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Immersive Virtual Reality in Primary Education: A Systematic Literature Review on 21st Century Learning Integration

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ABSTRACT

Purpose of the study: This study aims to review recent empirical studies on the use of Virtual Reality (VR) in primary education, with particular attention to how different levels of immersion contribute to 21st-century learning.

Methodology: This study followed PRISMA guidelines for a systematic literature review. Searches were conducted in Scopus, Web of Science, ERIC, ScienceDirect, and Google Scholar using the keywords (“Virtual Reality” OR “VR”) AND (“Primary Education” OR “Elementary School”). A total of 124 records were identified, 12 duplicates were removed, 34 records were screened, and 21 studies were included for final synthesis based on the eligibility criteria (peer-reviewed, 2019–2025, English, primary education context, full text accessible). Data were synthesized through qualitative content analysis by categorizing studies according to VR types (non-immersive, semi-immersive, fully immersive) and reported learning outcomes related to 21st-century skills.

Main Findings: The research results indicate that: (1) Non-Immersive VR provides ease of access and use with a learning experience that is still limited to basic interactions; (2) Semi-immersive VR offers a more interactive and immersive learning experience through the use of more realistic simulations and visualizations; and (3) Fully immersive VR was most frequently reported in the reviewed studies and was associated with deeper multisensory engagement, enhanced conceptual understanding, and the development of 21st-century skills in primary education.

Novelty/Originality of this study: This study offers a comparative synthesis of non-immersive, semi-immersive, and fully immersive VR in primary education and highlights the pedagogical factors that shape their educational contribution.

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1. INTRODUCTION

The transformation of education in the 21st century demands a paradigm shift in learning that aligns with the advancements in digital technology and the requirements of global competencies [1], [2]. Education is no longer solely focused on content mastery but also on developing critical thinking, collaboration, creativity, and communication skills the core competencies of the 21st century [3]-[6]. The integration of digital technology into the learning process has become imperative, especially to create a learning environment that is adaptive, relevant, and capable of meeting the needs of digital native generations [7], [8].

One form of digital technology that is increasingly discussed in the field of education is Immersive Virtual Reality (IVR) [9], [10]. This technology presents interactive three-dimensional virtual environment simulations, allowing users to experience and explore content in a contextual and multisensory manner [10], [11]. The emergence of IVR presents a strategic opportunity to revolutionize teaching practices, particularly in creating deep, engaging, and meaningful learning experiences for learners [9], [12].

Immersive Virtual Reality (IVR) is the most advanced form of virtual reality technology that allows users to deeply engage in a digitally simulated three-dimensional (3D) environment [13], [14]. Unlike other virtual technologies, IVR creates a high sense of presence, wherein users feel truly inside the virtual world. This experience is achieved by integrating hardware such as VR headsets, motion sensors, hand controllers, and software designed to create a responsive and realistic environment [15], [16]. IVR's primary characteristic lies in its level of interactivity and immersion. This technology involves the senses of sight, hearing, and even touch via haptic feedback, creating a profound multisensory experience [17], [18].

IVR holds significant potential in enhancing student engagement, facilitating the understanding of abstract concepts, and fostering higher learning motivation [19], [20]. The interactive and immersive learning experience provided by IVR also supports the development of 21st-century skills, including critical thinking, teamwork, and effective communication [21], [22]. This is particularly important at the primary education level, which forms the foundation for lifelong learning skills [23], [24].

Virtual Reality in primary education can be understood within established learning theories that emphasize active and experiential engagement [16], [25]. From a constructivist perspective, learning occurs when students actively interact with their environment rather than passively receive information [26]. Immersive VR environments allow learners to explore, manipulate, and experience content in contextualized settings, which may support deeper understanding compared to traditional instructional approaches [10], [13]. Experiential learning and the concept of presence further explain the pedagogical relevance of immersive technologies [27], [28]. When students feel psychologically involved in a virtual environment, their attention and emotional engagement may increase, potentially strengthening learning outcomes [29], [30]. However, the effectiveness of VR also depends on instructional design, as excessive sensory input may increase cognitive load [19], [31]. These theoretical considerations help clarify why different levels of VR immersion may relate differently to the development of 21st-century skills in primary education.

Recent studies have increasingly examined the pedagogical impact of virtual reality in school contexts. For example, Erviana & Sepriansyah [32], demonstrated that immersive VR environments can enhance creativity and problem-solving among elementary students, while Laine et al. [10], reported increased engagement and presence in classroom-based immersive VR use. Similarly, Agustini et al.[33], discussed both opportunities and pedagogical challenges of extended reality in primary education settings. Despite these contributions, most prior studies remain fragmented, focusing on specific learning outcomes or single VR implementations rather than providing a structured comparison across different levels of immersion. Furthermore, limited research synthesizes how non-immersive, semi-immersive, and fully immersive VR distinctly support 21st-century learning competencie

Primary education plays an important role in shaping the ways students think and learn in the future [34]. Therefore, the integration of IVR in learning at this level needs special attention from both pedagogical and technological perspectives. Various preliminary studies have shown that using VR in primary schools can improve student learning outcomes, both in cognitive and affective aspects. However, these studies remain partial, limited to certain subjects, or employ varied methodological approaches.

