International Journal of Research and Applied Technology

3(2)(2023) 391-398

Journal homepage: https://ojs.unikom.ac.id/index.php/injuratech

Virtual Classrooms and Digital Learning: An Analysis of Metaverse in Education

Chepi Nur Albar

Universitas Komputer Indonesia, Indonesia

Email: *chepi@email.unikom.ac.id

Abstract. The integration of the metaverse into education has the potential to revolutionize digital learning by creating immersive, interactive, and highly engaging virtual classrooms. This study examines how metaverse technologies enhance digital learning experiences, identifying both the opportunities and challenges they present. The research utilizes a mixed-method approach, combining surveys and interviews with educators and students to assess the effectiveness of metaverse-based learning. Findings suggest that while the metaverse fosters greater student engagement and collaboration, issues such as accessibility, high implementation costs, and ethical concerns must be addressed. This study contributes to the growing discourse on the future of education in a digital age, offering insights for educators, policymakers, and technology developers.

Keywords: Digital Learning; Immersive Learning; Metaverse in Education; Technology-Enhanced Learning; Virtual Classrooms.

1. Introduction

The rapid advancement of technology has transformed traditional education models, shifting from face-to-face classrooms to digital learning platforms [1]. Over the years, virtual classrooms have evolved from simple video conferencing tools to sophisticated Learning Management Systems (LMS) [2]. However, these systems still lack elements of engagement and interactivity that are crucial for effective learning [3]. The metaverse—a collective virtual shared space created by the convergence of virtually enhanced physical reality and interactive digital spaces—offers a new frontier in education. Through immersive experiences using virtual reality (VR) and augmented reality (AR), the metaverse has the potential to make digital learning more dynamic, interactive, and student-centered. Despite the widespread adoption of online learning, many educators and students find virtual classrooms lacking in engagement and social interaction. Traditional e-learning platforms often rely on passive learning methods, which can lead to lower student motivation and retention rates. The metaverse presents an opportunity to bridge this gap by fostering an immersive learning

International Journal of Research and Applied Technology

3(2)(2023) 391-398

Journal homepage: https://ojs.unikom.ac.id/index.php/injuratech

environment, but challenges such as accessibility, technological infrastructure, and the digital divide must be considered.

A previous study found that engineering students across four European universities rated a 3D metaverse platform as easy to use, fun, and satisfactory, with fair immersion, yet reported that interactivity and perceived usefulness remained neutral or insufficient compared to face-to-face teaching [4]. A review showed that metaverse-based blended English learning can significantly enhance academic success through high learner engagement in immersive 3D environments, but its effectiveness is constrained by both instructors' and learners' digital literacy levels [5]. Another research combined bibliometric and content analyses, it identified that educational metaverse research has evolved across generations—leveraging more AI for Gen Z—but still lacks studies on lifelogging applications, mobile/hybrid/micro-learning scenarios, and support for students with disabilities [6]. Another research defined the educational metaverse, proposes a detailed framework covering infrastructure and key components, and outlines four main applications (blended, language, competence-based, and inclusive education) alongside core challenges and future research directions [7]. Lastly, a qualitative ethnographic study proposed ten principles and "good practices" aimed at ensuring an inclusive, equitable, accessible, and safe metaverse, and highlighted a broad agenda of future research questions on social and ethical IDEAS in virtual spaces [8].

While recent studies have explored various aspects of metaverse applications in education, there remains a notable lack of empirical research that simultaneously examines the metaverse's impact on both students and teachers within general digital learning environments. Existing literature often concentrates on theoretical frameworks, specific subject areas, or conceptual analyses without generating new field data from educational practitioners and learners across disciplines. Based on this gap, this study aims to examine the impact of the metaverse on virtual classrooms and student engagement, assess the effectiveness of metaverse-based learning environments, and identify the challenges and opportunities associated with metaverse integration in education. This research is significant for educators, institutions, and policymakers seeking to understand the role of emerging technologies in education. By exploring the benefits and limitations of the metaverse, this study provides insights into how digital learning can be improved, fostering a more engaging and effective educational experience.

2. Method

This study employs a mixed-method research approach, integrating both qualitative and quantitative methods to provide a comprehensive understanding of metaverse-based learning in education. The research focuses on analyzing the effectiveness, benefits, and challenges of implementing metaverse technologies in educational settings. To achieve this, data collection consists of an extensive literature review spanning the years 2020–2023, specifically within the domain of Digital Learning, Virtual Classroom, and Metaverse. The research process is structured into three key stages: (1) Data Collection stage; (2) Data Analysis stage; and (3) Conclusion stage.

