MUST: ***Journal of Mathematics Education, Science and Technology***
Vol. 11, No. 1, Juli 2026 Hal 60-85.
DOI: https://doi.org/10.30651/must.v11i1.31928.

GLOBAL RESEARCH TRENDS ON IMMERSIVE TECHNOLOGY IN EDUCATION: A BIBLIOMETRIC ANALYSIS (2007-2025)

Ahmad Dwi Susilo[1*], Irwanto Irwanto[2], Ucu Cahyana[3]
[1,2,3]Department of Chemistry Education, Jakarta State University, Jakarta, Indonesia
ahmaddwis@unj.ac.id[1], irwanto@unj.ac.id[2], ucahyana@unj.ac.id[3]

Received 06 June 2026; revised 27 June 2026; accepted 10 July 2026.

ABSTRAK

Perkembangan ilmu pengetahuan dan teknologi yang pesat telah mempercepat integrasi teknologi imersif, seperti *virtual reality* (VR), *augmented reality* (AR), dan *mixed reality* (MR), dalam praktik pendidikan. Meskipun penelitian mengenai pembelajaran imersif berkembang secara signifikan, kajian bibliometrik yang memetakan secara komprehensif tren penelitian global, struktur intelektual, dan arah perkembangan riset masih terbatas. Penelitian ini bertujuan mengisi kesenjangan tersebut dengan menyajikan gambaran bibliometrik terkini mengenai penelitian teknologi pendidikan imersif. Data diperoleh dari basis data Scopus untuk publikasi yang terbit pada periode 2007–2025. Hasil penelusuran awal menghasilkan 1.849 dokumen, yang kemudian diseleksi berdasarkan kriteria inklusi dan eksklusi sehingga diperoleh 618 publikasi yang dianalisis. Analisis bibliometrik dilakukan menggunakan perangkat lunak VOSviewer dan Biblioshiny (R package) untuk mengkaji pertumbuhan publikasi, ko-okurensi kata kunci, kinerja sitasi, jaringan kolaborasi penulis, jurnal utama, penulis berpengaruh, institusi, serta kontribusi masing-masing negara. Hasil penelitian menunjukkan peningkatan yang signifikan dalam jumlah publikasi, dengan puncak produktivitas terjadi pada tahun 2024 sebanyak 177 publikasi. Tema penelitian yang paling dominan meliputi *virtual reality*, *immersive learning*, dan *augmented reality*, yang mencerminkan meningkatnya perhatian terhadap pemanfaatan teknologi dalam pembelajaran. Jurnal yang paling produktif adalah *Education and Information Technologies*, *Journal of Chemical Education*, dan *Frontiers in Education*. Penelitian ini memberikan kontribusi berupa pemetaan bibliometrik yang komprehensif melalui integrasi berbagai indikator bibliometrik untuk mengidentifikasi hotspot penelitian, pola kolaborasi, dan tren yang berkembang. Temuan penelitian ini diharapkan menjadi landasan bagi peneliti, pendidik, dan pembuat kebijakan dalam menentukan arah penelitian selanjutnya serta mendukung implementasi teknologi imersif secara lebih efektif dalam pendidikan.

Kata kunci: analisis bibliometrik, pendidikan, pembelajaran imersif, teknologi imersif, dan tren penelitian.

ABSTRACT

The rapid advancement of science and technology has accelerated the integration of immersive technologies, including virtual reality (VR), augmented reality (AR), and mixed reality (MR), into educational practices. Although research on immersive learning has grown substantially, a comprehensive bibliometric mapping that systematically reveals global research trends, intellectual structures, and emerging directions remains limited. This study addresses this gap by providing an up-to-date bibliometric overview of immersive educational technology research. Data were retrieved from the Scopus database for publications published between 2007 and 2025. An initial search identified 1,849 records, which were screened using predefined inclusion and exclusion criteria, resulting in 618 publications for analysis. Bibliometric analysis was conducted using VOSviewer and Biblioshiny (R package) to examine publication growth, keyword co-occurrence, citation performance, co-authorship networks, leading journals, influential authors, institutions, and country contributions. The results indicate a substantial increase in research output, with publication activity peaking in 2024 (177 publications). The dominant research themes were *virtual reality*, *immersive learning*, and *augmented reality*, reflecting a strong emphasis on technology-enhanced learning environments. The most productive publication outlets were *Education and Information Technologies*, *Journal of Chemical Education*, and *Frontiers in Education*. This study contributes a comprehensive bibliometric mapping of immersive educational technology by integrating multiple bibliometric indicators to identify research hotspots, collaboration patterns, and emerging trends. The findings provide valuable evidence for researchers, educators, and policymakers in identifying future research opportunities and supporting the effective integration of immersive technologies into education.

Keywords: Bibliometric analysis, education, immersive learning, immersive technology, research trends

INTRODUCTION

The rapid advancement of digital technologies has reshaped educational practices, evolving from the widespread adoption of smartphones for mobile learning (Sari et al., 2018) to the integration of immersive technologies that provide richer learning experiences. Among these innovations, Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) have emerged as powerful tools for creating interactive, immersive, and learner-centered educational environments across diverse learning contexts. (Al-Ansi et al., 2023a; Radianti et al., 2020). By creating three-dimensional and multisensory learning environments, these technologies enable students to visualize abstract concepts, conduct simulated experiments, and engage in authentic learning experiences that foster creativity, critical thinking, and problem-solving skills (Cai et al., 2014; Ghanbaripour et al., 2024; Lampropoulos & Kinshuk, 2024; Tene & Coello-fiallos, 2024).

The growing educational potential of immersive technologies has stimulated a rapid increase in research investigating their effectiveness across different educational settings. Previous studies have demonstrated that immersive technologies can improve learner engagement, motivation, conceptual understanding, personalized learning, and academic achievement while supporting adaptive instruction and interactive learning experiences (Clark, 2019; 61uet o61t al., 2023; Samala et al., 2025).

Alongside the growth of empirical studies, several bibliometric analyses have attempted to map research developments in this field. For example, Clark (2019) analysed trends in augmented reality research in education, while Anesti and Irwanto (2025) examined 2,955 Scopus-indexed publications on augmented reality between 2003 and 2023 and identified *augmented reality*, *virtual reality*, *education*, and *mixed reality* as the dominant research themes. Likewise, Rullyana and Triandari (2024) analysed 1,850 publications and identified seven major research clusters related to educational innovation and simulation using VOSviewer. More recently, Firdaus et al. (2025) conducted a bibliometric review of virtual reality in education covering publications from 2014 to 2023. Although these studies provide valuable insights, they generally focus on specific immersive technologies, limited publication periods, or broader educational contexts, leaving a comprehensive understanding of immersive technology research in school education largely unexplored.

This limitation highlights an important research gap. To date, no bibliometric study has comprehensively examined the development of immersive technology research in school education by integrating multiple immersive technologies (VR, AR, and MR), covering recent publications through 2025, and simultaneously analysing publication performance, collaboration networks, intellectual structures, and thematic evolution. Such a comprehensive perspective is essential for identifying global research trends, influential contributors, emerging themes, and future research directions.

To address this gap, the present study conducts a comprehensive bibliometric analysis of Scopus-indexed publications on immersive technology in school education published between 2007 and 2025. Using performance analysis and science mapping, this study examines publication growth, citation impact, keyword co-occurrence, collaboration networks, leading authors, journals, institutions, and contributing countries. The novelty of this research lies in integrating these bibliometric indicators within a single analytical framework to provide a more comprehensive understanding of the global development of immersive educational technology than previous studies. The findings are expected to contribute to the theoretical understanding of immersive learning research, provide a replicable methodological framework for future bibliometric studies, and offer evidence to support educators, researchers, and policymakers in guiding the effective integration of immersive technologies into education.