To date, comprehensive scholarship reviewing the use of Virtual Reality, particularly immersive Virtual Reality (IVR), in 21st-century learning at the primary education level remains limited. A systematic review is therefore needed to map the existing evidence, identify prevailing research patterns and emerging trends, and highlight gaps in the literature concerning the implementation of IVR in primary schools. Such a review can offer a stronger empirical basis as well as practical guidance for educators, policymakers, and educational technology developers. In response to this need, the present study systematically synthesizes and examines recent research on Virtual Reality in primary education. Specifically, it focuses on how VR has been integrated into 21st-century learning, while also exploring its forms, benefits, challenges, and future directions in order to support more effective and contextually relevant learning innovation for primary school students.

2. RESEARCH METHOD

This study adopted a Systematic Literature Review (SLR) approach, structured as a systematic mapping review with qualitative synthesis. The review was conducted to identify, classify, and compare empirical studies examining the implementation of Virtual Reality (VR) in primary education, with particular attention to immersion level, research design, and the learning-related variables investigated. To ensure relevance and methodological adequacy, explicit eligibility criteria were established. Studies were included if they: (1) were published in peer-reviewed academic journals; (2) appeared between 2019 and 2025; (3) were written in English; (4) explicitly addressed the use of Virtual Reality (VR) in primary education; and (5) were available in full text. Studies were excluded if they focused on secondary or higher education contexts, lacked empirical data, took the form of opinion pieces or brief reports, or did not examine VR implementation in educational practice.

The literature search was carried out across several academic databases, namely Scopus, Web of Science (WoS), ERIC (Education Resources Information Center), and Google Scholar. The search was conducted in January 2025. The Boolean search string applied to the title, abstract, and keyword fields was: ("virtual reality" OR "VR") AND ("primary education" OR "elementary school"). Database filters were used to restrict the results to peer-reviewed journal articles published within the predefined time span. All retrieved records were exported and screened in several stages. First, duplicate entries were removed. Second, title and abstract screening was performed based on the inclusion and exclusion criteria. Third, full-text assessment was undertaken to confirm final eligibility. Any differences in screening decisions were resolved through discussion among the authors.

The review process was guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to enhance transparency and reproducibility. In accordance with PRISMA, the study selection procedure involved four main stages: identification, screening, eligibility assessment, and final inclusion. The PRISMA flow diagram below presents the process of article selection.

