

METaverse-BASED EDUCATION AND STUDENT ENGAGEMENT IN FUTURE LEARNING SPACES

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Abstract

This study aims to analyze the role of metaverse-based education in enhancing student engagement and to identify the factors influencing learner engagement in future learning spaces. The research employs a literature review approach, examining various scholarly publications regarding the metaverse in education, student engagement, immersive learning, digital social interaction, and the transformation of learning spaces. The findings indicate that metaverse implementation can foster student engagement by enhancing interactivity, immersive learning experiences, collaboration, personalized learning, and opportunities for simulation within virtual environments. However, the effectiveness of its implementation is influenced by factors such as technological infrastructure readiness, the digital competence of educators and learners, the quality of instructional design, accessibility, data security, and the potential for digital fatigue and the digital divide. Thus, metaverse-based education serves not merely as a technological medium but as a component of a future learning ecosystem that prioritizes learner experience, interaction, collaboration, and engagement. A pedagogically oriented implementation supported by institutional readiness is essential to ensure that the use of the metaverse delivers meaningful, inclusive, and sustainable learning experiences.

Keywords: Metaverse-Based Education, Student Engagement, Future Learning Space, Immersive Learning, Digital Learning, Educational Technology.

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INTRODUCTION

Rapid advancements in digital technology have brought about fundamental changes across various aspects of life, including the delivery of education. Learning environments are no longer confined to physical classrooms; instead, they are evolving into digital spaces that enable learners to engage in flexible, interactive, and collaborative learning experiences (Sripan & Jeerapattanatarn, 2025a). This transformation is accelerating alongside the development of virtual reality, augmented reality, artificial intelligence, cloud computing, and various digital learning platforms. These changes compel educational institutions not only to adopt technology as a tool for content delivery but also to redesign learning experiences to align with learner characteristics and future competency demands (Yeganeh et al., 2025a). In this context, the concept of "future learning spaces" has become increasingly relevant, as it prioritizes flexibility, interactivity, collaboration, creativity, and learner engagement as integral components of the learning process.

One technological development gaining attention in the educational sphere is the metaverse (Buragohain et al., 2026a). The metaverse can be understood as a digital environment that allows users to interact within a virtual space via digital representations—or avatars—and engage in various activities in a more immersive manner (Dreamson & Park, 2023). In an educational context, the metaverse has the potential to create learning environments distinct from conventional online systems; learners do not merely receive information through a screen but can interact with virtual objects, simulated environments, educators, and fellow learners. This creates opportunities for more contextual learning experiences and enables activities that would be difficult to realize through text- or video-based learning alone. Metaverse-based learning can also be utilized to provide virtual laboratories, professional simulations, visits to physically inaccessible locations, and collaborative activities within digital spaces (Singh et al., 2024).

This potential is closely linked to the concept of student engagement. Learner engagement is a crucial aspect of successful learning, as it relates to the extent to which learners pay attention, participate, interact, and connect with learning activities. Engagement encompasses not only physical activity but also cognitive and emotional dimensions. Highly engaged learners tend to be more active in exploring material, interacting with the learning environment, completing tasks, and constructing understanding through the provided learning experiences (Buragohain et al., 2023). Therefore, the development of educational technology should be directed not merely toward increasing access

to learning materials but also toward creating conditions that foster deeper learner engagement.

Metaverse-based education offers characteristics that can potentially foster such engagement. Interactive virtual environments provide learners with opportunities for direct exploration, simulation, problem-solving, and collaboration. The use of avatars can also create forms of social interaction distinct from those found in video-conferencing-based online learning (Al-kfairy et al., 2024). Learners can communicate, work in groups, manipulate virtual objects, and complete learning activities within environments designed to resemble real-world situations or imaginative settings. Such experiences can broaden experiential learning approaches and allow learners to construct knowledge through more active engagement. Consequently, the metaverse has the potential to strengthen the behavioral, cognitive, and emotional dimensions of learner engagement, provided it is designed with clear pedagogical objectives (Al-kfairy et al., 2024).