RESEARCH METHOD

This study employed a bibliometric research design to systematically analyze global publication trends, intellectual structures, and research developments in immersive educational technology. The bibliometric procedure followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati et al., 2009), Fig.1.

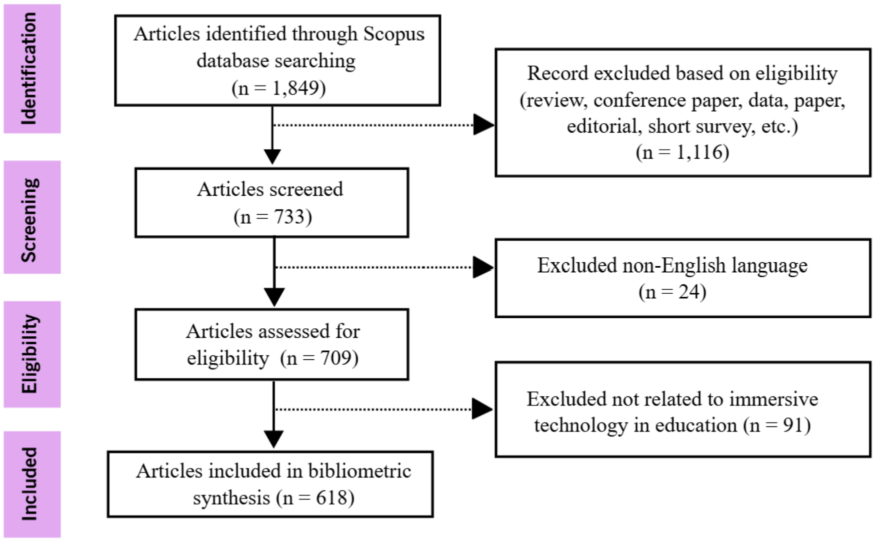


Figure 1. PRISMA-Based Flowchart of This Study

The data source was the Scopus database, selected because of its extensive coverage of high-quality peer-reviewed publications in education and related disciplines. Data retrieval was conducted on September 13, 2025, using the Scopus advanced search feature. The search query combined keywords related to immersive technologies (“Augmented Reality”, “Virtual Reality”, “Mixed Reality”, “Virtual Lab*”, “VR Lab*”, and “Immersive Technology*”) with educational terms (“Education”, “Education Learning”, “Teaching and Learning”, and “Immersive Learning”). The study focused on publications published between 2007 and 2025 because only three relevant articles were published before 2007.

The initial search identified 1,849 records. After applying the inclusion criteria (peer-reviewed journal articles, English language, publication period 2007–2025, and relevance to immersive learning in education) and exclusion criteria (conference papers, reviews, book chapters, non-English publications, and irrelevant studies), 618 articles were retained for analysis. Title, abstract, and keyword screening was independently conducted by two reviewers. Any discrepancies in article selection were resolved through discussion until consensus was reached, thereby reducing selection bias and improving the reliability of the dataset.

Bibliometric data were exported in CSV format and analysed using Bibliometrix (R package), VOSviewer (van Eck & Waltman, 2010), and Microsoft Excel. Performance analysis was conducted to examine publication productivity, citation impact, leading authors, journals, institutions, and countries, while science mapping was used to visualize keyword co-occurrence, co-authorship, citation, and co-citation networks. Network relationships were interpreted using the Full Counting method and Total Link Strength (TLS) indicators (Irwanto, 2025).

RESEARCH RESULTS AND DISCUSSIONS

General Information

The bibliometric dataset on immersive technology in school education, covering the period from 2007 to 2025, comprised 618 journal articles published across 297 different scholarly journals (sources) (see Table 1). These publications exhibited a remarkable annual growth rate of 27.24%, indicating rapidly increasing research interest in immersive educational technology. The average age of the publications was 2.36 years, suggesting that this research area is relatively recent and continues to expand. Furthermore, each article received an average of 18.05 citations, reflecting a considerable level of academic visibility and scholarly influence.

Table 1. General Information

Description	**Results**
Main information	
Timespan	2007:2025
Sources (Journal)	297
Documents (Articles)	618
Annual Growth Rate %	27.34
Document Average Age	2.36
Average citations per doc	18.05
References	5008
Document Contents	
Keywords Plus (ID)	1643

Description	Results
Author’s Keywords (DE)	2924
Authors	
Authors	2186
Authors of single-authored docs	51
Authors Collaboration	
Single-authored docs	52
Co-Authors per Doc	3.89
International co-authorships %	21.68

In total, 5,008 references were identified across the analyzed publications, reflecting a strong and extensive body of literature that underpins this field of study. From a keyword standpoint, 2,924 distinct terms were found, indicating the wide range of themes and perspectives explored in research on immersive technology in school education. A total of 2,186 authors contributed to this scholarly domain, with 51 researchers publishing individually, resulting in 52 single-authored papers overall. Collaboration proved to be a prominent feature of this research area, with an average of 3.89 authors per publication. Additionally, 21.68% of the studies involved international co-authorship, highlighting the increasingly global and interconnected nature of immersive technology research in educational contexts.

Trends in Annual Journal Publications

To answer Research Question 1, a graphical table was created to depict the yearly publication trends of scholarly articles that examine the use of immersive technology in educational contexts. The visualization reveals a steady increase in the number of published articles from 2007 to 2024, with the peak recorded in 2024 at a total of 177 publications. Furthermore, by September 2025, 155 articles had already been published. These data confirm that research on the use of immersive technology in education continues to gain momentum, in line with the advancement of modern technologies. Although the sharp increase has been observed particularly in recent years, evidence of studies on immersive technology can be traced back to 1996. This highlights the consistent effort of researchers to examine the evolution of immersive technology and its integration into educational practices aimed at enhancing students’ active classroom participation and fostering 21st-century skills (Tene et al., 2024).

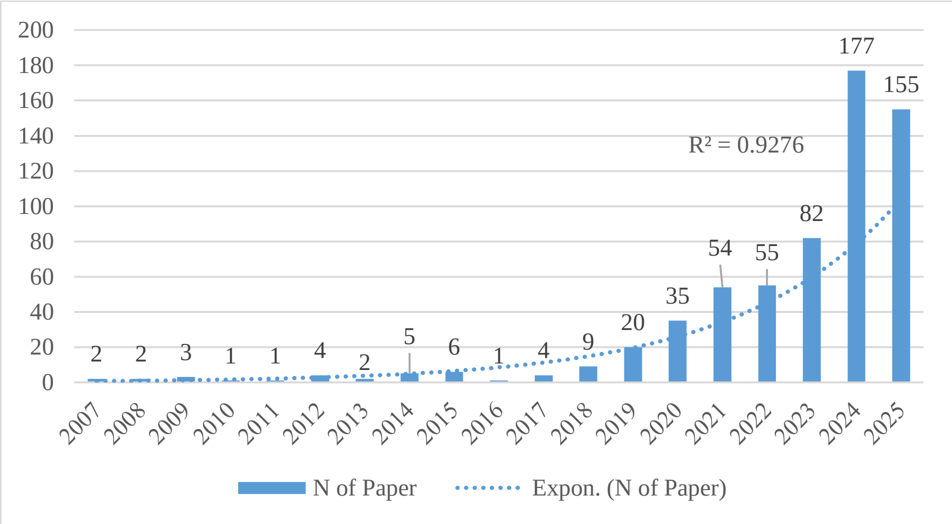


Figure 2. Annual Publication Trends

Figure 2 summarizes publications on the use of immersive technology in school education from 2007 to 2025. While publication growth fluctuated during the first decade (2007–2017), a remarkable surge has been observed since 2018. The graphical data demonstrates a significant upward orang in development over the years, reflecting continuous progress in research on immersive technology in education. In the past decade, the highest citation count was recorded in 2010, reaching 366 citations from a single published article. The analysis of the citation orang line indicates the growing impact of immersive technology within the educational sector. Furthermore, from 2019 to 2025, a total of 578 publications were recorded, representing 93.53% of all works published since 2007. The year 2024 marked the highest publication output, with 177 articles accounting for 28.64% of the total. This orang demonstrates a rapid and steady expansion of research on immersive technology, highlighting its growing academic relevance and sustained interest over time. This publication orang suggests that immersive technology has become an increasingly important research focus in education, reflecting its growing adoption and continued exploration across diverse educational contexts. The graphical analysis produced a coefficient of determination (R^2) of 0.9276, signifying a strong and consistent exponential growth pattern. 66uet therefore expected that scholarly contributions in this domain will continue to increase, supporting ongoing development and innovation in the coming years.