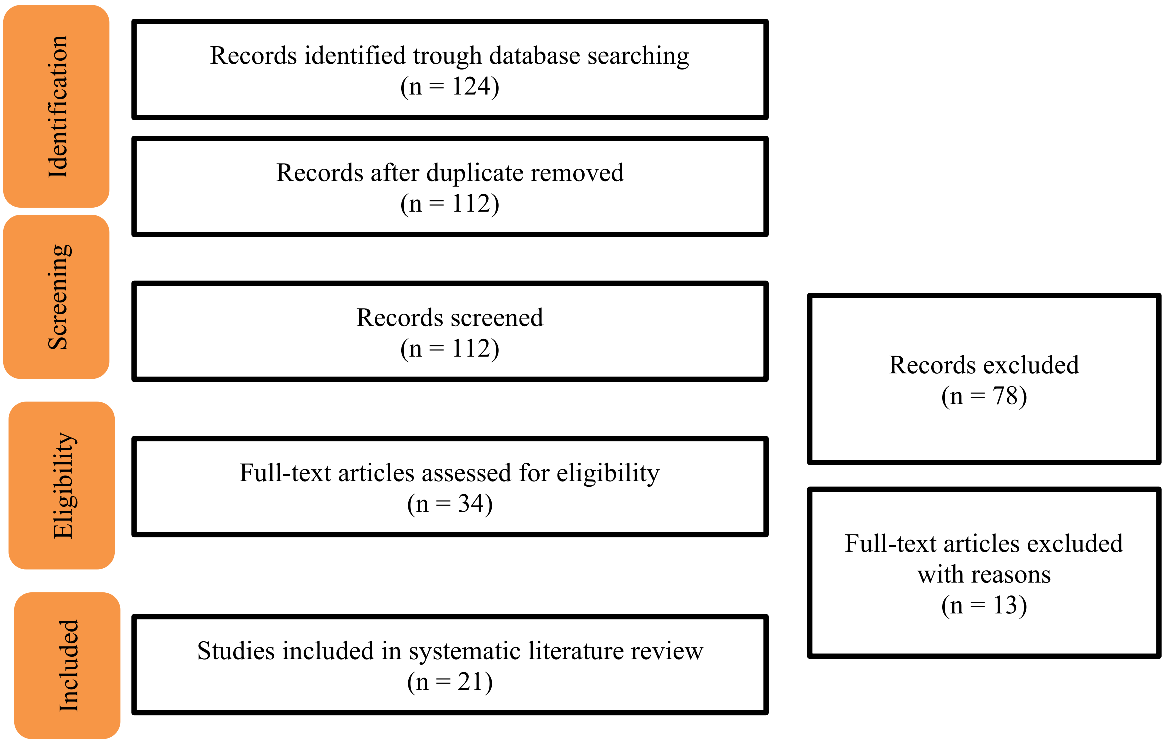

Figure 1. PRISMA diagram

To strengthen the methodological rigor of the review, the quality of the included studies was assessed using the Critical Appraisal Skills Programme (CASP) checklist. This framework was employed to examine several core dimensions of each study, including the clarity of the research objectives, the suitability of the research design, the transparency of data collection procedures, the credibility and validity of the findings, and the relevance of the study to primary education settings. Each article was reviewed systematically against these criteria before being included in the final synthesis. Studies that did not demonstrate sufficient methodological clarity or empirical rigor were excluded from further analysis. A comprehensive summary of the included studies along with their respective CASP appraisal results is presented in Table 1.

Table 1. Summary of Included Studies on Virtual Reality in Primary Education (2019–2025)

No.	Author(s) & Year	Sample	Country	Research Method	Indexing	Type of VR	CASP Score	Quality Level
1	Shim (2023)	162	South Korea	Quasi-Experimental	Scopus Q1	Semi-immersive VR	9/10	High
2	Boda & Brown (2020)	400	United States	Quasi-Experimental	Scopus Q1	Fully Immersive VR	9/10	High
3	Ironsi (2023)	85	Turkey	Mixed Methods	Scopus Q1	Non-Immersive VR	9/10	High
4	Chen, Chen & Shan (2024)	74	China	Mixed Methods	Scopus Q1	Fully Immersive VR	9/10	High
5	Fernández-Batanero et al. (2024)	36	Spain	Qualitative Descriptive	Scopus Q2	Semi-immersive VR	8/10	High
6	Sulisworo et al. (2022)	4	Indonesia	Qualitative Descriptive	Scopus Q2	Fully Immersive VR	7/10	Moderate
7	Mystakidis et al. (2022)	33	Greece	Research and Development	Scopus Q2	Fully Immersive VR	8/10	High
8	Campos, Hidrogo & Zavala (2022)	94	Mexico	Quasi-Experimental	Scopus Q2	Semi-immersive VR	8/10	High
9	Laine, Korhonen & Hakkarainen (2023)	59	Finland	Qualitative Descriptive	Scopus Q2	Fully Immersive VR	8/10	High
10	Utamayasa, Kusuma & Ariani (2025)	30	Indonesia	Mixed Methods	Scopus Q3	Semi-immersive VR	8/10	High
11	Agustini et al. (2023)	20	Indonesia	Research and Development	Scopus Q3	Non-Immersive VR	7/10	Moderate
12	Amprasi et al. (2022)	32	Greece	Quasi-Experimental	WoS ESCI	Non-Immersive VR	8/10	High
13	Sun & Peng (2019)	10	Japan	Mixed Methods	Scopus Proceedings	Semi-immersive VR	7/10	Moderate
14	Brown et al. (2020)	145	United States	Mixed Methods	Index Copernicus	Fully Immersive VR	7/10	Moderate
15	Acar & Cavas (2020)	26	Turkey	Quasi-Experimental	Index Copernicus	Fully Immersive VR	7/10	Moderate
16	Larsari & Abouabdelkader (2024)	220	Czech Republic	Quasi-Experimental	Index Copernicus	Fully Immersive VR	7/10	Moderate
17	Urhan & Akpinar (2024)	16	Turkey	Mixed Methods	Index Copernicus	Fully Immersive VR	7/10	Moderate
18	Umralieva et al. (2021)	25	Kazakhstan	Qualitative Case Study	EBSCO	Fully Immersive VR	8/10	High
19	Erviana & Sepriansyah (2024)	21	Indonesia	Quasi-Experimental	SINTA 2	Fully Immersive VR	8/10	High
20	Nugrahaningrum & Sayekti (2023)	30	Indonesia	Research and Development	SINTA 2	Semi-immersive VR	7/10	Moderate
21	Erviana et al. (2025)	150	Indonesia	Research and Development	SINTA 4	Semi-immersive VR	7/10	Moderate

Data synthesis was conducted using qualitative content analysis to systematically organize and interpret the findings of the 21 included studies. After the screening and quality appraisal stages, each article was carefully read in full to extract relevant information related to research design, sample characteristics, country of implementation, type of VR immersion (non-immersive, semi-immersive, fully immersive), indexing category, and reported learning variables. The coding process was performed using a structured data extraction table to ensure consistency across studies. Categories were developed deductively based on the research objectives and refined inductively during the review process when recurring patterns emerged. This approach allowed the comparison of methodological tendencies, thematic emphases, and immersion-level differences across studies. Through this structured synthesis, the review was able to identify dominant research trends, frequently examined learning outcomes, and conceptual distinctions among different VR implementations in primary education.

