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Metaverse in Education: A Survey-Based Investigation of Collaborative Learning and Immersive Experiences

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Abstract

This study employed a survey-based approach supported by the Community of Inquiry (CoI) framework to investigate the effect of the Metaverse on education, with a special focus on collaborative learning, opportunities, and immersive experiences. Data collected from 337 university students provided insights regarding the perceptions, opportunities, and experiences linked with metaverse technologies in educational settings. Study findings remained supportive towards the preliminary hypotheses. The first hypothesis confirmed a significant effect on Collaborative Learning. The second hypothesis also indicated a significant effect of metaverse technology on Learning Opportunities. Finally, the third hypothesis, focusing on Immersive Experiences, also remained significant. Overall, the respondents agreed that the Metaverse is a positive addition, improving their learning experiences and motivating them to engage in learning activities. Finally, the research discussed implications, limitations, and recommendations for future studies.

Keywords:

Metaverse; Learning; Immersion; Collaborative Learning; Structural Equation Modelling.

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1- Introduction

The concept of Metaverse technology has emerged from combining "meta" and "universe," initially introduced in the early 1990s through Neal Stephenson's novel "Snow Crash". However, its significant evolution came after 2018, following the adaptation of Ernest Cline's novel "The Ready Player One" into a blockbuster film, sparking broader public interest [1]. Today, Metaverse technology is widely integrated into various sectors, including education, business, healthcare, and organizational processes. As Wang et al. [2] highlight, metaverse technology enhances user experiences by enabling interactions within virtual environments [3], where avatars facilitate communication across both virtual and real domains [4]. To engage effectively with the metaverse, devices such as AR (Augmented Reality), VR (Virtual Reality), and MR (Mixed Reality) are crucial. These technologies provide immersive, 3D visual experiences with sensory interactions, including physical touch, bridging the gap between virtual and physical reality [5]. Bibri [6] emphasized the importance of metaverse devices in creating real-world-like interactions within virtual spaces. Lee et al. [5] categorized Metaverse technology (MT) on the "Simulation vs. Simulation" axis, encompassing dimensions such as lifelogging, augmented reality, virtual worlds, and mirror worlds. This categorization reflects the broad applicability of MT in virtual environments, extending beyond simple entertainment to complex applications in education, where simulations and virtual experiences enhance learning [7].

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In the educational sector, the potential of Metaverse technology to revolutionize learning has gained significant attention. During the COVID-19 pandemic, many institutions adopted 2D online learning platforms, providing limited engagement and interactivity. However, researchers have increasingly emphasized the transformative potential of metaverse technology in promoting immersive, collaborative educational spaces. MT allows students to explore intricate subjects through high-resolution, interactive simulations, offering a deeper understanding and enhancing engagement. As noted by Farhi et al. [8], the metaverse (MT), a virtual space where users interact with each other and digital content, has emerged as a promising innovation for transforming teaching and learning. Its integration into higher education can significantly improve student engagement and learning outcomes by creating immersive environments. Within the metaverse, students can participate in interactive learning experiences, simulations, and role-playing activities while collaborating with peers from various cultural and educational backgrounds. This immersive approach promotes critical thinking, deeper learning, and better preparation for the evolving demands of the digital workforce. Notably, integrating technology into higher education in the UAE brings numerous opportunities. It can increase student engagement, improve learning outcomes, and encourage collaboration and communication between students and faculty members. Also, technology supports personalized learning and provides access to diverse educational tools and resources. Given these potential benefits and the challenges of adopting educational technology, higher education institutions worldwide are exploring the enactment of the metaverse.

This research examines the effect of metaverse technology (MT) on education in the United Arab Emirates. The study investigates the effectiveness of metaverse tools in shaping collaborative learning dynamics within educational environments. It seeks to recognize and explore challenges related to integrating metaverse technologies in education, encompassing technical barriers, accessibility concerns, and pedagogical considerations. Also, this research focuses on examining the transformative potential of metaverse technologies, particularly virtual reality (VR) and augmented reality (AR), in creating immersive educational experiences for university-level students. The theoretical framework this research applies is the Community of Inquiry (CoI); there needs to be a theoretical gap in apprehending how the metaverse specifically influences these dimensions in educational settings. The literature on the metaverse in education is still evolving, and few studies have empirically applied the CoI framework to evaluate the effect of metaverse technology on collaborative learning, challenges and prospects, and immersive experiences [2, 9–11]. By addressing this theoretical gap, the research aims to contribute to the growing body of knowledge on the metaverse's role in education, providing in-depth insights into the complexities of interaction, critical thinking, and instructional design within metaverse-based learning environments [11-13]. This research has practical significance for educational practices. The findings will guide educators, instructional designers, and policymakers in using metaverse technologies effectively for collaborative learning and immersive educational experiences by providing discernment into the effect of metaverse adoption. Also, the study addresses technological challenges, crafting the way for a more inclusive and unrestricted learning environment. Comprehending the effect of the metaverse on collaborative learning and immersive experiences is important for developing educational strategies that improve student engagement. The focus is to create more interactive and engaging learning environments, improving the overall educational experience. The study's significance also expands to guiding future investigations in the junction of metaverse technologies (MT) and education. By examining both positive and challenging facets, this research lays the groundwork for further investigations to refine and optimize the integration of the metaverse in educational settings.

Thus, this research seeks to analyze how Metaverse technology enhances collaborative learning dynamics within educational environments in the UAE. By focusing on virtual reality (VR) and augmented reality (AR), the study examines the transformative potential of these technologies in creating immersive and interactive educational experiences for university-level students. The findings aim to guide educators and policymakers in integrating MT to create more inclusive and engaging learning environments. Furthermore, this study addresses technological challenges, paving the way for a more accessible and flexible learning environment. Through addressing the integration of MT, this research offers insights into the positive aspects of its adoption and its limitations, ultimately contributing to the development of strategies for optimizing educational experiences through metaverse technologies.

1-1- Metaverse Technology in the United Arab Emirates

Integrating technology into various sectors has become a central part of strategic planning in the United Arab Emirates (UAE) since its official adoption in 2018. This reflects the UAE government's strong commitment to technological advancement and the achievement of sustainable development goals. Farhi et al. [8] note that the UAE has significantly invested in technology and innovation to diversify its economy and reduce dependence on a single export. As a result, the UAE has established itself as a hub for technology and innovation, supporting startups through initiatives like the Abu Dhabi Global Market Innovation Challenge and Dubai Future Accelerators. Youssef et al. [12] highlight the UAE's rapid rise as a key player in developing Metaverse Technology (MT), a virtual space offering users an immersive experience. The Dubai Future Foundation (DFF), a government body dedicated to driving innovation and technology development, is crucial in advancing MT. The DFF has a specialized team working on immersive virtual worlds, including a project focused on a virtual marketplace utilizing digital currencies [13].

