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PAPER

3D Virtual Worlds as Educational Spaces: Analysis of Uses and Affordances

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ABSTRACT

A systematic literature analysis on integration of three-dimensional virtual platforms, augmented reality, virtual reality, and metaverse in educational contexts was conducted. Twenty publications were examined to identify technological characteristics, pedagogical affordances, and educational potential. Publications focused predominantly on higher education, with additional representation across secondary education and multiple disciplinary contexts. Findings revealed that, when integrated within coherent pedagogical designs, 3D virtual platforms generated improvements in critical thinking, creativity, communication, collaboration, memory retention, and problem solving, though outcomes were not uniformly positive across all interventions. Teacher training, contextualized pedagogical design, quality of technological infrastructure, and continuous evaluation were identified as critical factors. Limitations included eye strain, mental exhaustion, and privacy concerns. This study provides evidence on conditions necessary for effective integration of immersive virtual environments in education and suggests directions for future research on collaborative learning, equity of access, and long-term impact of these interventions.

KEYWORDS

virtual worlds, virtual reality, augmented reality, immersive education

1 INTRODUCTION

Digital transformation of educational systems has positioned three-dimensional virtual platforms as catalysts for pedagogical innovation. Over the past two decades, the accelerated development of immersive technologies has generated new possibilities for creating learning experiences that transcend the limitations of the traditional physical classroom. These include virtual reality, augmented reality, virtual worlds, and more recently, the educational metaverse, each with specific characteristics and possibilities that can enhance different aspects of the educational process.

Specialized literature documents multiple experiences of implementing 3D virtual environments in education, ranging from immersive simulations for professional

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training to collaborative spaces for the development of transversal competencies. These technologies promise to revolutionize medical education, engineering, natural sciences, and virtually all academic disciplines by creating experiences that would be impossible, dangerous, or excessively costly in physical environments. However, questions persist regarding the optimal conditions for their effective integration, the factors that determine their impact on learning outcomes, and the most appropriate methodologies for evaluating their effectiveness, alongside broader concerns about formative justice and the ethical dimensions of digitally mediated education [1].

Contemporary context is particularly conducive to this analysis. The COVID-19 pandemic dramatically accelerated the adoption of digital resources in education and generated a critical mass of documented experiences on remote teaching and virtual learning environments. This historical juncture has provided valuable evidence on the possibilities and limitations of technology-mediated education, as well as on the digital competencies necessary for students and teachers in the 21st century.

This study arises from the need to synthesize the knowledge generated in recent literature on the integration of 3D virtual platforms in educational processes. Its main objective was to systematically analyze the integration of 3D virtual platforms in educational processes. Four research questions guided the analysis: (RQ1) What are the technological characteristics of immersive platforms used in educational contexts? (RQ2) What pedagogical uses and instructional models predominate in their implementation? (RQ3) What learning outcomes have been documented across cognitive, affective-motivational, and collaborative domains? (RQ4) What contextual factors influence the effectiveness of these interventions? A central hypothesis maintains that effective integration of immersive technologies in education depends not only on the technical characteristics of the platforms, but fundamentally on their articulation with contextualized pedagogical designs, teacher training processes, and continuous evaluation strategies that consider both benefits and limitations of these environments.

2 METHODOLOGICAL DESIGN

A systematic literature analysis on the integration of 3D virtual platforms, augmented reality, virtual reality, and the metaverse in educational contexts was developed. The bibliographic search was conducted in Google Scholar, Scopus, Web of Science, SciELO, Redalyc, and ERIC, using terms such as virtual reality education, augmented reality learning, educational metaverse, 3D virtual worlds, immersive virtual platforms, and serious games education in both Spanish and English.

Inclusion criteria were: (a) publications between 2018 and 2024; (b) explicit and reproducible methodology; (c) documented analysis of implementations or reviews of immersive technologies in education; (d) diversity of educational levels and disciplines. Excluded were: purely speculative works without evidence analysis, articles with insufficient methodological information, and duplicate publications. The final selection included twenty publications that provided diverse representation of technologies, disciplines, educational levels, and geographic contexts.

The analysis was structured across four dimensions: (1) methodological characteristics of the research; (2) implemented technologies and pedagogical models; (3) results according to impact domains (cognitive, affective-motivational, procedural, collaborative, metacognitive); (4) contextual factors, limitations, and challenges. Thematic content analysis was used, identifying recurring patterns and determinants of effectiveness. Table 1 synthesizes the twenty studies analyzed.