3. RESULTS AND DISCUSSION

3.1. Research Trends in Virtual Reality Implementation in Primary Education

A total of 124 records were initially retrieved from database searches conducted in Scopus, Web of Science, ERIC, and Google Scholar. Following the removal of 12 duplicate entries, 112 articles remained for title and abstract screening. At this stage, 78 records were excluded because they were not relevant to primary education, did not contain empirical data, or were not published in peer-reviewed sources. The remaining 34 full-text articles were then examined for eligibility. Of these, 13 studies were excluded for failing to meet the predefined inclusion criteria, including insufficient methodological transparency or limited relevance to the implementation of Virtual Reality in primary education. As a result, 21 studies were retained for the final synthesis.

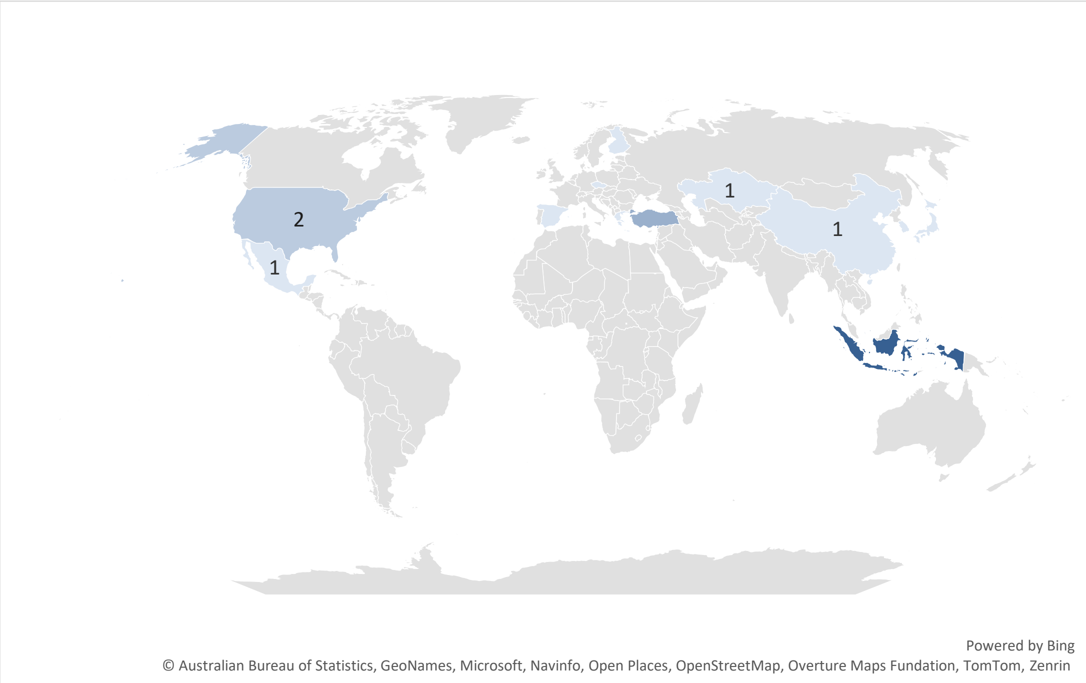

Figure 2. Publication trend by country

The geographical distribution of the included studies reflects more than a bibliographic trend; it may indicate differences in technological readiness and educational reform priorities across countries. The relatively high number of studies from Indonesia and Turkey, for instance, may be associated with ongoing efforts to integrate digital technologies into primary education curricula and to respond to post-pandemic digital transformation initiatives. In contrast, studies from technologically advanced contexts such as South Korea and the United States often emphasize immersive VR applications linked to innovation-driven pedagogies and STEM-oriented learning environments. These patterns suggest that national education policies, digital infrastructure, and curriculum reform agendas potentially shape how Virtual Reality is conceptualized and implemented in primary education settings. Therefore, country distribution should be interpreted within broader socio-technological and policy contexts rather than as a mere publication statistic. This finding highlights the importance of considering contextual educational ecosystems when evaluating the adoption and effectiveness of immersive technologies. Furthermore, the trend in publications based on research methods is shown below.

