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# Virtual reality platforms in education: a systematic literature review on features, pedagogical uses, and authoring potential

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**ABSTRACT:** This article presents a Systematic Literature Review (SLR) on Virtual Reality (VR) platforms in education, covering studies published between 2022 and 2024. The objective was to identify functionalities, pedagogical uses, authoring potential, and the learning theories underpinning these practices. The SLR followed the PICOC model and the PRISMA 2020 protocol to ensure methodological rigor, transparency, and reproducibility. Searches were conducted in the IEEE Xplore and ERIC databases, and fifteen studies were selected after applying inclusion and exclusion criteria. A quality assessment classified twelve studies as high quality, forming the analytical corpus. The analysis revealed a predominance of constructivist and socioconstructivist approaches, often expressed through project-based learning, gamification, and exploratory strategies. Platforms such as Unity 3D, CoSpaces Edu, and VRTY stood out for enabling student and teacher authorship, allowing for the creation, customization, and personalization of immersive experiences. Authorship was identified as a central pedagogical dimension, fostering agency, creativity, and engagement. Despite these potentials, challenges such as limited infrastructure, high implementation costs, steep learning curves, and insufficient teacher training were consistently reported. These barriers highlight the importance of institutional investment, technical support, and professional development to ensure meaningful integration. By synthesizing recent evidence, this review contributes to systematizing knowledge on VR in education, offering insights for pedagogical practice, guidance for technology developers, and directions for future research.

**Keywords:** authoring potential; educational technologies; immersive education; systematic review; virtual reality.

## *Plataformas de realidade virtual na educação: uma revisão sistemática*

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# *da literatura sobre funcionalidades, usos pedagógicos e potenciais de autoria*

**RESUMO:** *Este artigo apresenta uma Revisão Sistemática da Literatura (RSL) sobre plataformas de Realidade Virtual (RV) na educação, abrangendo estudos publicados entre 2022 e 2024. O objetivo foi identificar funcionalidades, usos pedagógicos, potenciais de autoria e as teorias de aprendizagem que fundamentam essas práticas. A RSL seguiu o modelo PICOC e o protocolo PRISMA 2020, garantindo rigor metodológico, transparência e reprodutibilidade. As buscas foram realizadas nas bases IEEE Xplore e ERIC, resultando na seleção de quinze estudos após a aplicação de critérios de inclusão e exclusão. A avaliação de qualidade classificou doze estudos como de alta qualidade, que compuseram o corpus de análise. Os resultados evidenciaram a predominância de abordagens construtivistas e socioconstrutivistas, frequentemente expressas por meio da aprendizagem baseada em projetos, gamificação e estratégias exploratórias. Plataformas como Unity 3D, CoSpaces Edu e VRTY se destacaram por possibilitar autoria de estudantes e professores, permitindo a criação, personalização e customização de experiências imersivas. A autoria foi identificada como dimensão pedagógica central, favorecendo agência, criatividade e engajamento. Apesar desses potenciais, desafios como infraestrutura limitada, altos custos de implementação, curva de aprendizagem acentuada e falta de formação docente foram amplamente relatados. Essas barreiras evidenciam a necessidade de investimento institucional, suporte técnico e desenvolvimento profissional para garantir integração significativa. Ao sintetizar evidências recentes, a revisão contribui para a sistematização do conhecimento sobre RV na educação, oferecendo subsídios para práticas pedagógicas, orientações para desenvolvedores e direções para pesquisas futuras.*

**Palavras-chave:** *potencial de autoria; tecnologias educacionais; educação imersiva; revisão sistemática; realidade virtual.*

## 1 Introduction

Virtual Reality (VR) has established itself as a promising technology in the educational field, enabling immersive experiences that foster active learning, engagement, and the simulation of educational scenarios (Freina; Ott, 2015; Radianti *et al*., 2020). The literature highlights that the immersion provided by such environments can enhance the understanding of abstract concepts, support knowledge construction, and stimulate both cognitive and socio-emotional skills (Dalgarno; Lee, 2010; Merchant *et al*., 2014).