However, the use of the metaverse in education does not automatically result in higher levels of learning engagement. While immersive technology offers novel experiences, its success depends on the quality of instructional design and user readiness. Complex virtual environments may prove ineffective if learning activities lack clear objectives or are overly focused on entertainment. Learners require digital literacy skills to use the technology productively, while educators need the competence to design learning activities suited to the characteristics of virtual environments. Furthermore, limitations regarding hardware, internet connectivity, implementation costs, accessibility, and the digital divide can hinder the widespread adoption of the metaverse. Issues concerning data security, user privacy, and physical and psychological comfort during the use of immersive devices also require attention in the development of metaverse-based learning ecosystems.

These issues indicate that discussions regarding the metaverse in education must be viewed from a broader perspective. The metaverse is not merely a matter of adopting new technology; it concerns how that technology is integrated into learning strategies, pedagogical interactions, and educational environments. Utilizing technology without corresponding changes in pedagogical approaches risks creating virtual spaces that simply replicate conventional learning activities within a digital environment. Conversely, a pedagogically designed metaverse integration can offer opportunities to develop learning that is more adaptive, collaborative, contextual, and learner-experience-oriented (Mustafa, 2022). Therefore, it is essential to understand

the relationship between the characteristics of metaverse technology and the various factors that shape student engagement.

Given this context, a study on "Metaverse-Based Education and Student Engagement in Future Learning Spaces" is crucial for understanding how metaverse-based learning environments can contribute to student engagement, while also identifying the conditions that either facilitate or constrain their implementation. This study aims to examine the interconnections among interactivity, immersive experiences, collaboration, personalization, digital competence, infrastructure readiness, pedagogical design, and aspects of security and accessibility in shaping the student learning experience. A comprehensive understanding of these aspects is necessary to ensure that metaverse implementation goes beyond mere technological adoption and genuinely delivers pedagogical value.

Thus, this research focuses on analyzing the role of metaverse-based education in supporting student engagement within future learning spaces. The study aims to provide conceptual insights into the opportunities and challenges of utilizing the metaverse in education and to reinforce the perspective that successful digital learning transformation depends on the alignment of technology, pedagogy, users, and the institutional environment. Furthermore, the findings are expected to serve as a foundation for educators and educational institutions in designing future learning environments that are more interactive, collaborative, and inclusive, and that prioritize meaningful learning experiences.

RESEARCH METHODS

This study employs a literature review approach to comprehensively analyze the relationship between metaverse-based education, student engagement, and the development of future learning spaces. Research data were gathered from various relevant scholarly sources—including national and international journal articles, conference proceedings, and academic publications—addressing the metaverse in education, immersive learning, student engagement, educational technology, and the transformation of learning environments. The review process involved identifying the topic, searching for and selecting literature based on its relevance to the research focus, conducting a content analysis of prior research findings, and synthesizing results to identify patterns, opportunities, challenges, and interconnections between concepts. The selected literature was evaluated based on thematic alignment, contribution to the discussion, and source credibility. A descriptive-

qualitative analysis was performed by categorizing findings into aspects such as interactivity, immersive experiences, collaboration, personalized learning, digital competence, infrastructure readiness, accessibility, data security, and pedagogical design. The synthesized results were then used to construct an integrative understanding of how metaverse utilization can foster student engagement and contribute to the creation of future learning spaces that are interactive, adaptive, inclusive, and oriented toward meaningful learning experiences.

RESULTS AND DISCUSSION

The Role of Metaverse-Based Education in Enhancing Student Engagement

Metaverse-based education transforms learning interaction patterns by creating virtual environments that enable learners to participate more actively in the learning process (Muthmainnah et al., 2023). Unlike conventional digital learning, which typically positions learners as passive recipients of information via text, video, or online conferences, the metaverse environment offers opportunities for direct interaction with virtual objects, simulated environments, educators, and fellow learners. These characteristics can strengthen student engagement, as learners gain experiences that require direct involvement, exploration, and decision-making. In this context, metaverse technology serves not merely as a medium for delivering content but as an environment that facilitates more active and contextual learning experiences (Sripan & Jeerapattanatorn, 2025b).