In the educational sector, Salloum et al. [4] emphasize the transformative impact of MT in the UAE. Students can explore various virtual worlds and scenarios without leaving the classroom, facilitated by virtual, augmented, and mixed reality. Abukhalaf et al. [14] further highlights how MT enhances engagement and immersion, allowing students to interact with digital objects and environments in previously impossible ways. Various companies and government organizations in the UAE actively invest in developing MT to support educational advancements.

According to Alderbashi [15], Metaverse Technology is a significant innovation that combines physical and virtual realities into a shared immersive space. This fully interactive environment can be accessed through various devices, including computers, smartphones, and virtual reality headsets. The concept of MT has gained substantial attention in higher education due to its potential to provide immersive learning experiences that mirror real-world scenarios. These experiences enhance student engagement and foster motivation. MT also supports collaborative learning and knowledge-sharing, offering educators and students opportunities to engage in innovative educational practices. A prominent example is the use of Second Life, a virtual learning environment adopted by public sector universities in the UAE. This platform enables students to interact with virtual simulations of real-world situations, leading to increased involvement and improved educational outcomes. However, integrating MT into higher education presents challenges such as accessibility, affordability, and adaptability, which must be addressed for successful implementation.

2- Literature Review

2-1- Metaverse Technology and Collaborative Learning

Research highlights the significant potential of metaverse technologies (MT) to boost intrinsic motivation and encourage active participation in student learning. Kaddoura & Al Husseiny [16] explored how MT impacts academic performance and engagement, with learning motivation playing a mediating role. Their study, based on data collected from 251 participants through an online survey, found that MT use positively enhances student engagement, which in turn improves academic outcomes.

To further advance MT's educational applications, Al Kfairy et al. [17] developed an innovative platform called *VoRtex*. This platform provides tools for creating immersive learning experiences within virtual environments, addressing challenges like those posed by the COVID-19 pandemic. Designed with a modern technological framework, *VoRtex* emphasizes collaborative learning and meets educational standards as an open-source, accessible solution.

Similarly, Chua & Yu [10] proposed an Edu-Metaverse framework aimed at improving learner engagement through human-machine interaction. This framework integrates two critical aspects: technological advancements in the Edu-Metaverse and the interactions between learners and avatars within the virtual environment. Learner engagement was categorized into three patterns: training engagement facilitated by the Edu-Metaverse, coalition engagement supported by collaboration within the platform, and creative engagement fostered by the metaverse's features. This framework envisions a transformative relationship between humans and machines in education [17].

Lee & Hwang [18] investigated an online medical education platform incorporating MT to simulate real-world clinical scenarios. Their redesigned blended learning model combined problem-based learning (PBL) and team-based learning (TBL), supported by clinical problem-solving mechanisms and the PAR cycle for training. The study revealed that MT enhanced student engagement and improved creativity, communication, clinical reflection, and collaborative skills. Students also reported better accessibility, immersive learning experiences, and increased confidence in this teaching approach. These findings highlight the transformative role of MT in education [18-20]. Thus, it is hypothesized that.

H1. *Metaverse Technology has a significant effect on Collaborative Learning among students in the UAE.*

2-2- Metaverse Technology and Learning Opportunities

The evolution of information technology has brought about noteworthy changes in traditional education throughout human history. In recent years, the concept of the MT has caught considerable attention, especially within the realms of big data and cyber-physical systems. This emerging idea encompasses various technologies, including big data, interaction, Internet computing, artificial intelligence, game design, Internet of Things, and blockchain, making it applicable across diverse applications [19]. The integration of MT in education brings about several opportunities. For instance, MT introduces gamification, using game-like experiences to improve learner motivation and engagement [20]. Diversity and inclusion are further promoted as MT helps students from diverse backgrounds to learn in the same environment, confounding real-world challenges. Also, it offers opportunities for skill-based learning and creating a virtual campus, linking learners in a realistic online environment [21]. However, while the MT holds promise as a novel social work concept, especially in its potential contributions to educational development, it is important to acknowledge that the architectural frameworks for its implementation in education are still in the early stages of development. Many questions and challenges remain to be addressed to incorporate the MT effectively into educational settings. For example, there are notable disadvantages to using MT in education. The cost of XR technologies, critical to the MT, is higher than traditional learning tools, and there is a need for fast internet connections and precise tools for content creation [21-23]. The lack of legislative restrictions raises security concerns, and cultural biases may broaden social and economic disparities [22]. Usability and accessibility issues may pose challenges for individuals with restricted movement or specific physical characteristics, and advanced use of MT devices may cause despair. Finally, there is a need to address expertise deficit, ensuring learners perceive technology as consistent with their backgrounds and established norms [7]. Thus, this research hypothesizes that.

H2. *Metaverse Technology has a significant effect on Learning Opportunities for students in the UAE.*

2-3- Metaverse Technology and Immersive Experiences

The concept of immersion in virtual reality (VR) relates to the ability of hardware and software to create a convincing sense of reality for users through sensory engagement. Immersion is crucial in enhancing a user's sense of presence within a simulated environment [24]. Kustiawan et al. [23] explored factors that influence student participation and perceptions across various metaverse technology (MT) platforms in Korea. Their study involved 57 undergraduate students and identified social and interactive learning, along with individualized and behavioral learning, as key contributors. Although there were no significant differences in social presence across the three platforms studied, students reported varying perceptions. Sentiment analysis revealed positive feedback from 61% of land users, 54.06% of Frame VR users and 51% of Gather Town users. Additionally, a keyword analysis provided insights into the reasons behind these differing perceptions.

To further emphasize the immersive learning experience, Zhang et al. [25] proposed the Immersive Atelier Model (IAM) as an innovative approach for remote inter-university studio courses. This model used Multi-User Virtual Environments (MUVEs) in two formats: a predefined MUVE and one shaped by students. The main question addressed how MUVEs could meet the needs of remote inter-university collaborations. The research monitored 46 students across three universities and gathered data through observations and post-course surveys. These insights offered a detailed understanding of the teaching and learning processes within each MUVE type. Notably, student-shaped MUVEs were particularly effective in promoting activities associated with indirect learning and conceptual development [25-27]. The study proposes the following hypothesis based on these findings and the literature.