However, despite the advancement of VR technologies in recent decades (Freina; Ott, 2015; Radianti *et al*., 2020), significant gaps remain in the literature, particularly regarding the systematization of platform functionalities, pedagogical applications, authoring possibilities for teachers and students, and the learning theories underpinning these practices (Parong; Mayer, 2018; Jensen; Konradsen, 2018). Notably, previous reviews have not examined in depth the authorship potential of contemporary VR platforms, an increasingly central aspect as creation-oriented tools and learner-generated content become more prominent in educational contexts.

Furthermore, a theoretical gap persists, as learning theories are often referenced superficially and without systematic categorization. These gaps reveal the need for a more comprehensive and integrated investigation.

In response, this study presents a Systematic Literature Review (SLR) addressing these four gaps, aiming to inform teachers in their pedagogical practices, guide developers in the design of educational technologies, and provide researchers with insights into trends, challenges, and opportunities for future studies in the fields of Education and Immersive Technologies.

The SLR aimed to analyze studies published between 2022 and 2024 that examined the use of VR platforms in education. The temporal scope was limited to the period between 2022 and 2024, a time marked by rapid advances in VR platforms, the growing integration of authoring tools, and the post-pandemic expansion of digital learning ecosystems, which makes this interval particularly relevant for analysis. The guiding research question was: "What functionalities, pedagogical uses, and authoring possibilities are described in academic studies on Virtual Reality platforms applied to education from 2022 to 2024, and which learning theories support these practices?"

To address this question, the article is organized into five sections. This first section presents the contextualization of the topic, the gaps identified in the literature, and the research question guiding the study. The *Materials and Methods* section (section 2) describes the review methodology, highlighting the PICOC model, the PRISMA 2020 protocol, the databases consulted, and the criteria for study selection and quality assessment. The *Results* (section 3) section presents the findings, including the processes of screening, data extraction, and thematic categorization. The *Discussion* section (section 4) then analyzes these results, emphasizing contributions, limitations, and implications for pedagogical practice, educational policies, and future research. Finally, the *Final considerations* section (section 5) synthesizes the main insights, offering recommendations and outlining directions for subsequent investigations.

## 2 Materials and methods

This study adopted the methodology of an SLR as its main guiding framework (Dermeval; Coelho; Bittencourt, 2020), and it was conducted in accordance with the guidelines of the PRISMA 2020 protocol (Page *et al*., 2021), aiming to promote greater methodological rigor, transparency, and reproducibility. The structure of the research was outlined based on the PICOC model, considering: (i) Population: educators and students in educational contexts; (ii) Intervention: VR platforms, immersive environments, and VR-based educational systems; (iii) Comparison: not applicable, given the descriptive nature of the review; (iv) Outcome: functionalities, pedagogical uses, and authorship of immersive experiences; and (v) Context: teaching and learning practices in formal and informal educational settings.

In order to deepen the investigation and broaden the understanding of the use of VR platforms in education, the main research question was unfolded into five specific questions. The formulated questions aimed to address the following inquiries: (a) which VR platforms have been most used in educational contexts?; (b) which pedagogical approaches are associated with the use of these platforms?; (c) which learning theory best represents the logic of each analyzed platform?; (d) in what ways do these platforms enable the authorship of immersive experiences by educators and/or students?; and (e) what challenges and limitations are identified in the studies regarding the educational use of these technologies?

The team responsible for conducting this SLR consisted of five researchers in the field of educational technologies: three Ph.D. candidates and one Master's student, supervised by professor specialized in the field. To ensure organization, traceability, and methodological standardization, the Parsifal platform was used. Parsifal is a free web-based tool developed to support the execution of systematic reviews and mappings, with features focused on collaborative protocol construction, study screening, categorization, and data extraction.