Table 1. Synthesis of analyzed publications on 3D virtual platforms in education

Lead Author	Year	Title	Technological Focus	Study Type	Scope
Sosa Alonso	2023	Plataformas Digitales Educativas y Justicia Formativa	Digital educational platforms	TMP	ML; Gen
Cano-Vásquez	2023	Perspectivas de los estudiantes sobre experiencias de aprendizaje en curso virtual y MOOC	Virtual courses and MOOCs	EMP	HE; Gen
Ferrante	2023	Plataformas Educativas: Usos y Desafíos en la Escuela Postdigital. Un Estudio en Escuelas Secundarias de la Ciudad de Buenos Aires	Post-digital educational platforms	EMP	K-12; Gen
Briceño Toledo	2020	Modelo de gestión educativa para programas en modalidad virtual de aprendizaje	Virtual program management	TMP	HE; Gen
Bautista	2020	Evaluación de satisfacción de los estudiantes sobre las clases virtuales	Virtual classes	EMP	HE; Eng
Bonilla Torres	2023	Estrategias didácticas y pedagógicas, modelos pedagógicos y herramientas tecnológicas en educación superior mediada por TIC	ICT pedagogical strategies	SR	HE; Gen
Acıkgul Fırat	2020	Web 3.0 In Learning Environments: A Systematic Review	Web 3.0 technologies	SR	ML; Gen
Guillén-Yparrea	2023	Framework of virtual platforms for learning and developing competencies	Virtual platforms for competencies	SR	HE; Gen
Damaševičius	2024	Virtual worlds for learning in metaverse: A narrative review	Educational metaverse	LR	ML; Gen
Wang	2018	Critical review of virtual reality in construction engineering education	Virtual reality in engineering	SR	HE; Eng
Kye	2021	Educational applications of metaverse: possibilities and limitations	Metaverse applications	LR	ML; Gen
Dávila-Morán	2024	Enseñanza virtual de la Educación Física durante la pandemia del COVID-19: una revisión sistemática	Virtual physical education	SR	ML; PE
Bermejo	2023	AR/VR Teaching-Learning Experiences in Higher Education Institutions (HEI): A Systematic Literature Review	Augmented and virtual reality	SR	HE; Gen
Nesenbergs	2021	Use of Augmented and Virtual Reality in Remote Higher Education: A Systematic Umbrella Review	AR/VR in higher education	SR	HE; Gen
Gorbanev	2018	A systematic review of serious games in medical education: quality of evidence and pedagogical strategy	Serious games in medicine	SR	HE; Med
Kuhail	2022	Exploring Immersive Learning Experiences: A Survey	Immersive learning	SR	ML; STEM
Pineda-Martínez	2023	Impact of Video Games, Gamification, and Game-Based Learning on Sustainability Education in Higher Education	Gamification for sustainability	SR	HE; Sust
van der Meer	2023	Virtual reality and collaborative learning: a systematic literature review	Collaborative virtual reality	SR	ML; Gen
Bisswang	2023	What is Your VR Use Case for Educational Like: A State-of-The-Art Taxonomy	Taxonomy of VR educational uses	TMP	ML; Gen
Lewis	2024	From static web to metaverse: reinventing medical education in the post-pandemic era.	Metaverse in medical education	LR	ML; Med

Notes: Study Type: EMP = Empirical study (primary data collection through surveys, experiments, or case studies); SR = Systematic review (literature synthesis with explicit, replicable search methodology); LR = Literature review (narrative, critical, or exploratory synthesis without systematic methodology); TMP = Theoretical-methodological proposal (development of models, taxonomies, or frameworks). *Scope* (Educational Level; Discipline): Educational Level—K-12 = Primary and/or secondary education; HE = Higher education; ML = Multiple levels or not level-specific. Discipline—Med = Medical education; Eng = Engineering; STEM = Science, Technology, Engineering, and Mathematics; PE = Physical education; Sust = Sustainability education; Gen = General or multidisciplinary.

3 RESULTS

3.1 Characteristics of implemented technologies

The analysis of the twenty studies revealed significant diversity in immersive technologies used in educational contexts. The platforms included immersive virtual reality through head-mounted display devices, marker-based and markerless augmented reality, virtual worlds accessible through desktop computers, and hybrid environments combining multiple technologies. These studies ranged from secondary education to higher education and specialized professional training, with a predominance of interventions in the areas of science, technology, engineering, mathematics, and medicine [2], [3], [4].