H3. *Metaverse Technology has a significant effect on Immersive Experiences for students in the UAE.*

2-4- Theoretical Underpinnings

This research study is supported by the Community of Inquiry (CoI) framework. This theoretical lens provides a broad approach to understanding the nature of online and immersive learning environments, especially within MT -based education [26]. The CoI framework consists of three key presences: Social Presence, Cognitive Presence, and teaching presence, all of which play a significant role in shaping the virtual learning experience. While this study primarily focuses on social and cognitive presences, the interrelation with teaching presence is also acknowledged as an integral component of effective instructional design. Social Presence is central to creating an authentic and supportive community within virtual environments. It involves the ability of participants to establish personal connections, foster trust, and engage emotionally in the learning process. Social Presence takes on heightened importance in MT -based learning, as students interact within simulated spaces that often replace physical classrooms. Through social Presence, learners develop relationships that facilitate collaboration, empathy, and mutual respect. This is especially critical in the MT, where interactions occur in dynamic, virtual settings with limited physical cues. Social Presence motivates students to communicate openly, participate actively, and build a shared sense of identity, promoting a cohesive learning environment [27].

As Cognitive Presence focuses on constructing meaning and understanding through collaborative and sustained communication, the virtual environments need participants to engage in deep cognitive processes, such as synthesizing information, analyzing situations, and applying knowledge to real-world scenarios. Cognitive Presence enables learners to move beyond surface-level engagement, enabling deeper exploration and the development of nuanced understanding. The exchanges between social and cognitive presences are particularly noteworthy in MT -based education [28]. Social Presence ensures learners feel connected to the learning community, while cognitive Presence drives intellectual engagement and knowledge construction. Concurrently, these dimensions contribute to a richer, more meaningful learning experience. Combining emotional engagement with intellectual rigor creates an environment where students are immersed and deeply invested in their educational journey [29, 30]. Furthermore, the CoI framework facilitates the investigation of instructional design in virtual spaces. Researchers and educators can assess how effectively virtual learning environments support collaborative learning by focusing on social and cognitive presences. This includes understanding potential challenges, i.e., limited interaction due to technological constraints and barriers to maintaining meaningful cognitive engagement. Through the lens of the CoI framework, the study highlights the significance of designing virtual spaces that balance social and cognitive elements to maximize learner outcomes. Also, the immersive nature of MT technology aligns closely with the principles of the CoI framework [30]. As students engage in virtual spaces, they experience heightened levels of immersion, which can improve both social interactions and cognitive exploration. This alignment underscores the potential of the MT to transform traditional education into an interactive, engaging, and inclusive experience [27]. Therefore, the CoI framework provides a robust structure to evaluate and refine the design and implementation of MT -based learning, ensuring that social and cognitive presences are fully integrated into the virtual learning experience.

2-5- Study Gaps

The gaps determined in the current literature primarily focus on applying the CoI framework within MT -based learning environments. While the CoI framework has been extensively used in traditional educational settings, its integration into virtual spaces, such as the MT, still needs to be explored. This study addresses this gap by applying the CoI framework to analyze social and cognitive presences, offering a systematic approach to understanding collaborative learning outcomes in immersive environments. Further, while immersive experiences are recognized, the relationship between these experiences and collaborative learning is constantly limited in existing research. This research bridges this gap by emphasizing how MT technology fosters collaborative learning through sustained communication and critical thinking.

Furthermore, many studies discuss the prospect of MT technology but fail to fully address the technical, accessibility, and pedagogical challenges it presents [3, 18, 20, 31]. This study takes a balanced approach by addressing both the benefits and challenges of integrating MT technology, offering insights into issues such as usability, accessibility, and the need for expertise. Besides, while existing research focuses on gamification and diversity [32], exploring how MT technology contributes to diverse learning opportunities beyond these areas is limited. This research extends this by investigating how MT technology impacts skill-based learning, the creation of virtual campuses, and its ability to address real-world challenges [33]. Moreover, while individual MT platforms are examined, comparative analysis across different platforms is often lacking. This study addresses this by comprehensively comparing various MT platforms, offering a subtle understanding of their unique contributions to immersive and collaborative learning. Eventually, while engagement and motivation are discussed [17, 34], there is a need for a more in-depth analysis of how MT technology influences student motivation and active participation. This research analyses how MT technology enhances learner engagement, promoting creativity, clinical reflection, and communication within immersive educational environments (Figure 1).

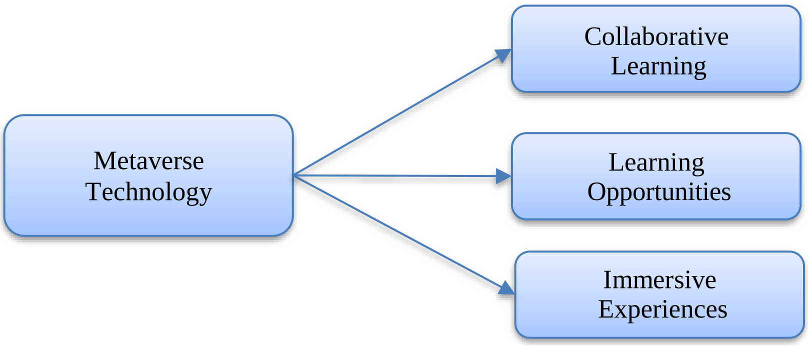

Figure 1. Explanatory Framework of Current Research

3- Research Approach

This study uses a case study approach to examine research hypotheses derived from existing empirical literature, testing them in a real-world educational setting [35]. Data collection depends on a survey method, using close-ended questionnaires to gather quantitative information. The participants in the survey were students with firsthand experience relevant to the topic being studied [36]. The questionnaire was designed using a five-point Likert scale, incorporating measurement items and scales adapted from previous research on metaverse technology adoption in various contexts (Appendix I). A detailed overview of the sources used to design the survey questionnaire is provided in Table 1.

The data collection process occurred between October and November 2023, combining physical visits to selected institutions with online methods. For the online procedures, Google Forms were distributed via email and personal messaging apps, ensuring that formal consent was obtained from all participants before their responses were collected.