Interactivity is a key characteristic that supports student engagement. Virtual environments allow learners to engage in various activities, such as manipulating objects, exploring spaces, participating in simulations, and communicating with other users. Such activities can boost behavioral engagement by encouraging learners to take a direct part in the learning process. When learning activities are designed as tasks requiring exploration and problem-solving, learners do more than simply follow an educator's instructions; they also have the scope to determine their own actions and receive feedback from the virtual environment. Consequently, participation can evolve from mere attendance into active engagement in completing the assigned learning experience (Mukred et al., 2025).

Immersive experiences also play a crucial role in fostering cognitive and emotional engagement. Metaverse environments can present learning situations that mirror real-world conditions, allowing abstract concepts to be learned through more concrete experiences (Muhammad et al., 2025). Virtual

spaces can be developed to host laboratory simulations, historical settings, professional workspaces, or various problem-solving scenarios, giving learners the opportunity to connect knowledge with its practical application. Such experiences have the potential to heighten learners' attention and curiosity while encouraging deeper cognitive processing (Alfaisal et al., 2024a). However, the level of immersion must be aligned with learning objectives, as excessive visual and interactive elements—lacking pedagogical direction—can distract from the core subject matter.

Beyond interactivity and immersion, the metaverse's capacity to provide collaborative spaces can strengthen the social dimension of student engagement. Learners can collaborate in groups, engage in discussions, complete projects, and interact via avatars within a shared virtual environment. These interactions foster communication and a sense of connection to the learning environment (Liu et al., 2025). Collaboration also encourages learners to exchange ideas and develop their communication and collective problem-solving skills. In collaboratively designed learning experiences, the metaverse serves as a social space that extends learning interactions beyond the confines of the classroom and geographical boundaries.

Personalizing learning is another aspect with the potential to strengthen learner engagement. Digital environments enable learning activities and resources to be tailored to the needs, abilities, and characteristics of learners (Çelik & Baturay, 2024). Learners can be given the opportunity to explore material at their own pace, select relevant activities, or engage in learning experiences suited to their level of understanding. Such flexibility can foster a sense of ownership over the learning process, as learners have the scope to participate in shaping their own learning experiences. However, personalization requires well-planned instructional design to ensure that the freedom to explore remains directed toward achieving established competencies (Munadi et al., 2026).

The Metaverse as Interactive, Adaptive, and Collaborative Future Learning Spaces

Digital transformation in education has reshaped the understanding of learning spaces. Learning spaces are no longer viewed merely as physical classrooms where educators and learners meet at the same time and place; instead, they have evolved into digital environments that enable flexible learning processes (Onu et al., 2024a). The development of the metaverse extends this transformation by introducing future learning spaces—virtual

environments where users interact via avatars, explore digital objects, conduct simulations, and communicate within spaces designed to either mirror or transcend real-world conditions. These virtual spaces offer educational institutions the opportunity to create more dynamic learning experiences and to integrate various learning resources, activities, and interactions into a single digital environment (Yeganeh et al., 2025b).

Interactivity is a key characteristic distinguishing the metaverse from conventional online learning spaces. In metaverse-based learning, students can directly engage with the learning environment and objects through exploration and simulation activities. Concepts previously studied only through images, text, or video can be visualized in three-dimensional environments, giving students the chance to grasp material through firsthand experience. Simulations also enable learning in situations that mimic real-world conditions without the constant need for complex physical facilities (Damaševičius & Sidekerskienė, 2024a). In fields such as science, health, engineering, and vocational education, simulated environments can provide virtual practical experience before students encounter actual situations. Thus, the metaverse expands the scope for experimentation and learning experiences while offering an alternative to the limitations of physical space.