The Data Collection stage involves gathering data from multiple sources. A literature review is conducted to examine existing research on metaverse-based learning within the field of Information Technology in Education. Studies published between 2018 and 2024 are analyzed to identify trends, theoretical frameworks, and key findings related to the topic. In addition, primary data is collected through surveys and interviews with educators and

International Journal of Research and Applied Technology

3(2)(2023) 391-398

Journal homepage: https://ojs.unikom.ac.id/index.php/injuratech

students who have experience with metaverse-based learning environments. The surveys aim to quantify participants' perceptions, engagement levels, and challenges, while the interviews provide in-depth qualitative insights into their experiences.

Once the data is collected, it undergoes a rigorous Data Analysis process. The literature review findings are systematically categorized to identify common themes, gaps in research, and potential areas for further exploration. Quantitative data from surveys are analyzed using statistical methods to measure the effectiveness of metaverse-based learning, student engagement, and pedagogical outcomes. Qualitative data from interviews are transcribed and subjected to thematic analysis to extract recurring patterns and significant insights. The combination of these analyses allows for a balanced and in-depth understanding of the research problem.

In the Conclusion stage, the analyzed data is synthesized to compile key findings. The results from both qualitative and quantitative analyses are compared to ensure consistency and validate the conclusions. Emerging themes, best practices, and challenges in metaverse-based learning are highlighted, forming the basis for recommendations and future research directions. Finally, a comprehensive conclusion is drawn summarizing the study's contributions and its implications.

3. Results and Discussion

A virtual classroom is a live, online learning environment that replicates the interactivity of a traditional classroom. In these settings, instructors and students connect synchronously—via video conferencing, shared whiteboards, chat functions, and collaborative tools—to present course materials, discuss concepts in real time, and work on group activities together. The 2000s saw the widespread adoption of Learning Management Systems (LMS) in higher education and K-12, integrating file sharing, quizzes, forums, and gradebooks into cohesive virtual classroom experiences. By the late 2010s, most institutions had established regular virtual or blended offerings [9]. The COVID-19 pandemic triggered an unprecedented shift to online learning. In early 2020 United States alone, 77 percent of U.S. public schools and 73 percent of private schools moved some or all instruction online, and global enrollment in virtual courses more than doubled that year; as reported by The National Center for Education Statistics (NCES) 2020 annual report.

On the other hand, Metaverse refers to a persistent, interconnected 3D digital universe where users—via avatars—interact in real time, blending virtual and physical realities. When applied in education, it extends virtual classrooms into immersive, spatial environments. Within the Metaverse platforms, educators can design lifelike simulations—historical re-creations, virtual labs, or interactive field trips—allowing students to explore and experiment with fewer restrictions than 2D video calls. Students navigate these shared virtual spaces as customizable avatars, fostering social presence and collaborative problem-solving that mimic in-person group work more closely than standard web conferencing. In addition, major technology firms are also laying the groundwork. Meta themselves have donated 300 Quest 2 VR headsets to 15 U.S. universities in 2023 to support immersive, Metaverse-powered classrooms, and established a $150 million Immersive Learning Fund to accelerate VR/AR integration into education; as reported by Axios Newsletter. As hardware becomes more accessible and platforms mature, metaverse classrooms promise to reduce geographic barriers, personalize learning pathways, and cultivate digital skills essential for tomorrow's

International Journal of Research and Applied Technology

3(2)(2023) 391-398

Journal homepage: https://ojs.unikom.ac.id/index.php/injuratech

workforce. In the research environment, the exploration about Digital Learning, Virtual Classroom, and Metaverse have increased in popularity among researchers (See Figure 1).