Table 2. Publication trend by research method

Method		Frequency
Quantitative	Quasi Experiment	7
	Descriptive	3
Qualitative	Case Study	1
Mixed Methods		6
Research and Development		4
Total		21

The predominance of quasi-experimental designs in the reviewed studies reflects the strong emphasis on measuring the instructional effectiveness of VR interventions in primary education. Most quasi-experimental studies were implemented to compare learning outcomes between VR-supported instruction and conventional teaching approaches, particularly in fully immersive environments. This suggests that researchers tend to treat VR primarily as an instructional intervention whose impact can be quantified through pre-test and post-test comparisons. In contrast, mixed-methods studies were more commonly associated with semi-immersive and non-immersive VR contexts, where researchers aimed to capture not only performance outcomes but also students' perceptions and learning experiences. Meanwhile, research and development approaches were predominantly conducted in emerging research contexts, focusing on designing and validating VR-based learning media rather than testing causal effects. These methodological patterns indicate that the choice of research design is closely linked to both the level of immersion and the intended educational objective of the VR implementation. Next, the publication trend based on journal indexing is illustrated below.

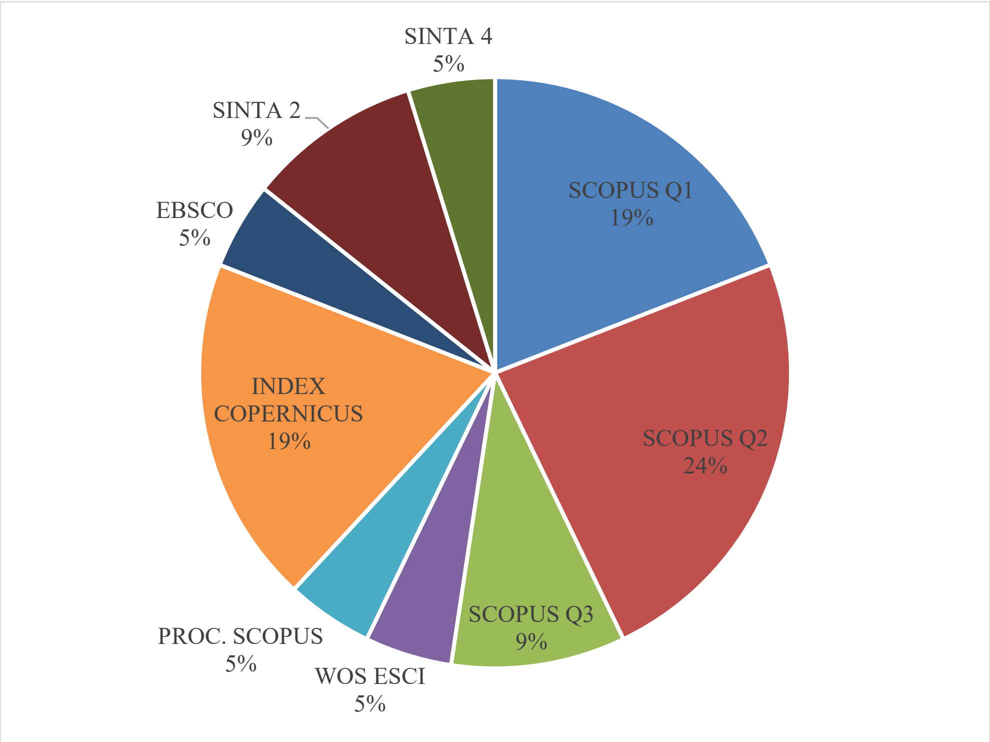

Figure 3. Publication trend by journal indexing

The distribution of studies across journal quartiles provides insight into the overall quality and rigor of the evidence base. A substantial proportion of the included studies were published in Scopus Q1 and Q2 journals, which generally apply stricter peer-review standards and methodological scrutiny. This pattern suggests that research on VR in primary education is increasingly being disseminated in high-impact academic outlets. Notably, studies indexed in higher-quartile journals also tended to demonstrate higher CASP appraisal scores, indicating stronger methodological transparency and research design robustness. In contrast, studies published in lower-indexed outlets more frequently showed limitations in reporting clarity or sample size. Therefore, the quartile distribution is not merely a publication statistic but reflects variations in methodological rigor and evidence strength within the field. Furthermore, the publication trend by type of VR is presented below.

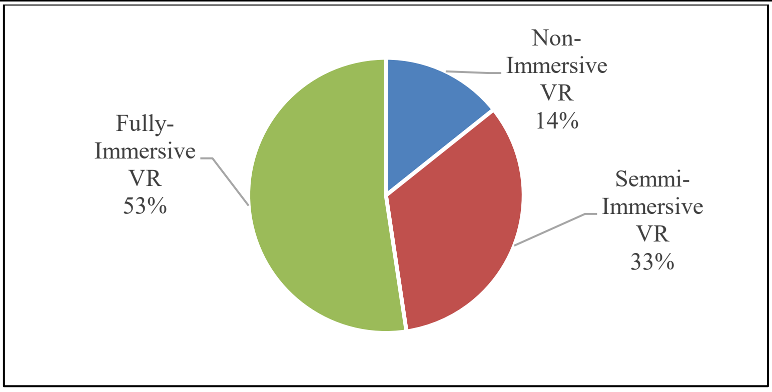

Figure 4. Types of Virtual Reality (VR)

When the findings are examined across immersion levels, a clearer pattern emerges regarding the type of learning outcomes reported. Fully immersive VR studies were more frequently associated with higher-order cognitive outcomes such as problem-solving skills, creativity, and complex conceptual understanding. These environments typically allowed students to interact dynamically with simulated contexts, which may explain their alignment with deeper learning processes. In contrast, semi-immersive VR studies were more commonly linked to learning experience, engagement, and motor skills development, suggesting a balance between immersion and instructional structure. Non-immersive VR applications, on the other hand, tended to focus on specific skill-based outcomes such as speaking skills, digital literacy, and learning performance. This distribution indicates that the level of immersion may influence not only instructional design but also the type of educational objectives targeted in primary education settings. The trend based on related variables is shown in the table below.