Searches were conducted in the IEEE Xplore Digital Library and ERIC (Education Resources Information Center) databases, recognized for their relevance in the fields of technology and education, respectively. The queries were carried out in April and May 2025 using the following search string, formulated with Boolean operators to maximize coverage: ("*virtual reality*" OR "VR" OR "*immersive environment*" OR "*3D virtual world*") AND ("*education*" OR "*educational use*" OR "*teaching*" OR "*learning*" OR "*pedagogical practices*") AND ("*platform*" OR "*software*" OR "*application*" OR "*tool*") AND ("*authorship*" OR "*content creation*" OR "*authoring tools*" OR "*customization*"). Filters were applied to limit results to publications from January 2022 to December 2024, available in full text in Portuguese, English, or Spanish, considering only journal articles and full conference papers.

Inclusion criteria involved studies addressing the use of VR platforms applied to formal or informal education, with empirical, conceptual, or exploratory approaches. Excluded were duplicate studies, publications that did not directly address VR platforms, studies unrelated to teaching and learning processes, or that did not discuss functionalities, pedagogical uses, or authorship. Abstracts, posters, presentations, non-systematic reviews, and short papers without sufficient data for analysis were also excluded.

The screening of studies was carried out in three stages: reading of titles, reading of abstracts, and full-text reading of the selected papers. Each stage was performed independently by four researchers, with discrepancies resolved by consensus. The complete process of identification, screening, and eligibility was documented in a PRISMA flow diagram, which will be presented in the next section.

For data extraction and analysis, a form was developed in Parsifal containing the following fields: study title, publication year, full reference, type of publication, name of the VR platform or tool analyzed, description of functionalities, educational level or subject area involved, pedagogical approach adopted (such as gamification, project-based learning, or constructionism), description of educational use, authorship possibilities (whether teachers or students were able to create, edit, or customize content), challenges and limitations mentioned, and the learning theories that could be associated with the logic of the platform.

During the data extraction and synthesis stage, the ChatGPT A.I., developed by OpenAI, was used to support the extraction and organization of information, refinement of categories, and drafting of descriptive analyses. It was used exclusively to support synthesis, never to decide inclusion/exclusion or extract non-explicit data. The application of AI-based language models in systematic reviews has been recognized as an effective complementary strategy capable of accelerating steps such as screening and data extraction, reducing inconsistencies, and promoting greater standardization of results. Recent studies, such as Syriani, David and Kumar (2024), have highlighted the potential of ChatGPT in assisting with article screening and data extraction in systematic reviews, provided there is human supervision to ensure the accuracy and integrity of the information.

It is worth noting that although ChatGPT, version 4.5, was used as a support tool, all extracted information was verified and validated by the researchers involved in the review. This step was essential to avoid the use of inaccurate data or content generated by potential AI "hallucinations", ensuring the reliability and quality of the results.

The quality assessment of the studies was carried out based on four criteria: (C1) clarity in the description of the VR platform used; (C2) explicit educational contextualization (education level, target audience, subject area); (C3) discussion of at least one of the following aspects: functionalities, pedagogical uses, or authorship resources; and (C4) presentation of results or methodological reflections that allowed for understanding the application or evaluation of the platform. Each item was rated using three possible scores: "yes" (1 point), "partially" (0.5 point), and "no" (0 points). Studies scoring between 3 and 4 were considered high quality; between 2 and 2.5, moderate quality; and below 2, low quality.

The data synthesis was carried out qualitatively, through thematic categorization guided by the research questions. The data were organized narratively, and the final review was conducted by the supervising professor. Since no meta-analysis was performed, no statistical effect measures or quantitative heterogeneity assessments were used.