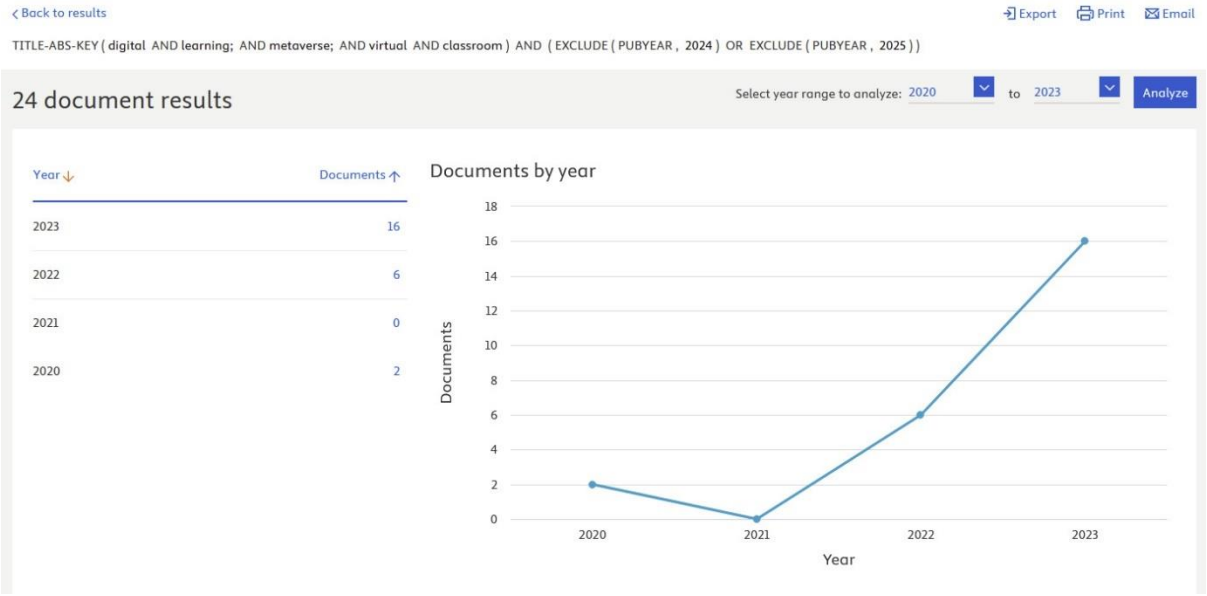

Figure 1. Research Trend of Digital Learning, Virtual Classroom, and Metaverse in Scopus

Based on Figure 1, Some initial interest is visible in 2020 – digital learning in the metaverse was a new concept, and few researchers were working on it. However, there are no publications in 2021 – possibly because either the concept was still too early, underdeveloped, or researchers were still exploring the idea without publishing yet. The concept experiences a noticeable growth in 2022 – likely influenced by global pushes toward digital transformation after COVID-19, where virtual classrooms and immersive learning became hot topics. Then, there is a research boom in 2023 marked by the sudden growth of publications – this phenomenon suggests that the concept of using the metaverse for digital learning became a serious research focus, with more academic interest and perhaps some initial real-world applications. If this trend continued into 2024 and 2025, it is highly likely the research volume would keep growing or stabilize at a high level. However, like every other method of learning, this new concept also has its own advantages and disadvantages:

3.1 Student Side

Multiple studies report significant boosts in student engagement when lessons are delivered in metaverse-style environments. A survey of 251 university students found that Metaverse Technologies (MT) "positively enhance student engagement," with higher motivation mediating improvements in academic outcomes (e.g., 68 % of respondents reporting increased focus) [10]. An experimental study in higher education similarly showed that, although test scores did not always rise immediately, students in Metaverse sessions demonstrated "heightened levels of engagement and creativity," often exploring tasks more deeply and experimenting with novel problem-solving approaches [11]. In secondary settings, a quantitative trial with 52 Mexican high-schoolers measured motivation across four dimensions–attention, relevance, satisfaction, and confidence–and found statistically significant gains ($p < .05$) in all areas after implementation of VR modules compared to

International Journal of Research and Applied Technology

3(2)(2023) 391-398

Journal homepage: https://ojs.unikom.ac.id/index.php/injuratech

traditional instruction [12]. Together, these studies suggest that the immersive, gamified, and interactive nature of metaverse platforms can draw in learners more effectively than many standard e-learning tools.

The metaverse also fosters richer peer interaction. In STEM subjects like maintenance and mathematics, students using a metaverse platform outperformed control groups on collaborative problem-solving tasks, reporting clearer role-sharing and more equitable participation in group work [13]. Moreover, gamified scenarios within the metaverse encourage "individualized and enjoyable tasks" that prompt learners to co-construct knowledge–74 % of participants in one survey agreed that these environments made them feel part of a community, compared to only 45 % in non-immersive settings [14]. Language learners similarly benefited: a quasi-experimental study with 86 Turkish high-school English students found that the metaverse boosted both vocabulary retention and "social presence," with learners reporting a stronger sense of belonging and peer support when interacting via avatars [15]. These findings highlight the potential for metaverse tools to break down geographical and social barriers, enabling more dynamic teamwork and communication.