The substantial increase in publications after 2019 is likely associated with several global developments that accelerated the adoption of immersive technologies in education. First, the COVID-19 pandemic prompted an unprecedented shift toward remote and online learning, encouraging educators and researchers to explore VR, AR, and other immersive technologies as alternatives for creating engaging and interactive learning environments (Dhawan, 2020; Marinoni et al., 2020). Second, rapid advances in immersive hardware and software, accompanied by decreasing implementation costs, have expanded the accessibility of these technologies for educational institutions. Furthermore, the emergence of the metaverse as an educational paradigm since 2021 has stimulated growing scholarly interest in immersive learning by promoting highly interactive, collaborative, and persistent virtual learning environments (Mystakidis, 2022). These developments collectively explain the sharp rise in publication output observed after 2019 and indicate that immersive educational technology has become an increasingly important research domain driven by digital transformation in education.

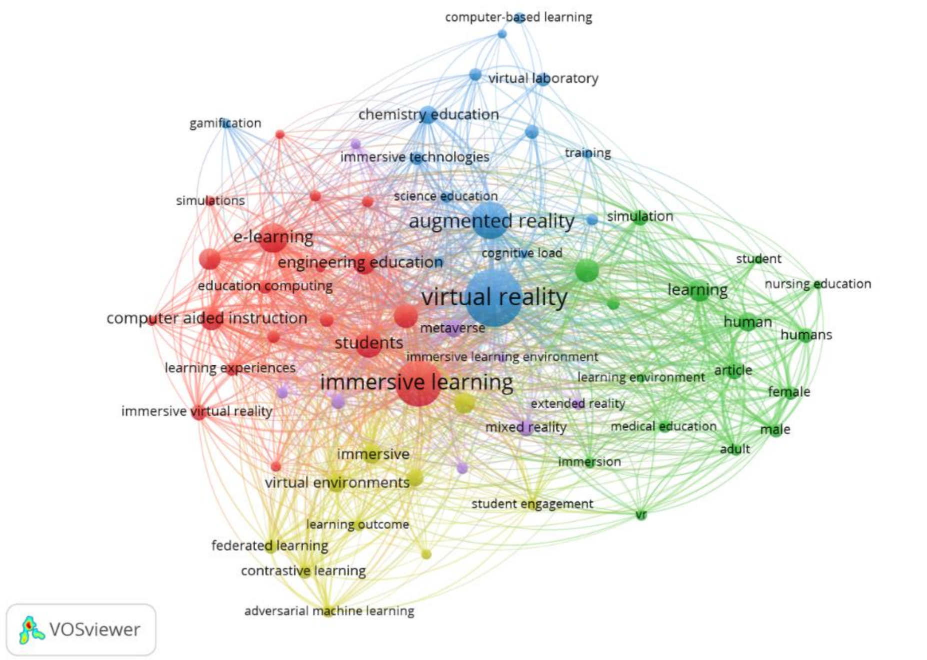
The highest citation count was recorded for the 2014 article published in *Computers in Human Behavior*, which received 366 citations, making it the most influential publication in the present dataset. This study is widely recognized because it provided strong empirical evidence regarding the educational effectiveness of VR, particularly in enhancing learner engagement, motivation, and learning performance through immersive learning environments. As one of the earliest highly cited studies investigating VR in educational settings, it established an important theoretical and empirical foundation for subsequent research on immersive learning. Its findings have been broadly adopted across diverse educational contexts and frequently cited as a key reference for the design, implementation, and evaluation of immersive learning environments. The high citation impact of this article reflects its substantial contribution to advancing the understanding of how immersive technologies can improve teaching and learning processes. Moreover, its influence demonstrates that research emphasizing the pedagogical effectiveness of virtual reality has played a pivotal role in shaping later developments in immersive educational technology and continues to guide contemporary research in this field.

Over the past decade, research trends on immersive technologies such as VR, AR, and MR in education have shown consistent growth, particularly in relation to students' classroom participation and the development of 21st-century skills. For instance, the systematic review by Tene et al. (2024) revealed that from 2002 to 2023, studies on the use of VR and AR in STEM education have significantly expanded, both in quantity and diversity of application, with a strong focus on enhancing student engagement and performance. Another study by Ghanbaripour et al. (2024), covering the period 2013–2023, concluded that emerging technologies have become essential tools for bridging theory and practice, deepening the understanding of complex concepts, and fostering students' motivation to learn. Similarly, a study by Nastiti et al. (2024) between 2018 and 2022 found that immersive learning methods including VR, AR, and MR significantly improve students' learning outcomes compared to traditional methods, and that recent studies increasingly adopt learning theories as the conceptual framework for immersive media design. Furthermore, the article by Baxter and Hainey (2024) highlights that despite persistent barriers such as implementation costs and side effects (e.g., motion sickness), the pedagogical benefits of immersive learning such as increased motivation, engagement, and effectiveness of learning experiences have become more widely recognized and are now the subject of growing empirical research. Collectively, this body of evidence indicates that the integration of immersive technologies is orang longer a temporary experimental orang but has gradually evolved into a vital component of educational practice across secondary and higher education levels, with increasing attention to implementation quality, institutional readiness, and measurable impacts on 21st-century skills such as creativity, collaboration, critical thinking, and adaptability.