Adaptability is another crucial characteristic in the development of future learning spaces. Virtual environments can be designed to tailor learning activities to the goals, characteristics, and needs of the learners (Illi & Elhassouny, 2025a). This flexibility allows for the development of diverse learning scenarios within a single digital environment. Learners have the opportunity to explore material based on their level of understanding and learning pace, while educators can design activities that offer varied experiences tailored to the competencies they wish to develop. Adaptive learning spaces also enable the integration of diverse digital resources, ensuring the learning process is not reliant on a single form of media. However, adaptability still requires careful pedagogical planning to ensure that the flexibility of the virtual environment does not cause learners to lose direction in achieving their learning objectives (Joshi & P.j, 2023a).

Metaverse also has the potential to strengthen the collaborative dimension of education. Virtual environments can bring together students and educators who are in different geographical locations in the same digital space. Interaction via avatars allows students to have discussions, complete projects together, share virtual objects, and build learning experiences collectively. Collaboration across locations can expand students' opportunities to interact

with individuals from different backgrounds and develop communication and collaboration skills (Buragohain et al., 2026b). In the context of future education, this ability becomes important because the learning and work process increasingly involves collaboration through digital environments. Thus, the metaverse can function not only as a space for conveying knowledge, but also as a social space for developing interpersonal competence.

Experience-based learning is becoming increasingly possible through the integration of simulation and interaction in metaverse environments. Students can gain experience by carrying out activities directly, making decisions, facing certain scenarios, and evaluating the consequences of actions taken in a virtual environment. This approach can help connect theoretical concepts with applied situations so that learning becomes more contextual. Virtual experiences can also be used to present conditions that are difficult to realize in the classroom, such as exploration of certain environments, simulations of professional work, or reconstructions of events and places that have educational value. With the right design, these experiences can support the development of critical thinking skills, creativity, problem solving, communication, and collaboration (AbuKhousa et al., 2023).

Even though it offers various opportunities, the development of the metaverse as a future learning space still requires considering infrastructure readiness, digital competence, accessibility and learning design. Sophisticated virtual spaces will not provide optimal benefits if students and educators do not have sufficient abilities to use them or if access to devices and networks is still limited (Alfaisal et al., 2024b). Therefore, the transformation towards future learning spaces needs to be carried out in stages by considering pedagogical needs and institutional conditions. Metaverse should be positioned as part of a learning ecosystem that complements physical spaces and online learning, not merely as a replacement for both. Balanced integration allows educational institutions to take advantage of the advantages of virtual spaces while maintaining the value of direct interactions that remain important in the educational process.

Thus, the metaverse has the potential to become a form of future learning space that combines interactivity, adaptivity, collaboration and experience-based learning in a digital environment. This transformation provides opportunities for education to develop learning spaces that are more flexible and not limited by geographic location. However, the success of its implementation is largely determined by the suitability of technology with pedagogical goals, readiness of human resources, availability of infrastructure,

as well as attention to accessibility and user experience. When these various aspects are developed in an integrated manner, the metaverse can support the formation of a future learning environment that is not only oriented towards the use of technology, but also towards developing student competencies that are relevant to the demands of society and an increasingly digitalized world of work.

Challenges and Strategies for Metaverse Implementation in Sustainable and Inclusive Education

Implementing the metaverse in education offers opportunities to create more interactive, immersive, and collaborative learning experiences; however, its adoption also faces various challenges that require systematic attention (Onu et al., 2024b). One major challenge concerns the readiness of technological infrastructure. Metaverse environments require devices with specific capabilities, stable internet connections, adequate computing power, and platforms capable of optimally supporting virtual interactions. Disparities in infrastructure conditions across educational institutions can lead to inconsistent learning experience quality. Institutions with limited devices and network capabilities may struggle to integrate the metaverse into their learning processes (Yeganeh et al., 2025c). Therefore, implementing this technology requires an initial assessment of infrastructure readiness and a phased development of facilities tailored to each institution's needs and capabilities.

Beyond infrastructure, the digital competence of educators and learners is a crucial factor in the successful implementation of metaverse-based education. Educators need more than just the technical skills to operate platforms; they must also understand how to design learning activities suited to the characteristics of virtual environments. Using the metaverse without a sound pedagogical design risks allowing the technology to overshadow the actual learning objectives (Damaševičius & Sidekerskienė, 2024b). Learners also need the ability to adapt to virtual environments, manage digital interactions, and use technology responsibly. Consequently, strengthening digital competence requires continuous training that integrates technical and pedagogical aspects, digital ethics, and the management of learning experiences. Such an approach helps ensure that technology serves as a means to achieve educational goals rather than merely acting as a technological novelty (Illi & Elhassouny, 2025b).