Despite pedagogical gains, access remains uneven. A Brookings analysis showed that during the pandemic, 24 % of teens in households earning <$30 k and 25 % of Black teens couldn't finish homework due to device or connectivity issues, compared to 9 % of higher-income teens. In higher education, roughly one-third of low-income students and 25 % of all undergraduates report unreliable internet, seriously hampering AR/VR participation; as reported by EdTech Magazine. Even when institutions provide equipment, awareness is low: at one U.S. university, 87 % of students didn't know about on-campus VR lending programs, and 86 % were unaware of off-campus options; as reported by Georgia Institute of Technology. And while Meta's donation of 300 Quest 2 headsets to 15 universities aimed to broaden access, many schools still cite the high cost of headsets and maintenance as barriers to scaling immersive programs; as reported by Axios Newsletter.

Growing immersion brings new risks. Privacy and data-security worries top the list: reviews identify "significant ethical considerations, including privacy concerns, data security risks, and the widening digital divide" as urgent issues in educational metaverses. Physiological side-effects–cybersickness, eyestrain, and occasional overheating of headsets–were reported by 30 % of users in classroom pilots, sometimes forcing lesson pauses. Mental-health impacts also emerge: preliminary reviews warn of potential addiction, dissociation (blurring of virtual/reality boundaries), and harassment in avatar-based spaces, particularly for vulnerable students. Pediatric experts caution that younger learners may face dizziness, disorientation, or exposure to harmful content without tight supervision. Addressing these concerns will require robust ethical frameworks, clear privacy protections, and ongoing monitoring of student well-being.

3.2 Teacher/Lecturer Side

A phenomenological study of 32 Turkish teachers found unanimous agreement that "integration of metaverse technology into education and training processes will increase the quality, efficiency and permanence of this process [16]. Likewise, a survey of 20,876 Russian educators reported that immersive technologies spurred "innovative teaching approaches, education cost reduction, and increased access to open educational resources," with 88 % of respondents having at least basic VR/AR experience [17]. Together, these findings suggest

International Journal of Research and Applied Technology

3(2)(2023) 391-398

Journal homepage: https://ojs.unikom.ac.id/index.php/injuratech

teachers view the metaverse as a powerful medium for designing experiential, student-centered lessons that transcend traditional classroom constraints.

Despite strong interest, significant barriers persist. In the Russian study, 78.14 % of teachers agreed that VR "requires extra resources, time and effort" (Mean = 3.98, SD = 1.02) and 65.44 % felt VR "makes classroom management more difficult" (Mean = 3.62, SD = 1.08) [17]. Similarly, a qualitative case study of 36 Ghanaian pre-service teachers highlighted limited infrastructure, unreliable internet connectivity, and insufficient access to VR hardware as critical obstacles in resource-limited settings [18]. These challenges underscore the need for substantial institutional investment in both technology and support.

Adoption remains in its early stages: 71.7 % of Russian educators were at the awareness, learning, or understanding phases of VR integration, with fewer than 10 % regularly applying it in creative ways [17]. Teachers report that facilitating immersive experiences requires new skill sets—they must design interactive simulations, moderate avatar interactions, and troubleshoot technical issues on the fly, effectively doubling as both educator and IT support [18]. This role expansion increases workload and highlights the urgency of targeted professional development.

The shift to virtual environments brings novel ethical duties. A systematic review identifies "privacy concerns, data security risks, the widening digital divide, user safety, intellectual property rights, and the ethical use of AI" as critical challenges educators must navigate in metaverse settings. Furthermore, as AI-driven teacher avatars emerge, experts recommend embedding "privacy, ethics and security by design" processes and providing comprehensive training to ensure safe, transparent avatar-based interactions; as reported by 9ine News. Addressing these responsibilities will require clear institutional policies, cross-sector collaboration, and continuous teacher support to safeguard student well-being in virtual classrooms.

4. Conclusion

This study shows that while metaverse-based learning markedly boosts student engagement and collaboration—with 68 % of learners reporting greater focus and motivation and statistically significant gains in attention, relevance, satisfaction, and confidence ($p < .05$)—it is constrained by digital-divide issues affecting up to 25 % of low-income students and raising privacy and well-being concerns. For teachers, immersive technologies unlock innovative, experiential pedagogies embraced by 88 % of educators, yet over 78 % report increased workload, resource demands, and classroom-management challenges. Sustainable, scalable adoption therefore hinges on coordinated investments in hardware and connectivity, robust professional-development programs, equity-focused access policies, and comprehensive ethical frameworks to safeguard data security and mental health—laying the foundation for inclusive, impactful digital education in the metaverse.