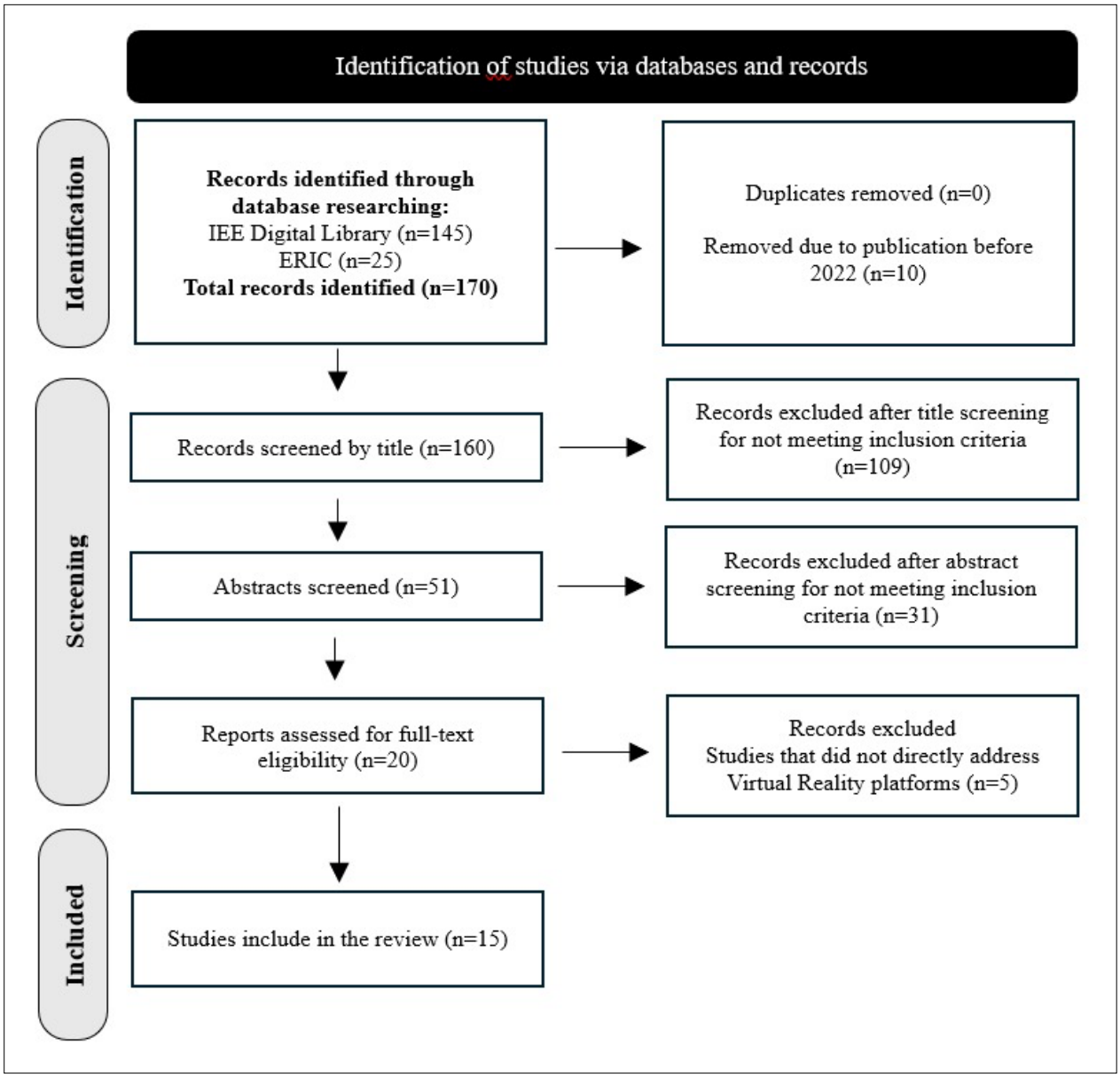
## 3 Results

The results of this systematic literature review are presented in the following subsections, organized according to the stages of study selection, quality assessment, and thematic data analysis. First, the screening and selection process is detailed in accordance with the PRISMA 2020 protocol. Next, the methodological quality of the included studies is examined. Finally, the extracted data are analyzed to identify patterns related to VR platforms, pedagogical approaches, learning theories, authorship features, and reported challenges in educational contexts.