Technological evolution documented in the research showed a progression from desktop-based platforms to increasingly immersive experiences. In the field of construction engineering education, for example, the adopted technologies evolved from desktop virtual reality to immersive virtual reality, 3D game-based virtual reality, and building information modeling-enabled virtual reality [2]. This technological evolution reflects both hardware and software advances, as well as greater sophistication in understanding how these tools can be articulated with specific pedagogical objectives.

An area of particular interest was the educational metaverse. Reviewed typologies identified four fundamental categories: augmented reality, lifelogging, mirror world, and virtual reality [5], each presenting distinctive characteristics and specific possibilities for learning. Virtual worlds in the metaverse demonstrated potential for creating immersive and interactive platforms that foster deep understanding, enhance problem-solving skills, and strengthen memory retention [6].

Web 3.0 also occupied a prominent place in the analyzed research. Studies from 2005 to 2020 showed significant increases in the number of studies on Web 3.0 technologies in learning environments during 2008 and 2013. Most of these studies were experimental and focused on science education, with particular emphasis on augmented reality applications [7]. This trend suggests a growing recognition of the potential of these technologies to transform the teaching of disciplines that have traditionally depended on physical laboratories and hands-on experimentation.

3.2 Applications across different disciplines and educational levels

Diversified applications of 3D virtual platforms were documented across multiple academic disciplines. Medical education showed particular effectiveness with immersive technologies. The transition from traditional didactic methods to dynamic and interactive approaches through simulation tools and virtual reality has transformed the training of healthcare professionals [8]. The COVID-19 pandemic dramatically accelerated the adoption of e-learning and digital resources in medical education, generating evidence on the viability and effectiveness of these modalities [8].

Within the medical field, serious games represent a specific category of application. One study found moderate evidence on the effectiveness of serious games, evaluated using the MERSQI score. Behaviorism and cognitivism stood out as the predominant pedagogical strategies in game development, focusing on knowledge retention and skill development. Games functioned as complementary devices rather than replacements for traditional teaching tools, with a preference for simulations and questionnaires [9].

Virtual reality applications in construction engineering were categorized into four main areas: architectural visualization and design education, structural analysis education, construction safety training, and operational and equipment task training [2]. This diversification of applications demonstrates how the same technology can be adapted to address different learning objectives within a professional discipline.

The development of competencies through virtual educational platforms showed significant growth. The analysis of scientific evidence and trends over five years revealed an increase in registered users worldwide in 2021 due to the pandemic, as well as growth in courses available on platforms such as Coursera and edX. Computer science and education were identified as the most significant subjects, indicating a departure from traditional educational paradigms [10].

Sustainability education also benefited from game-based technologies. The analysis found that the use of technology-mediated games favors sustainability education and promotes educational inclusion and social skills such as collaborative and cooperative work. These technologies specifically promoted Sustainable Development Goal 4 on quality education [11].

In the field of physical education, the transition to virtual environments during the COVID-19 pandemic demonstrated the capacity of virtual platforms to adapt traditionally in-person disciplines. A systematic review highlighted that these platforms facilitated learning continuity through the use of emerging technologies, promoting creative teaching strategies. However, significant challenges were identified, such as the need to ensure equitable access to technological resources and to overcome obstacles related to limited direct interaction [12]. This application highlights the potential of virtual technologies to transform practical disciplines, expanding training possibilities in remote education contexts.

3.3 Impact on learning outcomes and competency development

Significant improvements in multiple dimensions of learning were evidenced in the analyzed research. Virtual worlds demonstrated effectiveness in supporting the development of critical thinking, creativity, communication, and collaboration skills. These environments provided immersive and interactive platforms that fostered deeper understanding, enhanced problem-solving skills, and strengthened memory retention [6].

In the domain of immersive learning, evaluations showed improved performance and greater student engagement. However, usability problems were also identified, indicating the need for better organization and methodological orientation. Most studies covered science, technology, engineering, and mathematics topics, using virtual reality through head-mounted display devices and marker-based augmented reality, with a focus on active learning and interactive tasks [3].