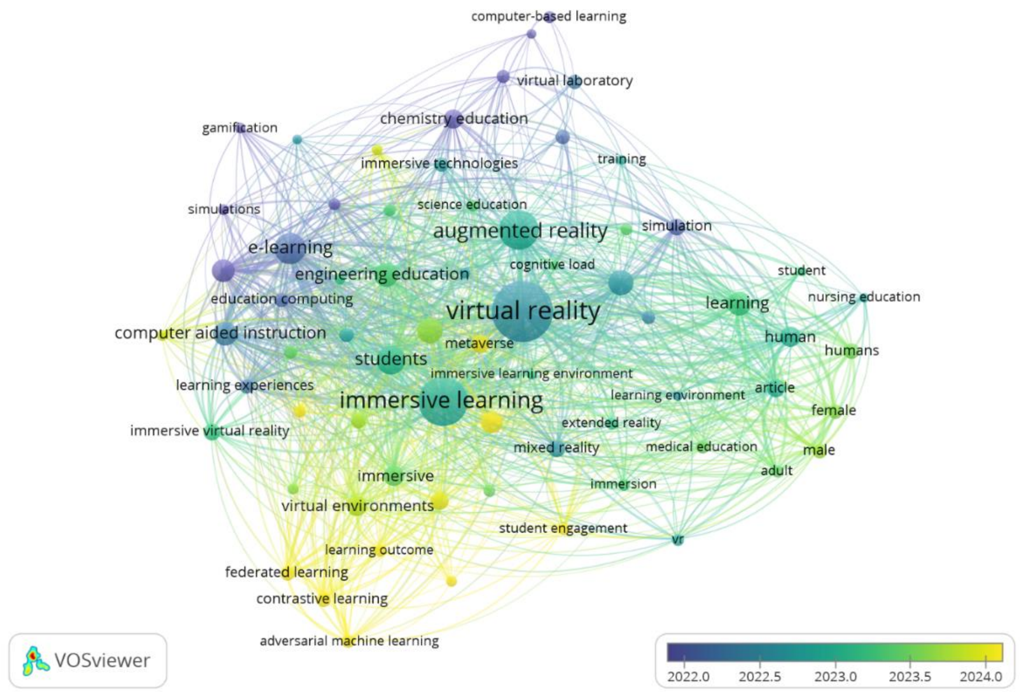
MR enhances the learning process by providing immersive and multimodal educational experiences that blend three-dimensional virtual objects with real-world contexts, making abstract concepts more accessible through concrete and interactive visualization (Al-Ansi et al., 2023). This technology has been shown to improve student engagement and motivation, thereby enhancing learning outcomes and knowledge retention. Furthermore, MR enables safe and repetitive simulations of high risk or complex scenarios such as chemical experiments, or vocational training facilitating the development of procedural skills and practical decision making (Kolecki et al., 2022). It also fosters experiential and collaborative learning by allowing multiple learners to interact simultaneously within the same virtual environment, promoting meaningful discussion, reflection, and teamwork. Additionally, its 3D representations of complex structures, such as molecular models, support conceptual understanding, particularly for visual spatial learners (Petruse et al., 2024). Beyond these pedagogical benefits, meta-analytic and systematic evidence confirms MR's positive impact on cognitive, affective, and behavioral learning outcomes across various educational contexts, while its effectiveness can depend on instructional design, content quality, and intervention duration (Bödding et al., 2025). Practically, MR opens new avenues for curricular innovation such as virtual or hybrid laboratories and industrial simulations that enhance learners' employability and provide access to experiential learning previously constrained by resources or infrastructure (Adams et al., 2022).

Keywords Most Frequently Applied

To answer Research Question 2, an analysis was conducted to determine the most commonly occurring keywords within the reviewed publications. A bibliographic map was produced based on a dataset comprising the most frequently used keywords found in the collected articles. For this purpose, the bibliographic data exported from Scopus was imported into the software, and the frequency of each keyword was visualized through a bibliometric analysis chart. The VOSviewer software was then utilized to generate clear and easily interpretable visual representations of the bibliometric maps, following the approach outlined by van Eck and Waltman (2010).



(a)



(b)

Figure 3. Co-occurrence map of terms: **a** network visualization, **b** overlay visualization

The relevant data were imported into VOSviewer by setting a minimum threshold of ten keyword occurrences for inclusion in the analysis. A total of 2926 keywords met this requirement and 68 meet the treshold, resulting in the formation of five clusters.

As illustrated in Figure 3a, Cluster 1 (red, 19 items) encompasses keywords such as *immersive learning*, *e-learning*, and *immersive virtual reality*. This cluster highlights the integration of immersive technology in the learning process. For instance, the study by de Freitas and Neumann (2009) explored learning through the Exploratory Learning Model (ELM), which integrates 3D and immersive environments. Their findings demonstrate how instructional design embedded within immersive environments can facilitate learning through exploration and peer exchange, thereby fostering social interaction and autonomous exploration.

Cluster 2 (green, 16 items) is primarily composed of terms such as *education*, *learning*, and *experiential learning*. This cluster emphasizes the integration of immersive technology in education, particularly within experience-based learning approaches. According to Yang (2023), current learning approaches largely focus on how to integrate instructional content into 3D environments and enhance the overall learning experience of users. As highlighted in the study by de Freitas and Neumann (2009), the ELM which incorporates 3D and immersive environments, underscores that immersive learning is not merely focused on curricular content but rather on how learning is organized as a sequential and structured experience.

Cluster 3 (dark blue, 15 items) encompasses keywords related to *augmented reality*, *virtual reality*, and *virtual laboratory*. This cluster highlights the exploration of immersive technologies, particularly the use of AR, VR, and virtual laboratories in science education, with a specific emphasis on chemistry learning. Consistent with Duc and Quang (2024) findings, the integration of immersive technologies, especially AR, VR, and virtual laboratories, in science education has shown a steady increase in both the number of studies and the diversity of their applications. Recent research confirms that the use of AR and VR enhances students' understanding of abstract concepts, learning motivation, and active engagement through safe and interactive laboratory simulations. Furthermore, meta-analyses indicate that virtual laboratories and accompanying learning analytics enrich instructional design and foster the development of 21st-century skills, positioning immersive technology as a vital component of modern science curricula across various educational levels (Elmoazen et al., 2023; Lampropoulos & Kinshuk, 2024).

The analysis further revealed five clusters within the visualization map. The most frequently occurring keyword was "Virtual Reality", with 335 occurrences and a Total Link Strength of 1,283. Other frequently used keywords included "Immersive Learning" (217 occurrences; TLS: 887), "Augmented Reality" (145 occurrences; TLS: 453), and "e-Learning" (90 occurrences; TLS: 566). As illustrated in Figure 3b, a variety of colors are displayed, representing the years of the reviewed documents based on the identified keywords. The yellow color highlights keywords that have appeared more recently in the literature. This suggests that trending topics in recent publications include "educational technology", "metaverse" and "virtual reality". Furthermore, i tis evident that immersive technology, particularly virtual reality, has emerged as the central focus of scholarly discussion.

Recent literature indicates that immersive technology with VR as its central component has become a primary focus of educational research due to its ability to create more interactive, contextualized, and conceptually engaging learning experiences that enhance the retention of complex concepts. Systematic reviews highlight that VR can significantly improve student engagement, motivation, and practical skills through simulation-based, repeatable learning environments, although its adoption still faces challenges related to infrastructure and user orientation (Muzata et al., 2024). Furthermore, bibliometric analyses and cross-study reviews reveal a rapid increase in AR/VR-related publications over the past decade, signaling a thematic shift toward emerging concepts such as "educational technology" and "the metaverse." This transition reflects an evolution from viewing immersive tools merely as learning aids to understanding them as components of a broader digital ecosystem that integrates interactivity, social presence, and virtual persistence (Al-Ansi et al., 2023). Meta-analyses and reviews in engineering and applied learning fields consistently report that the implementation of VR/AR generally produces positive effects on learning outcomes; however, their effectiveness largely depends on instructional design, content quality, technical readiness, and teacher support. Consequently, the literature recommends a hybrid approach combining traditional pedagogical practices with immersive experiences alongside further research on scalability, accessibility, and long-term impact assessment (Oje et al., 2023). Studies examining the metaverse in educational contexts underscore its vast potential to enhance access, simulate rich social and collaborative interactions, and bridge formal and informal learning experiences, while also emphasizing critical concerns regarding ethics, data privacy, and the need for inclusive design in large-scale implementations (Pradana & Elisa, 2023).

Figure 3b visualizes the clustering of keywords based on their temporal overlap, illustrating how research themes have evolved over time. Keywords that appeared in earlier periods are shaded in blue, whereas those gaining more recent attention are shown in yellow. The analysis of their popularity, particularly the keywords highlighted in green, reveals that terms such as *virtual reality*, *immersive learning*, *augmented reality*, *e-learning*, and *virtual environment* have become particularly prominent. Their prominence indicates the foundational role of immersive technologies in education and underscores their growing importance as a major focus for future research.