References

[1] Mahdi, M. F. (2023). The Role of IT in Transforming Traditional Education to Digital Learning. *International Journal of Computational & Electronic Aspects in Engineering (IJCEAE)*, *4*(4).

[2] Camilleri, M. A., & Camilleri, A. C. (2022). The acceptance of learning management systems and video conferencing technologies: Lessons learned from COVID-19. *Technology, Knowledge and Learning*, *27*(4), 1311-1333.

International Journal of Research and Applied Technology

3(2)(2023) 391-398

Journal homepage: https://ojs.unikom.ac.id/index.php/injuratech

[3] Almusharraf, A. I. (2024). An Investigation of University Students' Perceptions of Learning Management Systems: Insights for Enhancing Usability and Engagement. *Sustainability*, *16*(22), 10037.

[4] Rojas, E., Hülsmann, X., Estriegana, R., Rückert, F., & Garcia-Esteban, S. (2023). Students' perception of metaverses for online learning in higher education: Hype or hope?. *Electronics*, *12*(8), 1867.

[5] Li, M., & Yu, Z. (2023). A systematic review on the metaverse-based blended English learning. *Frontiers in Psychology*, *13*, 1087508.

[6] Tlili, A., Huang, R., Shehata, B., Liu, D., Zhao, J., Metwally, A. H. S., ... & Burgos, D. (2022). Is Metaverse in education a blessing or a curse: a combined content and bibliometric analysis. *Smart Learning Environments*, *9*(1), 1-31.

[7] Zhang, X., Chen, Y., Hu, L., & Wang, Y. (2022). The metaverse in education: Definition, framework, features, potential applications, challenges, and future research topics. *Frontiers in Psychology*, *13*, 1016300.

[8] Zallio, M., & Clarkson, P. J. (2022). Designing the metaverse: A study on inclusion, diversity, equity, accessibility and safety for digital immersive environments. *Telematics and Informatics*, *75*, 101909.

[9] Dindar, M., Suorsa, A., Hermes, J., Karppinen, P., & Näykki, P. (2021). Comparing technology acceptance of K-12 teachers with and without prior experience of learning management systems: A Covid-19 pandemic study. *Journal of computer assisted learning*, *37*(6), 1553-1565.

[10] Youssef, E., Al Malak, M., & Bayoumy, M. (2025). Metaverse in Education: A Survey-Based Investigation of Collaborative Learning and Immersive Experiences. *Emerging Science Journal*, *8*, 379-395.

[11] Luo, H., Li, X., Zhang, J., Zhang, F., Liang, J., & Yin, X. (2024, July). Metaverse improves the learning experiences rather than learning outcomes: Evidence from an experimental study in higher education. In *2024 International Symposium on Educational Technology (ISET)* (pp. 217-222). IEEE.

[12] Portuguez-Castro, M., & Santos Garduño, H. (2024). Beyond traditional classrooms: Comparing virtual reality applications and their influence on students' motivation. *Education Sciences*, *14*(9), 963.

[13] Maghaydah, S., Al-Emran, M., Maheshwari, P., & Al-Sharafi, M. A. (2024). Factors affecting metaverse adoption in education: A systematic review, adoption framework, and future research agenda. *Heliyon*.

[14] BenedettDörr, J., & BeatrysRuizAylon, L. (2023, September). A survey on the Metaverse aspects and opportunities in education. In *2023 International Conference on Intelligent Metaverse Technologies & Applications (iMETA)* (pp. 1-8). IEEE.

[15] Çelik, F., & Baturay, M. H. (2024). The effect of metaverse on L2 vocabulary learning, retention, student engagement, presence, and community feeling. *BMC psychology*, *12*(1), 58.

[16] Semerci, N., Sag, M., & Özçelik, C. (2024). Examination of Teachers' Views on Metaverse-Based Education. *Journal of Interdisciplinary Studies in Education*, *13*(1), 30-54.

[17] Khukalenko, I. S., Kaplan-Rakowski, R., An, Y., & Iushina, V. D. (2022). Teachers' perceptions of using virtual reality technology in classrooms: A large-scale survey. *Education and Information Technologies*, *27*(8), 11591-11613.

[18] Nyaaba, M., Akanzire, B. N., & Nabang, M. (2024). Virtual Reality in Teacher Education: Insights from Pre-Service Teachers in Resource-limited Region. *arXiv preprint arXiv:2411.10225*.