Table 1. Measurement Items and Sources of the Survey Instrument

Constructs	Items	Sources
Metaverse Technology	1. The Metaverse has the potential to enrich my understanding of this subject. 2. Applying the Metaverse can significantly elevate the entertainment value of course content. 3. Metaverse utilization can boost motivation for engaging in the course. 4. Recognizing the pedagogical advantages, I believe the Metaverse holds educational benefits. 5. The Metaverse can be effectively integrated into any course within the faculty.	[29, 30]
Collaborative Learning	1. I envision truly 'seeing' my professor and fellow students, simulating a genuine classroom experience. 2. I can develop clear impressions of some of my fellow students. 3. There is a sense of proximity among me and my fellow students. 4. The sensation is akin to all fellow students and me being in the same room. 5. I believe the virtual setup helps me understand educational concepts better.	[37–39]
Learning Opportunities	1. Metaverse technology can significantly improve learner motivation and engagement by introducing gamification experiences. 2. Integrating Metaverse technology in education promotes diversity and inclusion by providing a shared learning environment for students from various backgrounds. 3. Metaverse technology creates opportunities for skill-based learning and the establishment of a virtual campus, fostering a realistic online environment for collaborative educational experiences. 4. Metaverse technology can significantly enhance learner motivation and engagement through introducing gamification experiences. 5. Integrating Metaverse technology in education can promote diversity and inclusion by providing a shared learning environment for students from various backgrounds. 6. Metaverse technology creates opportunities for skill-based learning and the establishment of a virtual campus, fostering a realistic online environment for collaborative educational experiences.	[40, 41]
Immersive Experiences	1. Metaverse technology improves students' immersion in educational experiences by creating a virtual environment that feels realistic and engaging. 2. Metaverse technology helps students explore educational content in a three-dimensional, immersive space, making learning more interactive and memorable. 3. Students find Metaverse technology helpful in promoting a sense of presence and connection with their peers and educational content, contributing to a more engaging learning experience. 4. Metaverse technology offers a unique and immersive collaborative learning and social interaction space. 5. Integrating Metaverse technology in education is a promising avenue for improving the overall quality of our learning experiences.	[19, 25]

3-1- Sampling Approaches

This research focused on higher education students from Ajman University and the University of Sharjah currently working in the UAE. The study's population comprised 26,188 individuals enrolled in these universities. The researchers utilized Krejci & Morgan's formula to determine the sample size further, selecting n=377 individuals. The purposive sampling approach was used, considering the MT Experience Browser as a critical criterion. Further, purposive sampling is applied as respondents with experience or exposure to MT are selected, assuring that the sample is relevant to the research objectives. Notably, the researchers first obtained formal permission from the respective institutions (Figure 2). Further, informed consent was acquired from the potential respondents. The researchers ensured that the data would be kept private and the researchers refrained from using their personal data for commercial purposes. After data gathering, n = 373 questionnaires were finalized, as 3 were missing. Thus, the total response rate remained at 99.2%, higher than the threshold of 60.0%.

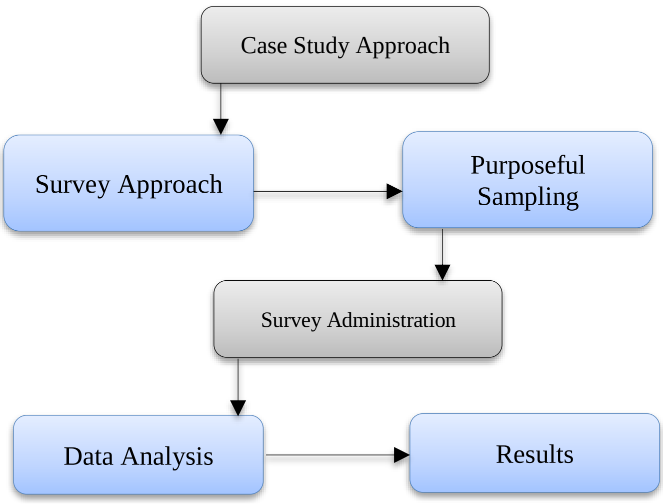

Figure 2. Illustration for Research Methodology in the Current Study

3-2- Data Analysis Techniques

Once the questionnaires were completed, the collected data underwent coding and manipulation for statistical analysis [40]. The researchers used Statistical Package for Social Sciences (SPSS) and Smart-PLS for the Partial Least Square- Structural Equation Modelling (PLS-SEM) to analyze. This study used descriptive and inferential statistics, making both software tools necessary for the selected analysis.

4- Data Analysis and Findings

Descriptive statistics were used to analyze the demographic information of the respondents, including their gender, age, educational level, and academic background. The results revealed that the majority of participants (66.8%) were male, while 24.1% were female. Regarding age, 46.1% of respondents were between 18 and 22 years old, 24.6% were aged 23 to 26, 16.1% were in the 26 to 30 age group, and 4.1% were 30 years or older.

When looking at educational levels, 46.1% were undergraduate students, 23.2% were pursuing postgraduate studies, 19.3% were graduates, and 2.4% were at the doctorate level. Regarding academic disciplines, 38.9% of respondents studied media, 37.0% were enrolled in engineering programs, 15.3% were from sociology, 4.8% were studying law, and 4.0% were in pharmacy or animal sciences. A detailed breakdown of the respondents' demographics is provided in Table 2.

Table 2. Demographics of Study Participants

Variables	Constructs	*N*	%
Gender	Women	99	24.1
	Man	274	66.8
Age Group	18-22	189	46.1
	23-26	101	24.6
	26-30	66	16.1
	30 and above	17	4.1
Study Level	Undergraduate	189	46.1
	Graduate	79	19.3
	Postgraduate	95	23.2
	Doctorate	10	2.4
University Major	Media	145	38.9
	Law	18	4.8
	Sociology	57	15.3
	Engineering	138	37.0
	Pharmacy/Animal Sciences	15	4.0

This study evaluates three hypotheses using a two-step Structural Equation Modeling (SEM) process, comprising "inner model analysis" and "outer model analysis." The initial phase assesses the inner model's validity and reliability through Confirmatory Factor Analysis (CFA), ensuring robust measurement tools. The second phase examines the relationships between variables outlined in the hypotheses, referred to as the "outer model analysis." The inner model's validity and reliability were prioritized. Convergent validity was analyzed to verify internal consistency among measurement items for each construct, as recommended. Additionally, discriminant validity was assessed to confirm that the constructs were distinct and uncorrelated, following the approach suggested by Rönkkö & Cho [42].