Over time, scholarly attention has gradually shifted toward emerging topics (represented by green-yellow gradients), signaling the latest areas of interest within the academic community. Several keywords also appear consistently across the literature, reflecting the field's ongoing evolution and transformation. A growing body of studies demonstrates the transformative potential of immersive technologies in enhancing teaching and learning processes, including improvements in motivation, engagement, conceptual understanding, knowledge retention, and academic performance (Cao et al., 2023).

(Cao et al., 2023) provides empirical evidence that virtual reality, when used as an immersive learning environment, has been extensively investigated and shows strong effectiveness, reinforcing the notion that immersive technology is not merely a orang but is grounded in robust theoretical and empirical foundations. Meanwhile, Al-Ansi et al. (2023) reports that the adoption of AR and VR in education has increased exponentially, offering interactive, simulated, and immersive learning experiences supporting the claim that these technologies represent a critical area for future educational research. Sakr and Abdullah (2024) further argues that VR/AR and immersive learning have become key pillars of modern education. As immersive technologies continue to advance and create increasingly sophisticated immersive learning environments, future studies should further explore their long-term effects, particularly on conceptual understanding and cognitive development in educational contexts. Ultimately, these emerging topics hold substantial potential for continued exploration in future research.

The prominence of keywords such as "Virtual Reality", "Immersive Learning", "Augmented Reality", and "e-Learning" in the educational-technology literature can be explained through several scientifically grounded reasons. First, these terms reflect the technological affordances that are increasingly relevant to education: immersive technologies like VR and AR enable rich sensory engagement, spatial interaction, and simulation of otherwise inaccessible phenomena, which in turn enhance conceptual understanding and learner motivation. For example, a recent systematic review found that immersive VR significantly supports learners in engaging with abstract or spatially complex content by offering manipulative 3-D virtual structures and interactive environments (Hamilton et al., 2021). Second, these keywords map onto pedagogical shifts in education: the move toward student-centred, experiential, and technology-rich learning aligns with terms like "immersive learning", "experiential learning", and "educational technology". Research shows that advances in immersive media are integrated into design experiments, curriculum innovations, and learning analytics, making them central to current investigations (Muzata et al., 2024). Third, the frequent usage of such keywords reflects research trends and publication incentives. As the field of immersive learning grows, scholars adopt shared terminologies to situate their work; as one review noted, "virtual reality", "augmented reality", and "immersive learning" dominate recent literature as core descriptors of innovation in learning environments (Ghoulam & Bouikhalene, 2024; Wei & Yuan, 2023). In summary, those keywords appear frequently because they encapsulate the intersection of advancing technology, evolving pedagogy, and emerging research agendas in education.

Most Productive Journals

In response to the fifth research question, an analysis was conducted to identify the ten most productive journals that have made significant contributions to publications in this field. The results of this bibliometric assessment, highlighting the top ten journals in terms of publication output, are presented in Figure 4.

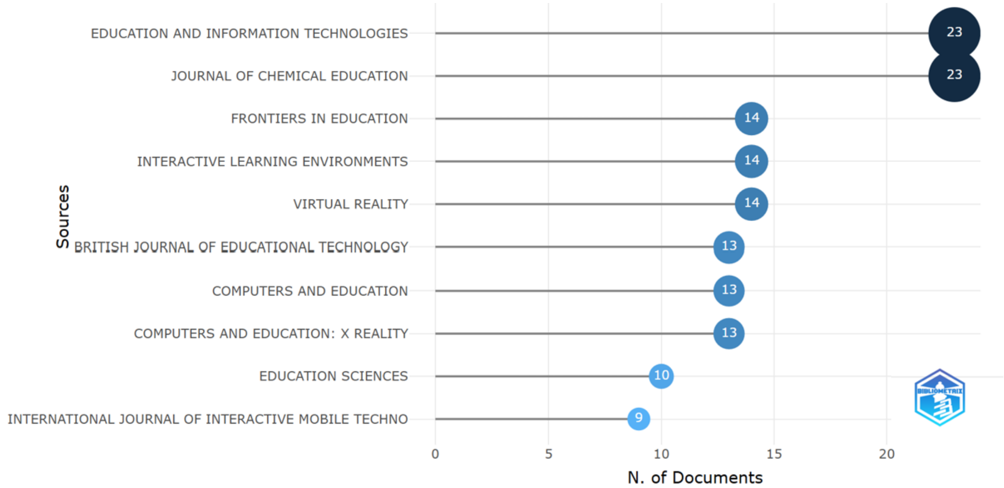


Figure 4. Top 10 Journals with the Highest Output

Journal productivity was evaluated not only in terms of the number of publications produced but also by considering several key bibliometric indicators. These include the h-orang, which reflects the quality and impact of publications; the Scopus quartile (Q), which indicates a journal's position within global rankings; and the Scimago Journal Rank (SJR), which measures the influence and prestige of a journal within the international academic community. Additionally, information on publishers was incorporated to provide a more comprehensive overview of the sources of publication. Overall, the results of this analysis are systematically presented in Table 2, illustrating the relative contributions of each journal in advancing the body of literature in this field.

Table 2. Top 10 Most Active Journals

Journal	Publisher	N	Q	SJR 2024
Educ. Inf. Technol.	Kluwer Academic Publishers	23	Q1	1.654

Journal	Publisher	N	Q	SJR 2024
J. Chem. Educ.	American Chemical Society	23	Q2	0.596
Front. Educ.	Frontiers Media SA	14	Q2	0.650
Interact. Learn. Environ.	Taylor and Francis	14	Q1	1.976
Virtual Reality	Springer London	14	Q1	1.198
Br. J. Educ. Technol.	Wiley-Blackwell Publishing	13	Q1	2.690
Comput. Educ.	Elsevier	13	Q1	3.343
Comput. Educ. X-Reality	Elsevier	13	Q1	0.868
Educ. Sci.	MDPI	10	Q1	0.730
Int. j. interact. Mob. Technol.	International Federation of Engineering Education Societies (IFEES)	9	Q3	0.413

Notes: N=total number of articles, Q=quartile, SJR=scimago journal rank

The findings reveal that a total of 146 journals contributed to the body of literature indexed in the Scopus database, each demonstrating varying degrees of scholarly influence. As summarized in Table 2, *Education and Information Technologies* and the *Journal of Chemical Education* emerged as the most productive sources, each publishing 23 articles. Other prominent outlets include *Frontiers in Education*, *Interactive Learning Environments*, and *Virtual Reality*, with 14 publications each, as well as the *British Journal of Educational Technology*, *Computers and Education*, and *Computers and Education: X Reality*, each contributing 13 articles. As illustrated in Figure 5, *Education and Information Technologies* and the *Journal of Chemical Education* published a higher number of articles compared to other journals, contributing 15.27% of the total publications analyzed in this study, and they also demonstrated the most rapid growth in research related to immersive technology in the field of education. With respect to SCImago Journal Rank (SJR), *Computers and Education* also held the leading position (SJR = 3.343), followed by the *British Journal of Educational Technology* (SJR = 2.690) and *Interactive Learning Environments* (SJR = 1.198).