### 3.1 Screening and study selection results

The screening and selection process followed the guidelines of the PRISMA 2020 protocol, covering its four fundamental stages: identification, screening, eligibility, and inclusion. A total of 170 articles were initially identified through virtual databases, with 145 from IEEE Digital Library and 25 from ERIC. After removing 10 articles due to publication dates prior to 2022 and none due to duplication, 160 articles were submitted to title screening, resulting in the exclusion of 109 for not meeting the inclusion criteria. The remaining 51 articles were then subjected to abstract reading, during which 31 were excluded. Advancing to full-text reading, 20 articles were evaluated, of which 5 were excluded for not directly addressing VR platforms. At the end of the process, 15 articles were included in the review. The complete process of identification, screening, and eligibility was documented in a PRISMA-format flow diagram, as shown in Figure 1.

Figure 1 ▼
PRISMA Flow Diagram.
*Source: adapted from Page et al. (2021)*




At the conclusion of the identification, screening, and inclusion stages described in the PRISMA flow diagram, the studies that met all criteria were systematized to support the analysis. Table 1 presents these works in detail, including information on authorship, title, year of publication, and type of study:

Table 1 ▼
Studies included in the SLR.
*Source: research data*

| ID | Author(s) | Title | Year of publication | Type of publication |
|---|---|---|---|---|
| **P1** | Wang *et al.* | Learning Analytics Enabled Virtual Reality Content Creation Platform: System Design and Preliminary Evaluation | 2022 | Conference paper |
| **P2** | Cibuļska; Boločko | Virtual Reality In Education: Structural Design Of An Adaptable Virtual Reality System | 2022 | Conference paper |
| **P3** | Hensen; Klamma | A Mixed Reality Teaching Course for Formal Higher Education | 2022 | Conference paper |
| **P4** | Southgate *et al.* | School students creating a virtual reality learning resource for children | 2022 | Conference paper |
| **P5** | Eloy *et al.* | From Users to Creators: Motivations, Implementation, and Impacts of Augmented and Virtual Reality in Science and Engineering Projects in K-12 Education | 2022 | Conference paper |
| **P6** | Müser *et al.* | Authoring Tools for Teaching in VR – an Evaluation Study | 2023 | Conference paper |
| **P7** | Al-Seiari; Al-Kaabi; Al-Karak. | Exploring Immersive Learning in the Metaverse: A Prototype for Interactive Virtual Classroom | 2023 | Conference paper |
| **P8** | Aresh *et al.* | Integration of Extended Reality (XR) in Non-Native Undergraduate Programmes | 2023 | Conference paper |
| **P9** | Pangsapa *et al.* | Enhancing Humanities Learning with Metaverse Technology: A Study on Student Engagement and Performance | 2023 | Conference paper |
| **P10** | Al-Karaki; Itradat; Mekonen | Immersive Cybersecurity Teaching/ Training Using Gamification on the Metaverse: A Hands-On Case Study | 2023 | Conference paper |
| **P11** | Waidyaratne *et al.* | Wat Arun Metaverse: A Virtual Reality Based Approach for Digitization, Education, and Exploration of Cultural Heritage | 2024 | Conference paper |
| **P12** | Wang; Ng; Hu | Learning Analytics for Collaboration Quality Assessment during Virtual Reality Content Creation | 2024 | Conference paper |
| **P13** | Bobko *et al.* | Exploring the Possibilities of Edu-Metaverse: A New 3-D Ecosystem Model for Innovative Learning | 2024 | Journal article |
| **P14** | Vashisht; Sharma | Interactive Learning: Travelling Through History Using Augmented Reality | 2024 | Conference paper |
| **P15** | Ang *et al.* | Tailored Virtual Environments for Facilitating School Transition in Children with Autism | 2024 | Conference paper |

## 3.2 Quality assessment results

After the selection of studies, the articles were subjected to a quality assessment, guided by the criteria presented in the methodology section. The result of the quality assessment is organized and presented below in Table 2:

Table 2 ▶
Quality Assessment.
*Source: research data*

| ID | C1 | C2 | C3 | C4 | Score | Classification |
|---|---|---|---|---|---|---|
| **P1** | Yes | Yes | Yes | Yes | 4.0 | High quality |
| **P2** | Yes | Yes | Yes | No | 3.0 | High quality |
| **P3** | Yes | Yes | Yes | Yes | 4.0 | High quality |
| **P4** | Yes | Yes | Yes | Partially | 3.5 | High quality |
| **P5** | Yes | Yes | Yes | Yes | 4.0 | High quality |
| **P6** | Partially | Yes | Yes | Yes | 3.5 | High quality |
| **P7** | Yes | Partially | Partially | Partially | 2.5 | Low quality |
| **P8** | Yes | Yes | Yes | Yes | 4.0 | High quality |
| **P9** | Partially | Partially | Partially | Yes | 2.5 | Moderate quality |
| **P10** | Yes | Yes | Yes | Yes | 4.0 | High quality |
| **P11** | Yes | Yes | Yes | Partially | 3.5 | High quality |
| **P12** | Yes | Yes | Yes | Yes | 4.0 | High quality |
| **P13** | Partially | No | Partially | No | 1.0 | Low quality |
| **P14** | Yes | Yes | Yes | Yes | 4.0 | High quality |
| **P15** | Yes | Yes | Yes | Yes | 4.0 | High quality |

Of the 15 studies analyzed, 12 were considered high quality, and 3 were classified as low quality. The studies rated as high quality satisfactorily met the previously established criteria, presenting clear descriptions of the VR platforms used, well-defined educational contextualizations, relevant discussions on pedagogical aspects, and data or methodological reflections that supported an understanding of their practical applications. On the other hand, the three studies classified as low quality presented significant gaps in the analyzed dimensions, which compromised their contribution to the objectives of the review. For this reason, and according to the adopted inclusion criteria, these studies were excluded from the final scope of the review, ensuring greater rigor and reliability in the results obtained.

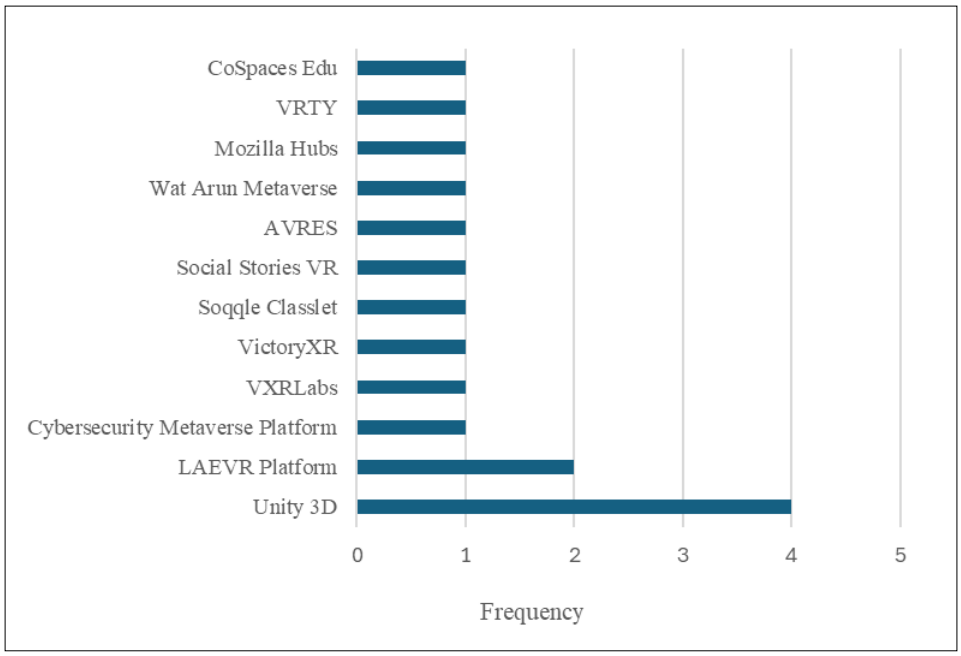
## 3.3 Results of extracted data analysis