4-1- Inner Model Analysis

The CFA results for convergent validity are summarized in Table 3. Most item loadings exceeded the recommended threshold of >0.5. Similarly, the Average Variance Extracted (AVE) values surpassed the >0.5 thresholds, confirming strong internal consistency for all constructs: Metaverse Technology (MT) at 0.507, Collaborative Learning (CL) at 0.599, Learning Opportunities (LO) at 0.518, and Immersive Experiences (IE) at 0.548. The reliability of the constructs was also confirmed. Cronbach's Alpha values demonstrated high reliability: MT at 0.836, CL at 0.881, LO at 0.758, and IE at 0.788. Composite Reliability (CR) values exceeded the recommended >0.7 thresholds: MT at 0.757, CL at 0.831, LO at 0.575, and IE at 0.718. Table 3 presents the CFA results and the findings for convergent validity and construct reliability.

Table 3. Confirmatory Factor Analysis and Construct Reliability

Constructs	Items	Loadings	AVE	CA	CR
Metaverse Technology	MET1	0.806	0.507	0.757	0.836
	MET2	0.725			
	MET3	0.691			
	MET4	0.698			
	MET5	0.633			
Collaborative Learning	COL1	0.772	0.599	0.831	0.881
	COL2	0.792			
	COL3	0.813			
	COL4	0.839			
	COL5	0.641			
Learning Opportunities	CON1	0.813	0.518	0.575	0.758
	COP2	0.470			
	COP3	0.583			
	COP4	0.464			
	COP5	0.754			
	COP6	0.662			
Immersive Experiences	COP5	0.860	0.548	0.718	0.788
	IMM1	0.729			
	IMM2	0.597			
	IMM3	0.600			
	IMM4	0.649			
	IMM5	0.743			

Furthermore, the study performed an examination of model fit following the removal of items with lower loading values. Consistent with the argumentation by Schermelleh-Engel et al. [43], the model fit evaluation allows for determining the extent to which the measurement model aligns with the expected model. The final measurement model for the current research is illustrated in Table 4 and Figure 3. After removing the items with lower loading values, the goodness of fit resulted in a Standardized Root Mean Square (SRMR) value of 0.130, which falls below the determined threshold of <0.80. The Non-Fit Index (NFI) recorded a value of 0.826, falling within the sufficient range of 0 to 1. The Tucker and Lewis Index (TLI) remained strong at 0.986, exceeding the recommended threshold of >0.90. Also, the chi-square value was 1.449, below the specified threshold of <3.00, suggesting a favourable fit for the study.

Table 4. Goodness of Fit

	Saturated model	Criteria
SRMR	0.130	<0.80
NFI	0.826	b/w 0–1
TLI	0.986	>0.90
Chi-square	1.449	<3.00

A two-step method was applied to evaluate the discriminant validity of the measurement tool, utilizing the Fornell-Larcker Criterion (FLC) and the Heterotrait-Monotrait Ratio (HTMT), as outlined by Hamid et al. [44] The results demonstrated that the correlation values for each construct were distinct, indicating minimal interrelationships. Additionally, the cumulative HTMT values for all constructs were below the recommended threshold of <0.90. These results confirm the presence of discriminant validity across the study constructs. Detailed results are presented in Tables 5 and 6.

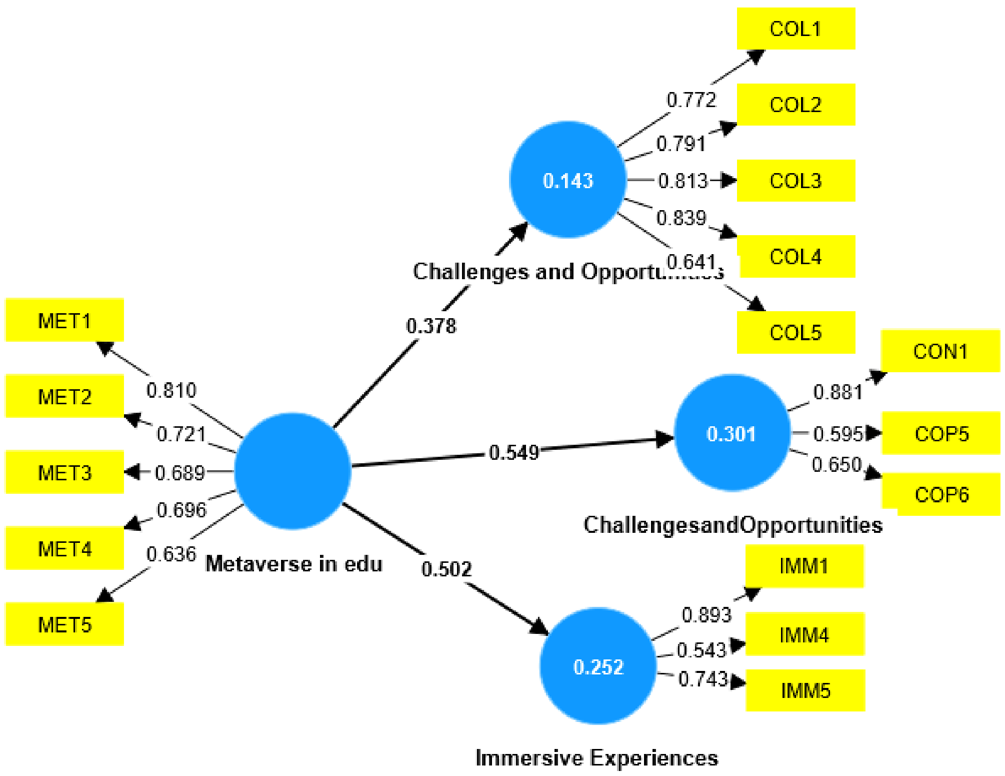

Figure 3. Final Measurement Model

Table 5. Fornell-Larcker Criterion

	Learning Opportunities	Collaborative Learning	Immersive Experiences	Metaverse Technology
Learning Opportunities				
Collaborative Learning	0.152			
Immersive Experiences	0.519	0.303		
Metaverse Technology	0.549	0.378	0.502	

Table 6. Heterotrait-Monotrait Ratio

	Learning Opportunities	Collaborative Learning	Immersive Experiences	Metaverse in Education
Learning Opportunities				
Collaborative Learning	0.297			
Immersive Experiences	0.593	0.018		
Metaverse Technology	0.461	0.417	0.394	

Before evaluating the structural model in the current study, the coefficient of determination (R2) was estimated. As Renaud et al. [45] stated, this analysis is important for assessing the predictive capability of predictor variables. In simpler terms, it helps calculate how much variance in endogenous variables is affected by predictor variables. The results revealed a 30.1% variance in Learning Opportunities, 34.3% in Collaborative Learning, and 45.2% in Immersive Experiences, indicating a moderate level of predictive power of the exogenous variable. Table 7 represents the results of the Coefficient of Determination R^2.