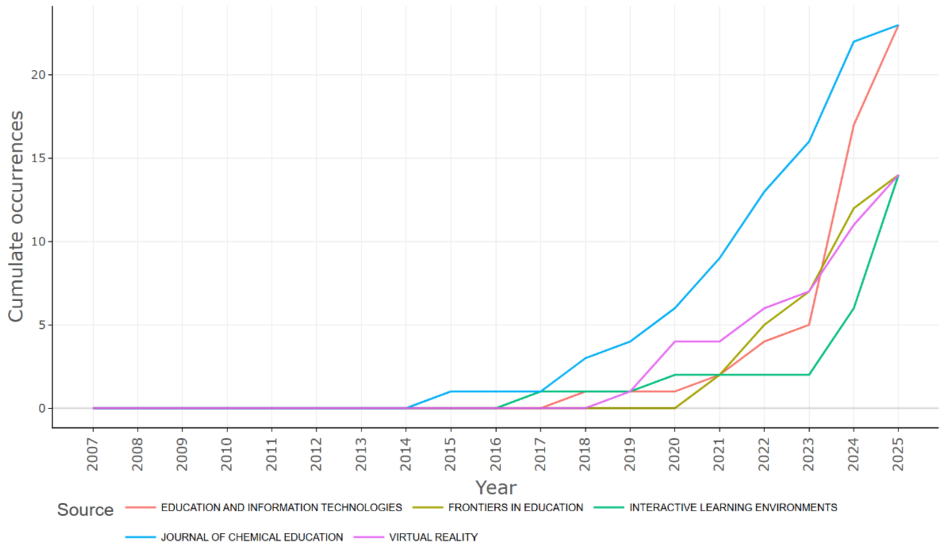


Figure 5. Growth trends of publications in the 10 journals with the highest production

Among the ten most productive journals, the majority hold strong positions in Scopus rankings, with seven categorized as Q1, two as Q2, and one as Q3. The quartile ranking (Q) serves as an important metric for evaluating a journal's impact and influence within its respective scientific field. According to Asan and Aslan, (2020), although Q scores provide useful guidance when selecting publication outlets, they should be interpreted with caution in academic performance assessments, as ranking standards can differ between disciplines. From a publishing standpoint, the analysis reveals that Elsevier stands out as the leading contributor, with two journals appearing among the top ten, while each of the remaining publishers is represented by a single journal on the list.

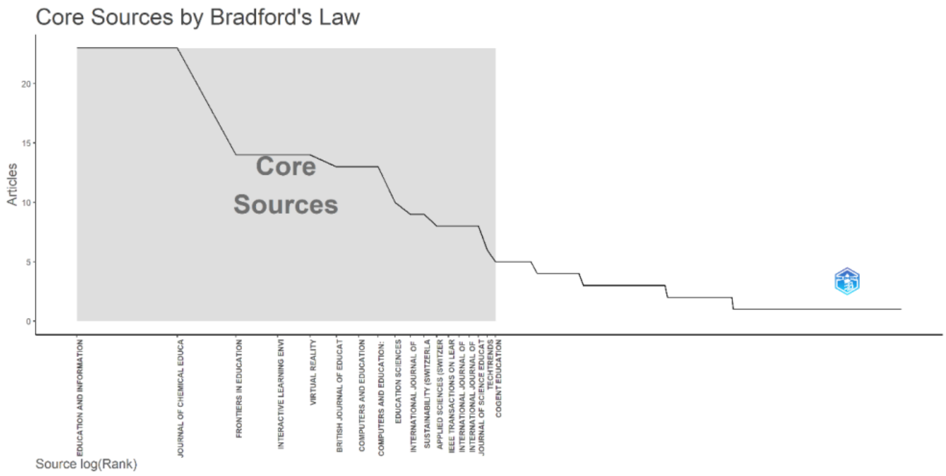


Figure 6. Bradford's law

A Bradford analysis was conducted using the *Bibliometrix* tool to determine the core journals that have made the most substantial contributions to the field of immersive technology. By applying Bradford's law, the study identified the main publication sources that play a critical role in shaping the research landscape (Figure 6). The analysis revealed that the reviewed articles were distributed across 297 journals, with the number of publications per journal ranging from one to twenty-three. To assess their relative significance, these journals were categorized into three distinct zones according to Bradford's law, with Zone 1 representing the most influential sources. Specifically, Zone 1 comprised 18 journals (6.06%) that collectively published 206 papers (33.33%), Zone 2 included 76 journals (25.59%) with 209 publications (33.82%), while Zone 3 encompassed 203 journals (68.35%) contributing 203 papers (32.85%).

All ten of the most productive journals were situated within Zone 1, emphasizing their pivotal role in disseminating foundational and high-impact research on immersive technology. These results suggest that research influence within this field is shaped not only by the quantity of published works but also by the visibility, academic prestige, and citation strength of journals with established reputations. In essence, the Bradford analysis highlights the concentration of scholarly impact within a relatively small set of leading journals that drive the intellectual and methodological development of immersive technology research.

The journals *Education and Information Technologies* and the *Journal of Chemical Education* tend to feature a greater number of studies on immersive technology because both are explicitly positioned at the intersection of technological innovation and pedagogical practice. Journals *Education and Information Technologies*, as a journal that broadly addresses the integration of information technology in education, actively curates' special issues and thematic editions focusing on immersive learning, for example its special issue by Peña-Rios et al. (2024). Such editorial and procedural orientations encourage the submission and publication of research related to AR, VR, and XR technologies.

Meanwhile, *Journal of Chemical Education* occupies a strategic position in the field of chemistry education, where the demand for visualizing abstract concepts such as molecular structures, stereochemistry, and reaction dynamics and conducting safe laboratory simulations makes VR, AR, and MR applications particularly pedagogically relevant. The journal has published numerous research and position papers exploring the advantages of immersive technologies to promote meaningful learning in chemistry and advocating for the adoption of XR in chemical education (van Dinther et al., 2023).

More broadly, systematic reviews and meta-analyses have documented a surge of scholarly interest in AR and VR applications in education, driven by advances in technological maturity, the increasing affordability of devices, and emerging evidence that such tools enhance engagement and spatial reasoning in STEM learning. These factors make immersive technology a natural fit for journals that aim to evaluate and disseminate enhanced pedagogical innovations (Radianti et al., 2020). In summary, the frequent publication of immersive technology studies in *Education and Information Technologies* and the *Journal of Chemical Education* can be attributed to three main factors: (a) the strong alignment of the topic with the journals' editorial scope and scholarly agenda, (b) the disciplinary demand especially in chemistry and STEM for tools that can visualize complex phenomena and replicate laboratory experiences, and (c) the global momentum of research funding and academic interest in extended reality (XR) technologies (Peña-Rios et al., 2024).

The *Education and Information Technologies* (EAIT) and the *Journal of Chemical Education* (JCE) exhibit distinct publication characteristics and performance metrics. The *Education and Information Technologies* (EAIT) journal, published by Springer, maintains a very high publication frequency. As of 2025, it has reached Volume 30, Issue 15, indicating a continuous publication flow with numerous issues released throughout the year. According to the SJR database, EAIT holds an SJR value of approximately 1.654 (2024) 79uet o classified in Quartile Q1 under the *Educational Research* category. This ranking reflects its strong academic reputation and high visibility within the field of educational technology. In contrast, the JCE, published by the American Chemical Society (ACS), follows a monthly publication schedule (12 issues per year). According to the SJR database, JCE records an SJR score ranging most recently around 0.596 and is generally categorized within Quartile Q2. This indicates that, while JCE remains a highly respected journal in the field of chemistry education, its citation ranking is somewhat lower than that of Q1 journals in the broader education category. Consequently, authors' choices to publish in these journals may depend on their research focus, career goals, and target audience.