The application of augmented reality and virtual reality improved learning immersion, especially in hospitality, medicine, and science studies. Experiences with these technologies were most commonly used in undergraduate programs and focused on enhancing student learning experiences [4]. Nevertheless, negative effects such as visual exhaustion and mental fatigue associated with prolonged use were also identified [4].

In remote higher education, an umbrella review synthesizing nine systematic reviews [13] extracted thirty interventions using AR and VR technologies—including VR simulations, virtual laboratories, and immersive environments—predominantly in medical education (six of nine reviewed papers), with additional applications in engineering, physics, and chemistry. Of 24 interventions measuring student performance, eleven yielded positive results, seven negative, and six showed no effect; negative outcomes were consistently associated with insufficient teacher preparation or cognitive overload from complex AR simulations. All six interventions measuring engagement reported positive effects, though the authors attribute this consistency partly to the novelty of the technology. Remote practice, laboratories, and kinesthetic learning accounted for the largest share of interventions (89% of reviewed articles), with particularly encouraging results in medicine-related training.

Collaborative learning mediated by virtual reality demonstrated particular effectiveness. Five categories of skills and competencies developed through virtual reality for collaborative learning were identified. Educational fields showed interest in this modality for innovation, community building, and remote collaboration. Virtual reality was consolidated as an effective tool for strengthening collaborative learning with five distinctive possibilities: engagement, support for distance learning, interdisciplinary collaboration, social skills development, and alignment with collaborative learning paradigms [14].

3.4 Pedagogical strategies and instructional models

The analyzed research documented innovative pedagogical approaches for the integration of 3D virtual platforms in education. Identified trends include gamification, storytelling, case-based learning, problem-based learning, collaborative learning, and the flipped classroom. The constructivist model and the integration of TPACK and TELL models prevailed in pedagogy. Learning management systems, social networks, and online simulators were recognized as technological opportunities to improve academic outcomes [15].

Virtual course design emerged as a critical factor for the success of interventions. The comparative study between students in fully virtual courses and in massive open online courses found that both groups perceived clarity and quality in content and instructional design, highly valuing ubiquitous access to materials. However, students in massive open online courses noted a lack of support, flexible pathways that did not impact learning, and an absence of advantages in collaborative work [16].

The educational management model for virtual programs developed at Arturo Prat University of Chile exemplifies systematic approaches to ensuring quality. This model was based on theoretical, normative, and policy foundations, integrating educational models, instructional material, technological support, and high-quality evaluation standards. The hybrid model integrates global trends with local needs and internationalization requirements, having been optimized since 2014 for quantitative evaluation and accreditation [17].

Student satisfaction with virtual platforms varied according to specific tool characteristics. The evaluation of student satisfaction with virtual classes during the first semester of 2020 found that a significant portion of students approved of Microsoft Teams as a tool for virtual classes due to its intuitive and accessible nature. However, there was notable dissatisfaction with the evaluation method used to assess knowledge acquisition. The use of Smowl for monitoring during virtual exams received divided opinions [18].

Use of educational platforms by teachers in secondary schools in Buenos Aires revealed patterns of integration in post-digital contexts. Studied across four schools, Google Classroom emerged as the most widely used pedagogical platform.

Digitalization of student records and attendance tracking was observed, with platforms such as MiEscuela and Xhendra being utilized [19].

3.5 Taxonomies and frameworks for use classification

The need to systematize knowledge about educational applications of virtual reality motivated the development of comprehensive taxonomies. The study developed a taxonomy for virtual reality educational use cases that includes seventeen dimensions and thirty-seven characteristics. This taxonomy provides a solid foundation for future research and helps to understand and compare different virtual reality use cases in education, addressing existing ambiguities and nuances in the field [20].

In addition to taxonomies, various analytical frameworks addressed the historical evolution of educational technologies. The review on medical education examined the evolution from traditional methods to the modern digital era, focusing on the shift from the static web to metaverse applications. The traditional didactic approach in medical education has been transformed toward more dynamic and interactive methods through technologies such as simulation tools and virtual reality. The metaverse offers transformative changes by enabling real-time interaction, immersive learning experiences, and global collaboration among students and educators [8].

Metaverse typologies provided conceptual frameworks for understanding different modalities of immersive experiences. Defining four types of metaverse: augmented reality, lifelogging, mirror world, and virtual reality, exploring their potential and limitations in educational applications. The metaverse offers potential benefits such as new spaces for social communication, greater creative freedom, and immersive experiences. Limitations include weaker social connections, privacy concerns, and potential maladaptation to the real world [5].