Table 3. Publication trend based on related variables

Related variables	Frequency
Creativity	2
Digital Literacy	1
Environmental Awareness	1
Learning Engagement	1
Learning Experience	7
Learning Outcomes	2
Learning Performance	1
Literacy	1
Moral	1
Motor Skills	1
Problem Solving	1
Reading Skills	1
Speaking Skills	1

A closer examination of the findings reveals that many studies emphasize learning experience and engagement rather than direct academic achievement. Immersive VR is frequently reported to increase motivation, enjoyment, and classroom engagement, and these outcomes are often highlighted as indicators of success. However, when it comes to academic performance, the results are not always consistent. Some quasi-experimental studies report meaningful improvements in problem-solving or conceptual understanding, yet others show only modest gains or no significant differences compared to traditional instruction. These variations suggest that VR itself is not a guarantee of improved achievement. Its impact appears to depend heavily on how it is integrated into the lesson, how long the intervention lasts, and how well the tasks align with learning objectives. The strong focus on experiential outcomes may also reflect the novelty of immersive technology, as engagement is more immediately visible and easier to capture than long-term academic development. This indicates a need for future research to move beyond short-term engagement measures and examine whether immersive VR can produce sustained cognitive and academic benefits over time.

3.2. Non-Immersive Virtual Reality in Primary Education

Non-Immersive Virtual Reality (NIVR) represents the most accessible form of VR implementation in primary education, as it relies on screen-based interaction without head-mounted displays [35], [36]. Compared to semi-immersive and fully immersive systems, NIVR interventions tended to focus on reinforcing specific competencies rather than creating fully experiential learning environments [21], [22], [35]. Comparative findings suggest that NIVR can produce measurable academic gains when integrated into guided instructional sequences with clear learning objectives [18], [191]. However, results were not entirely consistent. While some quasi-experimental studies reported statistically significant improvement in targeted skills, other investigations found that enhanced engagement did not necessarily translate into substantial achievement gains [17], [37]. These conflicting findings indicate that the instructional context, rather than the technological format alone, plays a decisive role in shaping learning outcomes [38], [39].

Several moderating factors appear to influence NIVR effectiveness. Subject domain is one important variable: NIVR showed relatively stronger outcomes in language-based or literacy contexts, where repetition, structured feedback, and interactive exercises align well with screen-based simulations [40], [41]. In contrast, in science subjects requiring spatial reasoning or embodied interaction, its impact was comparatively limited when not supported by additional visualization scaffolds [10], [42]. Age level may also influence outcomes, as younger primary students often require more explicit guidance to navigate digital tasks effectively. Furthermore, duration of use emerged as a critical factor. Short-term implementations frequently increased participation and interest, yet sustained academic improvement was more likely when NIVR was embedded over longer instructional periods within the curriculum [18], [21].

From a pedagogical standpoint, NIVR appears most effective when used as a complementary instructional tool rather than a stand-alone innovation. Its strength lies in structured practice, reinforcement, and accessible visualization, particularly in resource-limited contexts. In terms of learning design, clear task sequencing, feedback mechanisms, and alignment with assessment criteria are essential to maximize its impact. Without such design considerations, NIVR may enhance engagement without producing meaningful cognitive advancement.

3.3. Semi-immersive Virtual Reality in Primary Education

Semi-immersive Virtual Reality (SIVR) occupies a distinctive position between screen-based applications and fully immersive systems. In primary education contexts, it is typically implemented through shared projection environments or large interactive displays that allow an entire class to engage simultaneously [10], [12]. This collective configuration differentiates SIVR from the more individualized nature of NIVR and the highly personal immersion of FIVR.

Across the reviewed studies, SIVR frequently appeared in classroom-based science and environmental simulations, where visualization of complex systems supported shared inquiry [9], [43]. In several cases, meaningful conceptual gains were reported when SIVR was embedded within inquiry-driven or project-based instructional designs [13], [15]. However, not all findings were equally strong. Some implementations demonstrated heightened enthusiasm and discussion quality without clear evidence of substantial achievement growth [23], [44]. These variations suggest that while SIVR can stimulate collaborative engagement, its cognitive impact depends heavily on how classroom interaction is structured [45], [46].