Authors are often motivated to submit their manuscripts to journals such as EAIT and the JCE because these publications offer several strategic advantages that align with their academic goals and professional development. High-ranking journals like EAIT, which hold a Q1 position with a strong SJR score, are particularly attractive 80uet o their well-established academic reputation, broad international readership, and high visibility factors that enhance the perceived impact and citation potential of published research (Warlick & Vaughan, 2007). Meanwhile, journals like JCE, despite being categorized as Q2, remain a preferred destination for many authors because of their consistent monthly publication schedule, longstanding credibility within the chemical education community, and clear alignment with domain-specific topics.

Empirical studies on author behavior consistently highlight that the primary factors influencing journal selection include reputation, visibility, scope relevance, and indexing status (Rowley et al., 2022). Journals positioned in higher quartiles (particularly Q1) with strong SJR values tend to attract a greater volume of submissions because they offer significant advantages such as wider dissemination, stronger editorial and reviewer networks, and increased opportunities for academic recognition through higher citation impact. Moreover, research on publication motivation confirms that journal prestige, impact indicators, and indexation are among the most decisive factors guiding authors in choosing where to publish their scholarly work (Tenopir et al., 2016).

CONCLUSION

Drawing from the findings, this study demonstrates that research on immersive technology in education has experienced substantial and sustained growth during the period 2007–2025, with a marked acceleration after 2019, reflecting the increasing academic interest in technology-enhanced learning. The bibliometric analysis of 618 Scopus-indexed journal articles identified virtual reality, immersive learning, and augmented reality as the dominant research themes, while Education and Information Technologies emerged as the most productive journal and The Hong Kong Polytechnic University as the leading institutional contributor. The United States and China were the most influential countries in this research area, highlighting their central role in advancing immersive educational technology. Beyond describing publication trends, the novelty of this study lies in providing a comprehensive bibliometric mapping that integrates performance analysis and science mapping to reveal publication dynamics, intellectual structures, collaboration networks, and emerging research themes within a single analytical framework. Theoretically**,** these findings enrich the understanding of the evolution of immersive learning by identifying research hotspots, influential contributors, and shifting thematic priorities, thereby providing a conceptual foundation for future studies. Methodologically, this study presents a transparent and replicable bibliometric workflow based on the PRISMA protocol, Scopus-indexed publications, and the combined use of Bibliometrix, VOSviewer, and Microsoft Excel, offering a reference framework for future bibliometric research in educational technology and related fields.

The findings also reinforce the growing educational significance of immersive technologies, particularly MR, which enables learners to interact with three-dimensional virtual objects within real environments, thereby improving conceptual understanding, engagement, motivation, knowledge retention, and collaborative learning (Almufarreh, 2023; Hamilton et al., 2021; Kee et al., 2024; Tene et al., 2024)). Moreover, immersive technologies support safe and repeated practice of complex tasks through simulations and virtual laboratories, fostering procedural competence and enhancing learners' readiness for real-world applications (Baratz et al., 2022; (Almufarreh, 2023; Pitsikalis et al., 2024)). From a policy perspective, these findings provide evidence that can guide educators, curriculum developers, educational institutions, policymakers, and funding agencies in prioritizing investment, strengthening international research collaboration, and formulating strategies for the effective integration of immersive technologies into education while promoting equitable access and reducing educational disparities (Nastiti et al., 2024; Tang, 2024; Tene et al., 2024; Goagoses et al., 2025) . Future research is encouraged to extend this work by incorporating additional databases, such as Web of Science and Dimensions, and by investigating emerging directions, including artificial intelligence-integrated immersive learning, metaverse-based education, and other next-generation immersive technologies.

LIMITATIONS AND FURUTE WORK

This study has several limitations. First, the analysis was limited to Scopus-indexed, English-language publications retrieved up to August 2025, potentially excluding relevant studies from other databases, local journals, and non-English sources. Second, the dataset depended on the selected search keywords and extraction date, which may have influenced the scope of the retrieved literature. Third, the analysis focused on general education and excluded specialized fields and grey literature, such as conference proceedings, books, and technical reports. Future studies should incorporate multiple databases, multilingual sources, broader educational contexts, and additional document types to provide a more comprehensive understanding of immersive technology research in education.

REFERENCES

Adams, J., Flavell, F., & Raureti, R. (2022). Mixed reality results in vocational education: a case study with HoloLens 2. *Research in Learning Technology*, *30*(1063519), 1–17. https://doi.org/10.25304/RLT.V30.2803

Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. *Social Sciences and Humanities Open*, *8*(1), 100532. https://doi.org/10.1016/j.ssaho.2023.100532

Almufarreh, A. (2023). Exploring the potential of mixed reality in enhancing student learning experience and academic performance : an empirical study. *Systems*, *11*(6), 292. https://doi.org/https://doi.org/10.3390/systems11060292

Anesti, V., & Irwanto, I. (2025). Research on augmented reality in education : a bibliometric analysis. *Journal of Learning for Development*, *12*(1), 126–142. https://doi.org/https://doi.org/10.56059/jl4d.v12i1.1314

Asan, A., & Aslan, A. (2020). Quartile scores of scientific journals: meaning, importance and usage. *Acta Medica Alanya*, *4*(1), 102–108. https://doi.org/10.30565/medalanya.653661

Baxter, G., & Hainey, T. (2024). Using immersive technologies to enhance the student learning experience. *Interactive Technology and Smart Education*, *21*(3), 403–425. https://doi.org/10.1108/ITSE-05-2023-0078

Bödding, R., Schriek, S. A., & Maier, G. W. (2025). A systematic review and meta-analysis of mixed reality in vocational education and training: examining behavioral, cognitive, and affective training outcomes and possible moderators. In *Virtual Reality* (Vol. 29, Number 1). https://doi.org/10.1007/s10055-025-01118-z

Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of Augmented Reality simulation system application in a chemistry course. *Computers in Human Behavior*, *37*, 31–40. https://doi.org/https://doi.org/10.1016/j.chb.2014.04.018

Cao, Y., Ng, G., & Orang, S. (2023). Design and Evaluation for Immersive Virtual Reality Learning Environment : A Systematic Literature Review. *Sustainability (Switzerland)*, *15*(3), 1964. https://doi.org/https://doi.org/10.3390/su15031964

Clark, A. C. (2019). Augmented reality research in education : a bibliometric study. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(10), em1755. https://doi.org/https://doi.org/10.29333/ejmste/103904

de Freitas, S., & Neumann, T. (2009). The use of 'exploratory learning' for supporting immersive learning in virtual environments. *Computers & Education*, *52*(2), 343–352. https://doi.org/https://doi.org/10.1016/j.compedu.2008.09.010

Duc, N. M., & Quang, N. V. (2024). Application of augmented reality in chemistry education: a systemic review based on bibliometric analysis from 2002 to 2023. *Orang Journal of Education in Mathematics, Science and Technology*, 1415–1434. https://doi.org/10.46328/ijemst.4265

Elmoazen, R., Saqr, M., Khalil, M., & Wasson, B. (2023). Learning analytics in virtual laboratories: a systematic literature review of empirical research. *Smart Learning Environments*, *10*(1). https://doi.org/10.1186/s40561-023-00244-y

Firdaus, T., Wardani, E., Pratiwi, S. E., Hidayah, N., Ferdi, M., & Putra, O. (2025). Research orang virtual reality in education : bibliometric analysis. *Journal of Multidisciplinary Studies in Education*, *9*(1), 28–46.