The analysis of the extracted data was conducted in alignment with the research questions defined in the protocol. This subsection synthesizes the main findings regarding the technological platforms adopted, the pedagogical approaches associated with their use, the underlying learning theories, the degree of authorship enabled within immersive environments, and the challenges reported in the literature. The results are presented thematically to highlight patterns, convergences, and distinctions across the selected studies.

a) **Which platforms have been most used in educational contexts?**

Based on the data extracted from the twelve selected studies, a bar chart (Figure 2) was generated to identify which VR platforms, engines, or systems were most frequently used:

Figure 2 ▶
VR platforms.
*Source: prepared by the authors*




It is important to note that several studies employed more than one technology simultaneously – for example, combining a development engine with toolkits, metaverse infrastructures, or dedicated authoring environments. Although the corpus comprises twelve studies, the analysis includes sixteen distinct technological solutions, reflecting the heterogeneity of VR ecosystems adopted in educational contexts. From a functional perspective, eight studies explicitly investigate VR content-creation or authoring environments, including the works of Wang *et al*. (2022), Wang, Ng and Hu (2024), Cibuļska and Boločko (2022), Hensen and Klamma (2022), Southgate *et al*. (2022), Müser *et al*. (2023), Eloy *et al*. (2022), and Aresh *et al*. (2023).

The remaining studies focus on immersive platforms without authoring capabilities, in which learners explore or interact with predefined content rather than creating new VR experiences. This is the case for the works of Waidyaratne *et al*. (2024), Al-Karaki, Itradat and Mekonen (2023), Vashisht and Sharma (2024), and Ang *et al*. (2024).

As shown in Figure 2, Unity 3D appears with high frequency, being widely used as a development engine across several initiatives, often in combination with tools such as the Mixed Reality Toolkit (MRTK) and Vuforia to create immersive experiences (Hensen; Klamma, 2022). The VRTY platform was also mentioned for enabling elementary school students to develop their own VR content (Southgate *et al*., 2022).

Other identified solutions include CoSpaces Edu, used in K–12 education for building interactive digital narratives and STEM projects (Eloy *et al*., 2022), as well as proprietary or in-development systems such as the Adaptive VR Education System (AVRES) (Cibuļska; Boločko, 2022) and the Learning Analytics Enabled VR Content Creation Platform (Wang *et al*., 2022).

Unity also underpins creation-oriented or mixed-reality development efforts discussed in Eloy *et al*. (2022) and Aresh *et al*. (2023), reinforcing its central role in both K–12 and higher-education contexts. Another recurring category involves school-oriented or web-based authoring environments, such as those described by Southgate *et al*. (2022), who enabled students to design their own VR learning resources, and by Müser *et al*. (2023), who evaluated a VR authoring environment for higher-education instructors.

Complementing these tools, the Learning Analytics Enabled VR Content Creation Platform – examined individually in Wang *et al*. (2022) and collaboratively in Wang, Ng and Hu (2024) – offers creation, editing, and monitoring functionalities specifically designed for educational scenarios.

Two studies focus on emerging experimental systems, such as the adaptive VR architecture proposed by Cibuļska and Boločko (2022) and the customizable Social Stories VR environment developed by Ang *et al*. (2024). In contrast, several studies do not emphasize authoring capabilities but instead examine exploratory, domain-specific immersive environments. The Wat Arun Metaverse (Waidyaratne *et al*., 2024) offers a cultural-heritage VR experience with interactive elements but no user-generated content. A similar pattern appears in the metaverse-based cybersecurity training platform analyzed by Al-Karaki, Itradat and Mekonen (2023), in which participants engage in immersive simulations but cannot modify the underlying environment. The same applies to the AR/VR history-learning application developed by Vashisht and Sharma (2024), which focuses on interactive learning without providing authoring features.

