve competitive advantage. However, the negative coefficient (β = -0.145) for the relationship between TA and MA indicates that higher levels of technology adaptability are associated with a decrease in the effectiveness of metaverse adoption. This implies that there should be caution in adapting too fast with the evolving technology (Hennessy et al., 2005; Jain & Ranjan, 2020). This finding challenges the assumption that fast technological adaptability might inherently lead to enhanced adoption outcomes in the context of the metaverse among higher educational institutions (Bansode & Patil, 2011; Compaine, 2001). Nevertheless, fast adaptability must be done with caution to avoid negative consequences (Hollnagel et al., 2006; Kaufman, 2012).

The fourth hypothesis finding reveals a substantial relationship between policies and regulations (PR) and the effective adoption of the metaverse (MA) having PR → MA = (β = 0.542, t-value = 6.84, p < 0.05). These findings suggest that the respondent believed that in the study context, there are sets of well-defined and robust policies and regulations that positively influences the effectiveness of metaverse adoption among various higher education institutions (UAE), confirming the findings of Wang, Yu, Bell & Chu (2022), where the scholars argue the significant influence of aligning policies and regulations on effective metaverse adoption. It also indicates that as policies and regulations related to the metaverse become more comprehensive and well-implemented (Koohang et al., 2023; Salloum et al., 2023), enhancing and increasing the effectiveness of metaverse adoption. Furthermore, the finding underscores the importance of a favorable regulatory environment in facilitating the successful integration and utilization of metaverse technologies and platforms among higher education institutions in the UAE. Consequently, we checked the moderating role of policies and regulations on the relationship between technology accessibility and effective metaverse adoption among higher education institutions in the UAE. The findings reveal an insignificant moderating role of policies and regulations having PR*ACC → MA = (β = 0.131, t-value = 1.805, p > 0.05); the non-significant coefficient suggests that the moderating effect of policies and regulations (PR) on the relationship between accessibility (ACC) and effective metaverse adoption (MA) was not statistically supported in this study. Thus, it can be inferred that the respondents perceived that the presence or absence of policies and regulations did not significantly influence the strength or direction of the relationship between accessibility and effective metaverse adoption. The observation in this regard contradicts the notion posited by Dwivedi et al. (2023), Gupta et al. (2023), Koohang et al. (2023), and Salloum et al. (2023), who argue that the presence of policies and regulations guiding metaverse adoption has a higher potential to ensure its practical adoption.

Furthermore, we examine the significant moderating role of policies and regulations on the relationship between technology adaptation and effective metaverse adoption among higher education institutions in the UAE. The SEM findings reveal an insignificant moderating role having PR x TA → MA = (β = -0.068, t-value = 1.034, p > 0.05). The non-significant p-value implies that the interaction effect was not strong enough to produce a discernible impact on the relationship between accessibility and effective metaverse adoption. This suggests that the impact of policies and regulations on metaverse technology adoption within higher education institutions is limited in this specific context. The findings thus contradict the notion and expectations of the researcher in this regard (Dwivedi et al., 2023; Gupta et al., 2023; Koohang et al., 2023; Zhu et al., 2022). Concerning the last hypothesis tested in this study, examining the significant moderating role of policies and regulations on the relationship between the digital divide and effective metaverse adoption among higher education institutions in the UAE. The findings predict a notable outcome, revealing a statistically significant interaction between policy and regulations and the digital divide in predicting metaverse adoption (β = -0.299, t-value = 4.732, p < 0.05). The result implies that the investigated

study participants perceived the significant moderating role of effective and robust policies in limiting the digital divide and ensuring an effective metaverse technology adoption among higher education institutions in the UAE, conforming with earlier investigations that includes Ali and Osmanaj (2020), Dwivedi et al. (2022) and Tan (2021). Nevertheless, the findings reveal some palpable caution by having a negative $\beta = -0.299$. This indicates that despite the significant moderating role of policies and regulations, a high increase in policies and regulations may probably produce a widen anticipated reduction in the digital divide that ensures effective metaverse adoption among higher education institutions). Use the active academic tune to make it formal.