Cost is another critical consideration in the development of metaverse-based education. Procuring devices, developing or licensing platforms,

maintaining systems, upgrading networks, and training human resources can entail significant investment. This situation can pose a challenge, particularly for educational institutions with limited resources. Implementation strategies should prioritize efficiency by adopting technology gradually and focusing on learning needs that offer the greatest benefits. Institutions might develop learning models that utilize relatively accessible devices before transitioning to higher-specification immersive technologies. Collaboration among the government, educational institutions, technology developers, and industry stakeholders offers another avenue for expanding infrastructure and resource support (Joshi & P.j, 2023b).

Another challenge concerns accessibility and the digital divide. Not all learners possess the necessary devices, internet connectivity, or environmental conditions to support the use of metaverse technology (Buragohain et al., 2026c). Failure to address these factors could lead to the metaverse creating new disparities in access to learning experiences. Consequently, the principle of inclusivity must be integrated into the implementation design from the outset. The development of platforms and learning activities needs to account for varying user capabilities, economic circumstances, device limitations, and the diverse needs of learners. Providing alternative access methods such as using different devices or non-immersive supporting materials alongside flexible participation options, can help mitigate barriers for learners unable to fully utilize metaverse technology (Alfaisal et al., 2024c).

Data security and privacy are also critical concerns, as the metaverse environment facilitates the exchange of various types of user information. Learner activities within virtual spaces can generate interaction data, digital identities, usage patterns, and other information that requires responsible management. Educational institutions must establish clear policies regarding the collection, storage, usage, and protection of user data. Educators and learners also require education on digital security so they can understand the risks associated with virtual interactions. Furthermore, the selection of platforms must take into account security mechanisms, access rights management, data usage transparency, and compliance with applicable data protection regulations (Jovanović & Milosavljević, 2022).

Intensive use of virtual environments also necessitates attention to the comfort and sustainability of the learning experience. Prolonged use of immersive devices can lead to digital fatigue and diminish the quality of learners' concentration. Therefore, instructional design should balance the duration of virtual activities and integrate them with other learning activities.

The metaverse need not be utilized at every stage of learning; rather, it can be applied to activities that derive genuine added value from the virtual experience such as simulations, exploration, practical exercises, and collaboration. This approach enables a more targeted use of technology while mitigating the risks associated with excessive usage.

CONCLUSION

Literature reviews indicate that metaverse-based education has the potential to enhance student engagement by fostering learning environments that are interactive, immersive, collaborative, and adaptive. Utilizing the metaverse enables learners to engage in virtual exploration, participate in simulations, interact with learning objects, collaborate with peers, and gain more contextualized learning experiences. These characteristics can foster student engagement across behavioral, cognitive, and emotional dimensions. From the perspective of future learning spaces, the metaverse expands the concept of the learning environment by bridging physical and digital experiences and enabling learning activities to occur without geographical constraints. However, realizing these benefits depends heavily on the alignment between technology, learning objectives, pedagogical design, and learner needs.

Implementing the metaverse in education also presents challenges, including infrastructure readiness, digital competence, technology costs, accessibility, the digital divide, data security and privacy, and the risk of digital fatigue. Therefore, the development of metaverse-based education should proceed incrementally, focusing on strengthening institutional readiness, the digital competence of educators and learners, and pedagogically sound learning designs, alongside robust data protection mechanisms and inclusive access strategies. The metaverse should be positioned as a component of the learning ecosystem that complements—rather than merely replaces—physical and online learning spaces. With proper management, the metaverse can serve as a key approach to creating future learning environments that are meaningful, inclusive, adaptive, and sustainable, while supporting the development of learner competencies to meet the demands of an increasingly digitalized educational landscape and society.

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