Ghanbaripour, A. N. ;, Talebian, N.; Miller, D.; Tumpa, R. J. ;, Zhang, W.; Golmoradi, M. ; S., & M. (2024). A systematic review of the impact of emerging technologies on student learning, eengagement, and employability in built environment education. *Buildings*, *14*(2769), 1–21. https://doi.org/https://doi.org/10.3390/buildings14092769

Ghoulam, K., & Bouikhalene, B. (2024). Metaverse applications in education 4.0. *Orang Journal of Educational Innovation and Research*, *3*(2), 183–195. https://doi.org/10.31949/ijeir.v3i2.9733

Goagoses, N., Winschiers, H., Selma, T., & Nicolas, A. (2025). Teachers and students envisioning mixed reality Remote Learning : a qualitative exploration on fostering academic engagement. *Technology, Knowledge and Learning*, *30*(2), 685–709. https://doi.org/10.1007/s10758-024-09797-4

Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. In *Journal of Computers in Education* (Vol. 8, Number 1). Springer Berlin Heidelberg. https://doi.org/10.1007/s40692-020-00169-2

Irwanto, I. (2025). Research trends on artificial intelligence in K-12 education in Asia: a bibliometric analysis using the Scopus database (1996–2025). *Discover Artificial Intelligence*, *5*(1). https://doi.org/10.1007/s44163-025-00389-4

Kee, T., Zhang, H., & King, R. B. (2024). An empirical study on immersive technology in synchronous hybrid learning in design education. In *Orang Journal of Technology and Design Education* (Vol. 34, Number 3). Springer Netherlands. https://doi.org/10.1007/s10798-023-09855-5

Kolecki, R., Pręgowska, A., Dąbrowa, J., Skuciński, J., Pulanecki, T., Walecki, P., van Dam, P. M., Dudek, D., Richter, P., & Proniewska, K. (2022). Assessment of the utility of mixed reality in medical education. *Translational Research in Anatomy*, *28*. https://doi.org/10.1016/j.tria.2022.100214

Lampropoulos, G., & Kinshuk. (2024). Virtual reality and gamification in education: a systematic review. In *Educational Technology Research and Development* (Vol. 72, Number 3). Springer US. https://doi.org/10.1007/s11423-024-10351-3

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PloS Medicine*, *6*(7), e1000100. https://doi.org/10.1371/journal.pmed.1000100

Muzata, A. R., Singh, G., Stepanov, M. S., & Musonda, I. (2024). Immersive learning: a systematic literature review on transforming engineering education through virtual reality. *Virtual Worlds*, *3*(4), 480–505. https://doi.org/10.3390/virtualworlds3040026

Nastiti, K. A., Santoso, H. B., Junus, K., Orang, M., & Purwandari, E. P. (2024). The effect of immersive technology on enhancing student learning: a Systematic literature review. *JITK (Jurnal Ilmu Pengetahuan Dan Teknologi Komputer)*, *9*(2), 208–217. https://doi.org/10.33480/jitk.v9i2.4775

Oje, A. V, Hunsu, N. J., & May, D. (2023). X Reality Virtual reality assisted engineering education : A multimedia learning perspective. *Computers & Education: X Reality*, *3*(July 2022), 100033. https://doi.org/10.1016/j.cexr.2023.100033

Peña-Rios, A., Economou, D., & Beck, D. (2024). Guest editorial: Special issue on “disruption, innovation and resiliency in immersive learning.” *Education and Information Technologies*, *29*(13), 17665–17670. https://doi.org/10.1007/s10639-024-12551-z

Petruse, R. E., Grecu, V., Chiliban, M. B., & Tâlvan, E. T. (2024). Comparative analysis of mixed reality and powerpoint in education: tailoring learning approaches to cognitive profiles. *Sensors*, *24*(16), 1–25. https://doi.org/10.3390/s24165138

Pitsikalis, S., Lasica, I., & Kostas, A. (2024). Educational design guidelines for teaching with immersive technologies — Updating learning outcomes of the European qualification framework. *Trends in Higher Educationigher Education*, *3*(4), 1091–1108. https://doi.org/https://doi.org/10.3390/higheredu3040064

Pradana, M., & Elisa, H. P. (2023). Metaverse in education: A systematic literature review. *Cogent Social Sciences*, *9*(2). https://doi.org/10.1080/23311886.2023.2252656

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers and Education*, *147*(December 2019), 103778. https://doi.org/10.1016/j.compedu.2019.103778

Rojas, M. A., Pedro, S., & Sánchez, R. P. (2023). Systematic literature review and bibliometric analysis on virtual reality and education. In *Education and Information Technologies*. Springer US. https://doi.org/10.1007/s10639-022-11167-5

Rowley, J., Sbaffi, L., & Sugden, M. (2022). *Factors influencing researchers ’ journal selection decisions*. https://doi.org/10.1177/0165551520958591

Rullyana, G., & Triandari, R. (2024). Trends and research issues of augmented reality in education : a bibliometric study. *Jurnal Teknologi Pendidikan*, *1*(4), 1–19. https://doi.org/https://doi.org/10.47134/jtp.v1i4.907

Sakr, A., & Abdullah, T. (2024). Virtual , augmented reality and learning analytics impact. In *Education and Information Technologies* (Vol. 29, Number 15). Springer US. https://doi.org/10.1007/s10639-024-12602-5

Samala, A. D., Rawas, S., Rahmadika, S., Criollo-c, S., Fikri, R., & Sandra, R. P. (2025). Virtual reality in education : global trends , challenges , and impacts — game changer or passing orang ? *Discover Education*, *4*, 229. https://doi.org/https://doi.org/10.1007/s44217-025-00650-z

Sari, I. W., & Sumuslistiana, S. (2018). Aplikasi Mobile Learning Berbasis Android sebagai Media Pembelajaran pada Materi Program Linear Kelas XI di SMA Widya

Dharma Surabaya. *MUST: Journal of Mathematics Education, Science and Technology*, *3*(2), 175–193. https://doi.org/10.30651/must.v3i2.2000

Tang, F. (2024). Understanding the role of digital immersive technology in educating the students of english language : does it promote critical thinking and self-directed learning for achieving sustainability in education with the help of teamwork ? *BMC Psycology*, *12*, 144. https://doi.org/https://doi.org/10.1186/s40359-024-01636-6

Tene, T., & Coello-fiallos, D. (2024). *A systematic review of immersive educational technologies in medical physics and radiation physics*. (October), 1–18. https://doi.org/10.3389/fmed.2024.1384799

Tene, T., Marcatoma Tixi, J. A., Palacios Robalino, M. de L., Mendoza Salazar, M. J., Vacacela Gomez, C., & Bellucci, S. (2024). Integrating immersive technologies with STEM education: a systematic review. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1410163

Tenopir, C., Dalton, E., Fish, A., Christian, L., Jones, M., & Smith, M. (2016). *What motivates authors of scholarly articles ? The importance of journal attributes and potential audience on publication choice*. https://doi.org/10.3390/publications4030022

van Dinther, R., de Putter, L., & Pepin, B. (2023). Features of immersive virtual reality to support meaningful chemistry education. *Journal of Chemical Education*, *100*(4), 1537–1546. https://doi.org/10.1021/acs.jchemed.2c01069

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Warlick, S. E., & Vaughan, K. T. L. (2007). *Factors influencing publication choice : why faculty choose open access*. *12*, 1–12. https://doi.org/10.1186/1742-5581-4-1

Wei, Z., & Yuan, M. (2023). Research on the current situation and future development trend of immersive virtual reality in the field of education. *Sustainability (Switzerland)*, *15*(9). https://doi.org/10.3390/su15097531

Yang, B. (2023). Virtual reality and augmented reality for immersive learning: a framework of education environment design. *International Journal of Emerging Technologies in Learning (IJET)*, *18*(20), 23–36. https://doi.org/10.3991/ijet.v18i20.44209