Table 7. Coefficient of Determination R2

Constructs	R-square	R-square adjusted
Learning Opportunities	0.301	0.299
Collaborative Learning	0.343	0.141
Immersive Experiences	0.452	0.25

Path analysis is a robust statistical technique used to examine the relationships between variables in a structured model. In this research, path analysis was employed to explore the directional relationships between exogenous (independent) and endogenous (dependent) variables, specifically focusing on the impact of MT on Collaborative Learning, Learning Opportunities, and Immersive Experiences among Emirati students. The findings from this analysis provided crucial insights into how MT influences these variables and offered a deeper understanding of the underlying relationships. The first hypothesis (H1) tested the relationship between MT and Collaborative Learning. The results indicated a significant positive effect, with a beta coefficient (β) of 0.377 and a t-statistic of 7.581, well above the critical threshold of 1.96 for statistical significance. The p-value of 0.000 further supports the robustness of this finding. These results imply that MT has a substantial influence on enhancing Collaborative Learning among Emirati students. This is consistent with the idea that virtual learning environments in the MT provide opportunities for students to engage in interactive, immersive experiences that promote teamwork, communication, and shared understanding [3, 41]. The collaborative aspect of learning in the MT encourages deeper engagement, where students can actively participate in group activities and problem-solving within a virtual space. Despite the significance, this path showed the weakest relationship compared to other paths, indicating that while MT positively influences Collaborative Learning, it might require complementary factors, such as effective instructional design and teacher facilitation, to maximize its impact.

Hypothesis H2 examined the impact of MT on Learning Opportunities. This relationship showed a stronger effect, with a beta coefficient (β) of 0.542 and a t-statistic of 11.317. The p-value was again significant at 0.000, reinforcing the significance of this pathway. These results indicate that MT significantly enhances Learning Opportunities for Emirati students. The immersive and interactive nature of the MT allows students to engage in gamified learning experiences, skill-based activities, and diverse educational content that are not easily obtainable in traditional learning environments [10, 16, 21]. The MT creates an environment conducive to personalized learning consistent with the diverse needs of students from various backgrounds. The higher beta coefficient signifies a stronger impact of MT on Learning Opportunities, underscoring its ability to expand the scope and depth of educational experiences. This finding is particularly important as it highlights how virtual platforms in the metaverse can overcome the physical limitations of classroom settings, offering boundless opportunities for exploration and growth. The third hypothesis (H3) focused on the relationship between MT and Immersive Experiences. Path analysis indicated a significant positive effect, with a beta coefficient (β) of 0.481 and a t-statistic of 9.930, accompanied by a p-value of 0.000. These results confirm that MT enhances Immersive Experiences for students [46], providing them with engaging, interactive, and memorable learning opportunities. The MT allows for three-dimensional visualization, realistic simulations, and social interactions that create an environment rich in sensory and emotional engagement. This enhances the overall educational experience, promoting deeper learning and knowledge retention. Although slightly weaker than Learning Opportunities, the relationship between MT and Immersive Experiences still demonstrates the MT's potential to enrich educational engagement through immersive, realistic experiences. The results suggest that students benefit from the multidimensional aspects of the MT, leading to a more interactive and engaging form of education.

Table 8. Hypotheses Testing (Path Analysis)

Constructs	*M*	*SD*	*β*	*t*	*P*
Metaverse in Technology → Collaborative Learning	3.70	0.822	0.377	7.581	0.000
Metaverse Technology → Learning Opportunities	4.04	0.681	0.542	11.317	0.000
Metaverse Technology → Immersive Experiences	4.11	0.465	0.481	9.930	0.000

Furthermore, the comparative analysis of paths highlights that the strongest relationship exists between Metaverse Technology and Learning Opportunities (0.542), followed by Immersive Experiences (0.481), with Collaborative Learning showing the weakest relationship (0.377). This pattern reflects the varying degrees of influence that Metaverse Technology has on these constructs. While Collaborative Learning is positively impacted, it may need additional elements, i.e., structured group tasks and the facilitation of peer-to-peer interactions, to fully leverage its potential. Conversely, Learning Opportunities and Immersive Experiences showcase a more robust relationship, suggesting that the MT excels in creating diverse, interactive, and meaningful educational experiences. These findings have implications for educators, policymakers, and technologists seeking to integrate MT into higher education, highlighting the importance of promoting comprehensive strategies that balance social, cognitive, and technological factors to optimize learning outcomes.

5- Discussion

This study examined how MT influences education in the United Arab Emirates. Specifically, it focuses on how MT affects collaborative learning in educational settings and determines challenges in incorporating these technologies. The research also focuses on the transformative possibility of MT, particularly virtual reality (VR) and augmented reality (AR), in creating immersive educational experiences for university-level students. Education. The results confirmed that MT significantly affects collaborative learning despite challenges using surveys and statistical analysis with partial least squares structural equation modelling. The findings showed the potential of MT to transform educational experiences, providing new ways for engaging learning environments. Talking about the study hypotheses and responses, a general agreement regarding the role and effect of MT in education remained prevalent. First, regarding the MT, respondents agreed that it can enrich understanding of the subject under study and significantly elevate the entertainment value of course content. According to the respondents, using MT can boost motivation for engaging in the course. They further agreed that the MT holds educational benefits, recognizing the pedagogical advantages. Thus, MT can be effectively integrated into any course within the faculty (M 3.91, SD 0.645). These results are consistent with the existing literature witnessing MT 's positive role and effect in education [21, 37, 47]. For instance, Lo & Tsai [38] examined students' perspectives concerning the educational application of the MT in Turkey. Data from a mixed-method approach revealed that most students showed positive opinions about multiple classroom experiences. Students acknowledged the prospect of the MT across different fields and disciplines, albeit with some concerns about its application in all academic courses. They deemed that the MT can improve their understanding of subjects, making course content more enjoyable and improving motivation. Students also indicated that they perceive the pedagogical benefits of the MT and anticipate its integration into classroom settings as a strong improvement in education and learning.