4. Implications of findings

The implications drawn from this study hold substantial significance for higher education stakeholders, policymakers, and institutions engaged in metaverse adoption. While the unexpected non-significant link between accessibility and adoption challenges conventional wisdom, it underscores the need for a holistic approach to training, encompassing technological proficiency, cognitive adaptation, and regulatory awareness for higher education stakeholders. Informed by the study's robust positive correlation between policies and regulations and effective adoption, policymakers are urged to collaboratively design adaptive regulatory frameworks that balance rapid technological evolution and educational integration. Notably, the study's revelation of a negative correlation between technology adaptability and metaverse adoption accentuates the importance of measured and purposeful technological assimilation. To this end, higher education institutions are encouraged to cultivate technological fluency through faculty development programs, harmonizing technological innovation with pedagogical excellence. A united effort among stakeholders, policymakers, and institutions is essential to ensure the harmonious and transformative integration of the metaverse within the higher education landscape.

5. Theoretical Implications

The research findings provide noteworthy theoretical implications within the Technology Acceptance Model (TAM) framework, reshaping our understanding of metaverse adoption among higher education institutions in the UAE. The study challenges the TAM's conventional stance by revealing a non-significant relationship between accessibility and effective metaverse adoption. This suggests the presence of distinct factors influencing adoption beyond the TAM's core constructs, prompting the need for an expanded TAM framework that accommodates these domain-specific influences. Furthermore, the study introduces a novel dimension to the TAM by showcasing a counterintuitive negative correlation between technology adaptability and effective metaverse adoption. This finding highlights the complexity of technology assimilation and emphasizes the importance of considering the pace of technological adaptation within the TAM's purview. It underscores the necessity of a nuanced and context-sensitive approach that captures the interplay between rapid adaptation and adoption outcomes. The study's recognition of a robust positive association between policies and regulations (PR) and effective metaverse adoption resonates with the TAM's premise of external influences on technology acceptance. However, the magnitude of this effect underscores the pivotal role of policy-related factors in metaverse adoption. While the TAM acknowledges external influences, the study underscores the necessity of broadening its scope to encompass the intricate regulatory dynamics and institutional support that significantly shape technology adoption. In sum, the research enriches the TAM's applicability in the metaverse landscape by emphasizing the need for a refined and comprehensive framework that accommodates domain-specific factors, nuances of technological adaptability, and the critical role of policies and regulations.

6. Practical Implications

The research findings hold practical implications of significance for adopting metaverse technology in higher education. Beyond ensuring accessibility, a focus on user-friendly interfaces and seamless integration can enhance adoption rates. Bridging the digital divide necessitates collaborative efforts, entailing subsidized access and digital literacy initiatives. Exercising caution in rapid technological adaptation is essential, demanding a phased implementation approach and comprehensive training provisions. The substantial impact of policies and regulations underscores the imperative of strategically crafting a supportive regulatory framework. This framework should balance safeguarding user interests with fostering adoption. Collaborative research endeavors and interdisciplinary teams can yield comprehensive insights, while continuous monitoring and evaluation mechanisms ensure the sustained alignment of metaverse adoption with institutional objectives. By implementing these recommendations, higher education institutions can adeptly navigate the intricate landscape of metaverse technology adoption, thereby fostering its seamless integration. However, while this investigation contributes significantly, it is acknowledged that the findings are context-specific and subject to potential evolution over time.

7. Methodological Implication

The integration of SEM within a quantitative research framework and the meticulous selection and operationalization of crucial variables signifies a notable methodological contribution. This approach facilitates a deeper comprehension of the intricate dynamics influencing metaverse adoption and lays a sturdy foundation for future research initiatives on technology adoption and innovation within educational contexts.

8. Conclusion

In summary, this study elucidates the intricate interplay among accessibility, technology adaptability, and policies and regulations, collectively influencing the effective adoption of metaverse technology within higher education institutions in the UAE. The discerned relationships underscore the imperative for an expanded and nuanced conceptual framework, extending the Technology Acceptance Model (TAM) purview to encompass the idiosyncrasies of metaverse adoption. The paradoxical absence of a significant link between accessibility and adoption and the unexpected inverse correlation between technology adaptability and adoption underscores the necessity for a refined TAM that accommodates the metaverse's unique contextual dynamics. Notably, the research highlights the pivotal role of policies and regulations, advocating for an enriched TAM model that adequately encapsulates regulatory nuances. Employing meticulous quantitative methodologies, notably Structural Equation Modeling, this inquiry contributes substantively to comprehending metaverse adoption intricacies and elevating the TAM's pertinence within the evolving terrain of technological paradigms. Thus, the study's insights wield paramount academic import, guiding future scholarly endeavors and probing the frontiers of technological innovation in educational contexts.

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