Across the reviewed studies, differences in age group, subject domain, and duration of exposure appear to shape the effectiveness of SIVR. Younger primary learners often responded positively to collective visual immersion, yet required structured teacher guidance to translate shared simulations into conceptual understanding [16]. Older primary students, in contrast, demonstrated stronger ability to connect simulated environments with analytical reasoning tasks and problem formulation [32], [43]. Subject domain further influenced outcomes: SIVR was more consistently effective in spatially intensive disciplines such as science and geography, where visualization of environmental systems and abstract processes supported shared inquiry, whereas its pedagogical contribution in literacy-oriented subjects was less prominently reported [13], [24]. Duration of implementation also moderated results. Short-term demonstrations frequently enhanced classroom engagement and discussion quality, while longer-term curricular integration was more closely associated with conceptual consolidation and reflective understanding [10], [32].

The reviewed studies demonstrate that the effectiveness of SIVR cannot be attributed solely to its immersive properties. Although increased engagement during shared simulations was frequently observed, the degree of conceptual development differed across implementations. Substantial learning gains were reported primarily in cases where SIVR was embedded within structured instructional sequences that included guided questioning and reflective discussion. In contrast, implementations limited to visual presentation without explicit pedagogical framing tended to enhance participation without producing comparable academic improvement. These findings indicate that immersion intensity alone does not determine learning outcomes. The instructional design, teacher mediation, and integration within curricular objectives play a decisive role in shaping the cognitive impact of semi-immersive environments.

3.4. Fully Immersive Virtual Reality in Primary Education

Fully Immersive Virtual Reality (FIVR) provides the highest level of sensory and spatial engagement through head-mounted displays and motion-based interaction systems [33], [48]. In the reviewed studies, FIVR was most frequently associated with higher-order cognitive outcomes, particularly in STEM-related subjects involving spatial reasoning, simulation-based exploration, and problem-solving tasks [37], [40]. Several quasi-experimental investigations reported statistically significant improvements in conceptual understanding and problem-solving performance when immersive simulations were embedded within structured instructional designs [49]-[51]. Unlike NIVR, which often reinforces discrete skills, FIVR tends to be employed in situations where embodied exploration and environmental interaction are central to the learning objective.

However, the evidence also reveals a distinct tension. While immersive presence enhances realism and emotional involvement, it may simultaneously increase cognitive load. Some studies reported that younger primary learners experienced difficulty maintaining focus when interaction demands were high or when the immersive environment lacked structured guidance [10], [13]. In such cases, the richness of the simulation did not automatically translate into deeper understanding. Instead, the intensity of immersion required careful instructional mediation to prevent distraction or surface-level engagement [9], [10]. A notable distinction of FIVR lies in its capacity to support embodied cognition. When students physically interact with simulated environments, such as navigating ecological systems or manipulating virtual scientific models the learning process shifts from observational to participatory. Studies that incorporated guided exploration and reflection activities reported stronger conceptual integration than those relying solely on immersive exposure [16], [32].

The evidence indicates that FIVR's educational impact is not determined by immersion intensity alone. While immersive presence can enhance attention and experiential involvement, its cognitive effectiveness depends on instructional alignment and learner readiness. In cases where immersive simulations were supported by guided inquiry, reflection tasks, and clear learning objectives, stronger conceptual gains were observed. Conversely, when FIVR was implemented primarily as a technological novelty without structured pedagogical sequencing, improvements tended to remain at the level of engagement rather than durable academic achievement. These patterns suggest that immersive technology functions most effectively as a pedagogically mediated learning environment rather than as an autonomous instructional solution.

The synthesized findings suggest that the educational impact of Virtual Reality (VR) in primary education is shaped not only by the level of immersion but also by pedagogical design and contextual factors. Different immersion levels tend to align with different types of learning outcomes, ranging from skill-based to higher-order cognitive processes. Therefore, a conceptual framework is proposed to illustrate the interaction between VR immersion, instructional design, moderating factors, and learning outcomes.