First, regarding the first research hypothesis (H1), "Metaverse Technology has a significant effect on Collaborative Learning among students in the UAE", the respondents indicated their agreement towards its significant effects on collaborative learning. The respondents envision truly 'seeing' professors and fellow students, simulating a genuine classroom experience. Respondents agreed that they could develop clear impressions of some of their fellow students through MT as there is a sense of proximity among them and their class fellows. Respondents also agreed that MT helps them have a sensation akin to all fellow students and them being in the same room. Thus, respondents believed the virtual setup helps them better understand educational concepts (M 3.70, SD 0.822). These findings are compatible with the existing literature indicating MT as providing students with collaborative learning and educational experiences in the best possible manner [1, 2, 6, 39]. A study by Yenduri et al. [47] also examined the educational potential of the MT in South Africa. The qualitative data showed that the metaverse provides personalized and adaptive learning experiences through its immersive and interactive features. Students engage in virtual environments designed to their needs, which enhance learning and collaboration. However, challenges such as network connectivity, organizational readiness, standardization, and the need for specialized skills exist (Table 9).

Table 9. Descriptive of Gathered Responses

	Range	Mean	Std. Deviation	95% Confidence Interval	
				Lower	Lower
Metaverse Technology	3.00	3.9147	0.64535	0.601	0.684
Learning Opportunities	4.00	3.7056	0.82299	0.743	00.896
Collaborative Learning	3.00	4.0456	0.68165	0.633	0.728
Immersive Experiences	3.00	4.1171	0.76532	0.720	0.804

Regarding the second research hypothesis, **“*Metaverse Technology has a significant effect on Learning Opportunities for students in the UAE*”**, respondents agreed that MT can significantly improve learner motivation and engagement by introducing gamification experiences. Besides, integrating MT in education promotes diversity and inclusion by providing a shared learning environment for students from various backgrounds. Respondents also agreed that MT creates opportunities for skill-based learning and the establishment of a virtual campus, fostering a realistic online environment for collaborative educational experiences. Respondents also agreed that Metaverse technology could significantly enhance learner motivation and engagement by introducing gamification experiences. Also, integrating MT in education can promote diversity and inclusion by providing a shared learning environment for students from various backgrounds [47]. Finally, a wider agreement remained apparent that MT creates opportunities for skill-based learning and the establishment of a virtual campus, fostering a realistic online environment for collaborative educational experiences. In their study Zhang [37] also validated the opportunities and proposed a unique model for students known as “CO-MATE”. As noted, CO-MATE (Collaborative MT -based A-La-Carte Framework for Tertiary Education) aims to be futuristic in its approach. The architectural structure of CO-MATE is foreseen with a four-layered model that summarizes myriad functionalities within the infrastructure and service layers. CO-MATE is a technologically advanced MT, integrating loosely connected building blocks to present an a-la-carte model catering to the needs of platform designers. Thus, designing the new model highlighted the opportunities offered by MT for the students and explained its component offerings for developing a technologically driven and automated immersive environment for the instructors. Consistent with these results, Chua & Yu [10] examined the potential of the metaverse to transform internet-based education, particularly in physical education. The results revealed that the MT applies to education only at a basic, intermediate level. Also, by integrating advanced and specialized technologies, the metaverse offers significant opportunities to improve education programs at universities.

Finally, the third hypothesis was "***Metaverse Technology has a significant effect on Immersive Experiences for students in the UAE***". The respondents agreed that MT improves students' immersion in educational experiences by creating a virtual environment that feels realistic and engaging. Besides, MT helps students explore educational content in a three-dimensional, immersive space, making learning more interactive and memorable [41]. According to the respondents, MT is useful for promoting a sense of presence and connection with their peers and educational content, contributing to a more engaging learning experience. The respondents further agreed that MT offers a unique, immersive space for collaborative learning and social interactions. Thus, respondents agreed that integrating metaverse technology in education is a promising avenue for improving the overall quality of our learning experiences. Existing studies also witness the effect of MT on providing students with immersive experiences in other regions [48]. Consistent with the existing findings, Kanematsu et al. [33] focused on evaluating students' perceptions of MT (MS) application in medical education in the United Arab Emirates (UAE). Data from 1858 university students correlated technology-based features with individual-based features, using hybrid analyses such as Machine Learning (ML) algorithms and Structural Equation Modelling (SEM). The study identified User Satisfaction (US) as a critical determinant affecting users' intention to use the MT (UMS). In line with the current study, a study by Phakamach & Senarith [49] examined the advantages of using virtual environments in academia, aiming to enhance curricula through innovative technologies. Data was gathered using case studies on the MT and AR-based applications such as MathBuilder, which uses math games for elementary students, and AR-enabled storybooks, which reduce anxiety related to learning math, demonstrating how AR supports student engagement and learning outcomes. The results confirmed that the MT and AR technologies add value for teachers, educators, and educational policymakers, offering meaningful tools to improve learning experiences.

6- Conclusions

This research highlights the transformative potential of MT in education, particularly within the United Arab Emirates. The results emphasize how MT tools reshape collaborative learning dynamics, offering immersive and interactive experiences beyond traditional methods. This study indicated metaverse technology challenges traditional education by introducing immersive, interactive, and dynamic learning environments extending beyond physical classrooms' confines. Traditional educational methods usually rely on static content delivery and passive learning experiences, whereas the MT offers a more engaging and personalized approach. Through virtual reality (VR) and augmented reality (AR), students can immerse themselves in simulations, virtual labs, and collaborative projects, allowing for a deeper understanding of complex concepts. This shift toward experiential learning empowers students to actively participate, explore, and interact with the subject matter, leading to higher retention and comprehension levels. Additionally, the MT breaks down geographical barriers, enabling learners to access global resources and engage with diverse perspectives, promoting a more inclusive and interconnected educational experience.

Furthermore, the adaptability and customization of MT platforms challenge traditional education by promoting individualized learning paths. Students can design their learning experiences to suit their unique needs, strengths, and preferences, receiving real-time feedback and adjusting their approach as they progress. This personal touch enhances engagement and allows for a more collaborative environment where students can actively contribute to learning. Teachers, too, can benefit from these advancements by creating dynamic, interactive curricula that align with students' learning styles and interests, thereby enriching the educational journey. Hence, the MT is reshaping education by moving beyond conventional methods to create a more flexible, innovative, and technology-driven approach to learning. Universities can create enriching environments that promote deeper student engagement and interaction by integrating virtual reality (VR) and augmented reality (AR) into educational settings. MTs provide a distinctive platform for students to explore complex subjects through dynamic, hands-on learning experiences. This immersive approach motivates creativity, critical thinking, and collaboration, essential skills for navigating a rapidly evolving digital world. Also, the ability of MT to bridge geographical barriers allows students access to a diverse range of global educational resources, enriching their academic journeys and preparing them for a technology-driven future. As institutions increasingly adopt these advancements, students benefit from personalized and adaptive learning experiences tailored to their needs. The MT is a powerful tool for educators to design instruction that aligns with different learning styles, improving student achievement and engagement. Finally, integrating MT in education represents a significant shift, changing how students engage with knowledge and prepare for the challenges of the digital age. This innovation holds extensive prospects for fostering a more inclusive, innovative, and forward-thinking educational ecosystem in the UAE.