3.6 Critical factors for effective implementation

Analysis identified contextual and strategic conditions that determine the effectiveness of interventions with 3D virtual platforms. Teacher training proved to be a fundamental factor. Research on augmented, virtual, and mixed reality identified ongoing research areas that include teacher training, design principles, acceptance and attitudes, perceived difficulties, cognitive variables, and comparative studies on effectiveness [4].

Quality pedagogical design and institutional preparedness constituted critical elements. The review on the use of virtual reality in engineering education found scaling in the use of virtual classroom environments as a complement to traditional teaching environments, with substantial benefits for cognitive and skill-based learning outcomes. However, assessment metrics and processes lacked clarity, and unrealistic virtual scenarios along with small sample sizes may have confounded comparisons and reported benefits [2].

Novelty as a motivational factor required careful consideration. Studies speculated that the novelty of augmented and virtual reality technology had a direct positive impact on student engagement, and that well-designed courses with qualified professors were crucial for positive outcomes [13]. This observation suggests that initial effects might not be sustained once technology becomes normalized, requiring pedagogical designs that transcend mere novelty.

Technological infrastructure and technical support represented essential enabling conditions. Studies that reported difficulties frequently pointed to limitations in connectivity, availability of specialized equipment, and access to timely technical assistance. These barriers proved particularly significant in resource-limited contexts, suggesting that the digital divide could be amplified if implementations of immersive technologies do not carefully consider equity and access issues.

3.7 Limitations and identified challenges

Multiple limitations and challenges were documented regarding the use of 3D virtual platforms in education. Negative effects on student well-being stood out as a significant concern. Adverse effects such as visual exhaustion and mental fatigue associated with the use of augmented and virtual reality were identified [4]. These physical and cognitive limitations require careful consideration in the design of learning experiences, particularly for prolonged sessions.

Privacy and data security also emerged as critical issues. The limitations of the metaverse include weaker social connections, privacy concerns, and potential maladaptation to the real world [5]. In a context where virtual platforms collect massive amounts of data on student behaviors and performance, questions of personal data protection and ethical use of information become fundamental.

A gap between technological potential and implementation reality constitutes another recurring challenge. Students in massive open online courses noted a lack of support, flexible pathways that did not impact learning, and an absence of advantages in collaborative work [16]. This observation suggests that the mere availability of sophisticated technology does not guarantee effective educational experiences without appropriate pedagogical design and robust student support systems.

4 DISCUSSION

Findings of this analysis engage with previous research that has documented the transformative potential of 3D virtual platforms in education. Accumulated evidence suggests that these constitute powerful tools for creating immersive learning experiences, developing complex competencies, and facilitating forms of collaboration that transcend spatial and temporal limitations. However, results also underscore that their effectiveness depends critically on their integration into coherent pedagogical ecosystems that consider both technological possibilities and specific educational needs.

The diversity of documented applications confirms the versatility of 3D virtual platforms for addressing different learning objectives across multiple disciplines. From medical education to engineering, from sustainability education to collaborative skills training, these technologies have demonstrated the capacity to enrich educational experiences in fundamental ways. Nevertheless, it is necessary to deepen the understanding of the specific mechanisms through which different types of virtual environments generate particular learning outcomes.

Documented technological evolution from desktop-based platforms to increasingly immersive experiences reflects both hardware and software advances and greater sophistication in articulating these tools with pedagogical objectives. This evolutionary trajectory raises questions about the future direction of technological development and about how educational institutions can stay current without becoming trapped in cycles of premature technological obsolescence.

Central importance of teacher training identified across multiple studies resonates with literature on educational innovation that emphasizes the protagonism of faculty in change processes. Effective integration of 3D virtual platforms requires that teachers develop not only technical competencies to operate the technologies, but also advanced digital literacy to understand the pedagogical, ethical, and social implications of these environments. Educational institutions face the challenge of designing professional development programs that strengthen these capabilities in a systematic and sustainable manner.

Visual exhaustion and mental fatigue, among other documented negative effects, require careful attention in the design of learning experiences. These findings suggest that interventions with immersive technologies must be carefully calibrated in terms of duration, frequency, and intensity of use. Effective integration likely implies hybrid models that combine immersive experiences with other learning modalities, optimizing benefits while minimizing adverse effects.