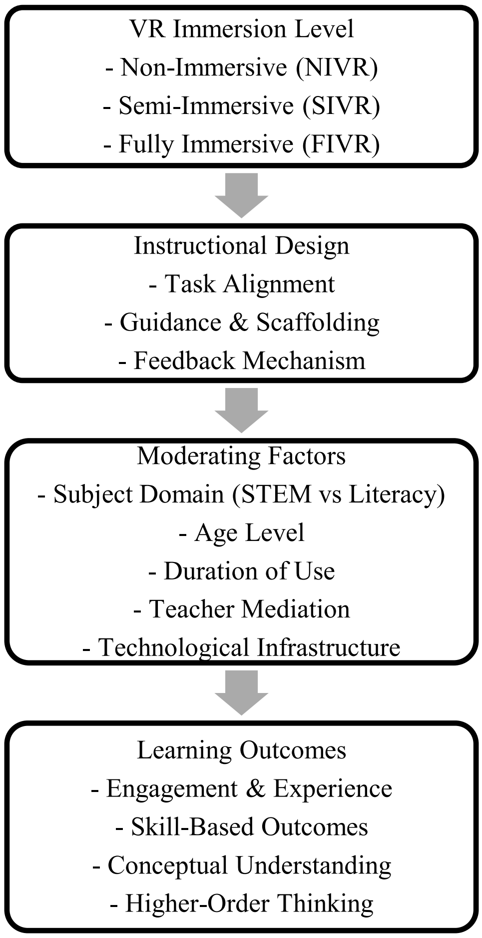

Figure 5. Conceptual framework

Across the reviewed literature, several important research gaps remain evident. First, only a limited number of studies directly compare different immersion levels (non-immersive, semi-immersive, and fully immersive VR) within the same experimental framework. Most investigations examine a single immersion type in isolation, making it difficult to determine whether learning outcomes are influenced primarily by immersion intensity or by instructional design. Second, longitudinal evidence remains scarce. The majority of studies focus on short-term interventions and immediate post-test results, leaving unanswered questions regarding long-term knowledge retention and transfer. Third, relatively few studies explicitly analyze how age differences within primary education (early vs. upper primary grades) influence the effectiveness of immersive technologies. Another gap concerns subject specificity. While STEM-related applications dominate the literature, fewer studies explore immersive VR in literacy, social studies, or interdisciplinary learning contexts. Additionally, the interaction between duration of use and cognitive outcomes remains underexamined. Short-term implementations often emphasize engagement and motivation, but systematic evidence linking extended VR exposure to sustained academic achievement is limited.

The novelty of this review lies in its integrative comparison across immersion levels while simultaneously identifying moderating variables such as subject domain, age group, and intervention duration. Rather than treating VR as a homogeneous technological intervention, this study highlights how contextual and pedagogical factors shape learning outcomes. By synthesizing patterns across multiple research designs and indexing levels, the review provides a more nuanced understanding of when and how immersive VR contributes to primary education.

The implications of these findings are relevant for both educational practice and future research. In practical terms, the review indicates that the adoption of VR in primary education should be aligned with instructional objectives, learner characteristics, and the technological readiness of schools. For teachers and schools, this means that the use of VR should be planned as part of a pedagogical strategy rather than introduced merely as a technological innovation. In broader contexts, the findings also suggest the importance of expanding access to appropriate digital infrastructure and strengthening teacher preparedness to support meaningful VR integration in primary classrooms. For future research, greater attention is needed to comparative designs, longer intervention periods, and more diverse subject areas in order to build a stronger evidence base on the educational value of immersive technologies.

Despite these contributions, this review has several limitations. The analysis was restricted to English-language publications between 2019 and 2025, which may exclude relevant studies published in other languages or earlier foundational work. Variations in research design, sample size, and intervention duration across studies limit direct comparability of findings. Although the CASP framework was applied to ensure methodological quality, differences in reporting standards may still affect interpretation. Furthermore, the review synthesizes qualitative and quantitative findings without conducting a meta-analysis; therefore, conclusions regarding effect magnitude should be interpreted cautiously.

4. CONCLUSION

This review set out to examine how different levels of virtual reality immersion are implemented and studied in primary education. The findings indicate that non-immersive, semi-immersive, and fully immersive VR are not interchangeable formats; each serves different instructional purposes and is associated with different types of learning outcomes. Non-immersive applications tend to reinforce structured skills, semi-immersive systems support shared visualization and classroom interaction, and fully immersive environments are more frequently linked to experiential and spatial learning processes. At the same time, the evidence shows that technological immersion alone does not determine academic impact. The way VR is integrated into lesson design, the developmental readiness of learners, and the alignment between task and learning objective remain central to its effectiveness. Future research would benefit from direct comparisons across immersion levels within similar instructional settings, as well as longer-term investigations into knowledge retention and transfer in primary education contexts.

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AUTHOR CONTRIBUTIONS

Conceptualization, L.E.W.F., M.S., and R.H.; Methodology, L.E.W.F., M.S., and N.A.; Software, L.E.W.F.; Validation, M.S., R.H., N.A., B.S.A., T., and H.Z.; Formal Analysis, L.E.W.F. and M.S.; Investigation, L.E.W.F., R.H., and N.A.; Resources, L.E.W.F., B.S.A., T., and H.Z.; Data Curation, L.E.W.F.; Writing – Original Draft Preparation, L.E.W.F.; Writing – Review & Editing, M.S., R.H., N.A., B.S.A., T., and H.Z.; Visualization, L.E.W.F.; Supervision, M.S.; Project Administration, L.E.W.F. and M.S.; Funding Acquisition, L.E.W.F., M.S., R.H., N.A., B.S.A., T., and H.Z.

INFORMED CONSENT STATEMENT

Informed consent was not applicable to this study because this research was a systematic literature review and did not involve direct participation of human subjects or animals.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried **out** entirely by the authors without the assistance of AI-based technologies.

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