6-1- Theoretical Implications

This research proposes theoretical implications based on the applied theory and obtained results. First, applying the CoI framework presents a theoretical structure that promotes apprehending how MT affect different dimensions of educational settings. This research revealed in-depth details regarding the interaction between students, teachers, and the virtual environment by focusing on the MT 's role in facilitating collaborative learning. This approach systematically examines the transformative possibility of MT in enabling meaningful educational experiences. The research contributes to the theoretical discourse by expanding the application of CoI, which has conventionally been used in online and blended learning contexts, to the emerging discipline of MT -enhanced education.

Further, the theoretical implications of this research lie in addressing a perceived gap in the literature. The study acknowledges the evolving nature of literature on the MT in education. Consequently, the theoretical implications expand to increase the understanding of the MT 's impact within the framework of established educational theories. Also, this research contributes theoretically by acknowledging and analysing challenges associated with integrating MT in education. This study examined the complexities of adopting MT tools in educational environments by encompassing barriers and concerns. This theoretical exploration offers practical insights into the pragmatic limitations that may impede the seamless integration of MT technology, thereby reporting both theoretical discussions and practical implementations in education. Finally, the theoretical implications extend to the wider academic community by emphasizing the need for a more comprehensive understanding of how MTS, especially virtual reality (VR) and augmented reality (AR), affect collaborative learning dynamics. The research contributes to the continuing conversation about the theoretical underpinnings of educational technology, highlighting the significance of adapting existing frameworks to novel technological landscapes.

6-2- Study Limitations and Recommendations

This study has several limitations that narrow its scope and impact. Firstly, the research is limited to the United Arab Emirates (UAE), which limits the generalizability of the findings to other regions or countries. While the UAE provides a rich context for exploring the role of MT in education, future studies should consider replicating this research in diverse geographic regions to enhance the external validity of the results. By doing so, researchers can acquire a broader understanding of how MT influence collaborative learning and immersive experiences across different cultural and educational contexts.

Secondly, the study uses a single research method, which may restrict the depth of insights into the complexities of MT 's impact on education. Utilizing mixed methods—combining both qualitative and quantitative approaches—could offer a more comprehensive understanding of the variables at play. This approach would enable researchers to explore subjective experiences and objective data, addressing potential limitations associated with using quantitative or qualitative methods. Mixed methods would provide richer, more nuanced insights into how students engage with MT. Finally, the study uses purposive sampling, which, although carefully applied to ensure relevant and suitable respondents, remains a point of critique due to potential biases in selection. Despite this limitation, purposive sampling was considered appropriate for this research, as it allowed the inclusion of participants directly relevant to the study's objectives. However, future research could explore other sampling techniques, such as stratified random sampling, to reduce bias and improve the sample's representativeness. While these limitations are acknowledged, the study offers practical contributions to the existing literature, providing a substantial foundation for further exploration of MT in educational settings.

7- Declarations

7-1- Author Contributions

Conceptualization, E.Y., and M.M.; methodology, E.Y.; validation, E.Y., M.M., and M.B.; investigation, M.B.; writing—original draft preparation, E.Y.; writing—review and editing, M.M.; visualization, M.B.; supervision, E.Y.; funding acquisition, E.Y. and M.M. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7-3- Funding and Acknowledgments

This research is supported by Ajman University, United Arab Emirates.

7-4- Institutional Review Board Statement

The Research Ethics Committee at Ajman University, United Arab Emirates, has approved this research.

7-5- Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I: Questionnaire

Dear Respondents! This research is aimed at examining the *impacts of family communication and supervision practices on the academic performance of the students*. Your participation will be helpful to attain and highlight the relevant phenomenon. Please note that your participation and voluntary and the research will refrain from disclosing your personal data for any other purposes. You can quit filling in the survey whenever you want, without any further obligations.

I would recommend you to please select only one most suitable option:

Gender

a) Female
b) Male

Age Group

a) 18-22
b) 23-26
c) 26-30
d) 30 and above

Study Level

a) Undergraduate
b) Graduate
c) Postgraduate
d) Doctorate

University Major

a) Media
b) Law
c) Sociology
d) Engineering
e) Pharmacy/Animal Sciences

Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The Metaverse has the potential to enrich my understanding of this subject.					
Applying the Metaverse can significantly elevate the entertainment value of course content.					
Metaverse utilization can boost motivation for engaging in the course.					
Recognizing the pedagogical advantages, I believe the Metaverse holds educational benefits.					
The Metaverse can be effectively integrated into any course within the faculty.					
I envision truly 'seeing' my professor and fellow students, simulating a genuine classroom experience.					
I can develop clear impressions of some of my fellow students.					
There is a sense of proximity between me and my fellow students.					
The sensation is akin to all fellow students and me being in the same room.					
I believe the virtual setup helps me understand educational concepts better.					
Metaverse technology can significantly improve learner motivation and engagement by introducing gamification experiences.					
Integrating Metaverse technology in education promotes diversity and inclusion by providing a shared learning environment for students from various backgrounds.					
Metaverse technology creates opportunities for skill-based learning and the establishment of a virtual campus, fostering a realistic online environment for collaborative educational experiences.					
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Metaverse technology creates opportunities for skill-based learning and the establishment of a virtual campus, fostering a realistic online environment for collaborative educational experiences.					
Metaverse technology improves students' immersion in educational experiences by creating a virtual environment that feels realistic and engaging.					
Metaverse technology helps students explore educational content in a three-dimensional, immersive space, making learning more interactive and memorable.					
Students find Metaverse technology helpful in promoting a sense of presence and connection with their peers and educational content, contributing to a more engaging learning experience.					
Metaverse technology offers a unique and immersive collaborative learning and social interaction space.					
Integrating Metaverse technology in education is a promising avenue for improving the overall quality of our learning experiences.					