Privacy and data protection concerns raise fundamental ethical questions that transcend purely technical or pedagogical considerations. As virtual platforms collect increasingly granular data on student behaviors, performance, and interaction patterns, educational institutions must develop robust ethical frameworks to govern the use of this information. The tension between leveraging data to personalize and improve learning experiences versus protecting student privacy and autonomy represents one of the most complex challenges in this field.

Limitations of this study stem from the heterogeneity of the analyzed corpus. As shown in Table 1, over half the studies (eleven) employed systematic review methodology, while three corresponded to literature reviews, three to empirical studies, and three to theoretical-methodological proposals. Such methodological distribution implies that most findings derive from secondary evidence synthesis rather than primary data collection, strengthening the breadth of the analysis but limiting the availability of original effect measures. Regarding educational level, ten studies focused on higher education and nine addressed multiple levels, with only one at the K-12 level, a gap that reveals scarce evidence for primary and secondary contexts. Discipline-specific studies concentrated in medical education and engineering (two each), alongside one in STEM, one in physical education, and one in sustainability education, while thirteen adopted general or multidisciplinary approaches. Furthermore, the methodological composition of the corpus itself shapes its overall tone: systematic reviews, which dominate the sample, tend to report broader positive trends that may reflect publication bias, whereas the three empirical studies reported more mixed results, particularly regarding assessment methods and surveillance tools [16], [18], [19]. The transferability of findings to underrepresented disciplines and educational levels therefore warrants caution, and future research should prioritize these gaps. Most analyzed studies also reported short- or medium-term interventions, leaving the sustained impact of immersive technologies on long-term learning trajectories insufficiently understood.

The strengths of this analysis include the incorporation of studies with diverse methodological designs, educational levels, and types of technology, which provides a comprehensive view of the possibilities and challenges of integrating 3D virtual platforms in education. The identification of critical contextual factors offers practical guidance for educational institutions planning to implement these technologies. Explicit consideration of both benefits and limitations allows for a balanced perspective that avoids both technophobia and uncritical technophilia.

Identified opportunities include the development of longitudinal studies that examine the long-term impact of sustained exposure to immersive technologies on competency development and educational trajectories. It is necessary to explore how these tools influence the construction of learning identities, student autonomy, and the development of lifelong learning skills. Future research must also address equity issues more systematically, examining how different groups of students with varying levels of access to technology, digital literacy, and cultural capital experience and benefit from interventions with 3D virtual platforms.

5 CONCLUSIONS

Integration of three-dimensional virtual platforms, augmented reality, virtual reality, and the metaverse in educational processes represents a consolidated trend that will continue to expand in coming years. Systematic analysis of twenty recent studies provides evidence on the technological characteristics of these platforms, their predominant pedagogical applications, documented learning outcomes, and the conditions necessary for effective implementations. Immersive technologies have demonstrated the capacity to strengthen the development of critical thinking, creativity, communication and collaboration skills, as well as to improve memory retention and problem-solving abilities when implemented within coherent pedagogical designs.

Findings confirm the proposed hypothesis: effectiveness of these technologies does not reside exclusively in their technical characteristics, but in their articulation with teaching capabilities, adequate infrastructure, contextualized pedagogical designs, and continuous evaluation strategies. Educational institutions that aspire to successfully integrate 3D virtual platforms must invest in teacher professional development, build robust technological infrastructure, develop ethical frameworks for data governance, and foster cultures of pedagogical innovation that value both experimentation and rigorous evaluation.

Documented limitations, particularly adverse effects on student well-being and privacy concerns, require systematic attention in the design and implementation of educational interventions with immersive technologies. Effective integration demands balanced approaches that optimize benefits while minimizing risks, recognizing that 3D virtual platforms constitute tools that complement and enrich existing pedagogical repertoires rather than completely replacing them.

Future research should focus on longitudinal studies of sustained impact on learning trajectories, research on equity in access to and benefits of immersive technologies, development of more sophisticated evaluation frameworks that capture the complexity of learning experiences in virtual environments, and exploration of hybrid modalities that productively integrate in-person and virtual experiences. Advancing the field requires interdisciplinary collaboration that articulates perspectives from technological design, pedagogy, ethics, and public policy to maximize transformative potential while protecting the rights and well-being of students and educators.

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