Overall, this distribution of platforms reveals a clear distinction between creation-oriented and exploration-oriented technologies. While authoring environments promote agency, creativity, and learner-generated content, exploratory platforms emphasize immersion, guided interaction, and predefined learning trajectories. This duality reflects contemporary trends in VR research and practice, in which educational outcomes depend heavily on the role learners assume within virtual environments: creators or explorers.

b) **Which pedagogical approaches are associated with the use of these platforms?**

The analysis indicated that the use of VR platforms in educational settings was predominantly associated with pedagogical approaches centered on active student participation. Project-based learning was identified in several studies, particularly applied in higher and elementary education, in fields such as Science, Technology, and Interdisciplinary Education. In these cases, students were challenged to plan, develop, and present immersive digital products using tools like Unity 3D and CoSpaces Edu, such as virtual experiences, simulations, and interactive prototypes (Hensen; Klamma, 2022; Eloy *et al*., 2022; Wang; Ng; Hu, 2024; Aresh *et al*., 2023).

Gamification, which is an approach based on the use of game elements in various contexts, appeared in three studies, being employed to increase student engagement through game-inspired dynamics, using challenges, symbolic rewards, and interactive narratives (Waidyaratne *et al*., 2024; Al-Karaki; Itradat; Mekonen, 2023; Vashisht; Sharma, 2024). In other studies, VR was used as a tool to support the active exploration of environments, allowing students to investigate 3D scenarios, access visual content, and carry out tasks requiring decision-making and problem-solving, particularly in science activities in lower secondary education (Southgate *et al*., 2022; Eloy *et al*., 2022; Ang *et al*., 2024).

Additionally, the data show that the platforms were used in diverse ways: in some cases, students created immersive experiences based on their own ideas and research

(Wang *et al*., 2022; Hensen; Klamma, 2022; Southgate *et al*., 2022; Müser *et al*., 2023; Eloy *et al*., 2022; Wang; Ng; Hu, 2024; Ang *et al*., 2024); in others, they navigated preconfigured scenarios as a way to visually explore curricular concepts or cultural heritage (Waidyaratne *et al*., 2024; Al-Karaki; Itradat; Mekonen, 2023; Vashisht; Sharma, 2024).

The most common educational level was higher education, especially in teacher training and educational technology courses (Wang *et al*., 2022; Cibuļska; Boločko, 2022; Hensen; Klamma, 2022; Müser *et al*., 2023; Aresh *et al*., 2023; Wang; Ng; Hu, 2024; Vashisht; Sharma, 2024), followed by lower secondary education, with a focus on science and interdisciplinary projects (Southgate *et al*., 2022; Eloy *et al*., 2022; Ang *et al*., 2024).

c) **Which learning theory best represents the logic of these platforms?**

The examination of the twelve studies reveals that the educational use of VR technologies is grounded in five distinct learning theories, each shaping how the platforms are designed and implemented in pedagogical contexts. Constructivism emerged as the predominant theoretical orientation, guiding six studies (Wang *et al*., 2022; Cibuļska; Boločko, 2022; Hensen; Klamma, 2022; Müser *et al*., 2023; Eloy *et al*., 2022; Aresh *et al*., 2023). In these cases, VR environments were structured to support active engagement: learners manipulated digital objects, explored virtual scenarios, produced immersive artifacts, and refined ideas through practical experimentation. The emphasis on "learning by doing" aligns closely with constructivist principles of meaning-making through interaction with the environment. These studies follow Piaget's line of research, considering the human being as an active agent in the learning process (Oliveira; Costa; Moreira, 2001).

A second group of studies was best explained through a cognitivist lens, particularly those that foregrounded information processing and structured exploration (Southgate *et al*., 2022; Waidyaratne *et al*., 2024). These platforms presented multimodal representations, spatial visualizations, and problem-oriented tasks designed to activate attention, memory, and conceptual organization. Here, VR operated less as a space for creation and more as a medium for guided cognitive engagement with complex content.

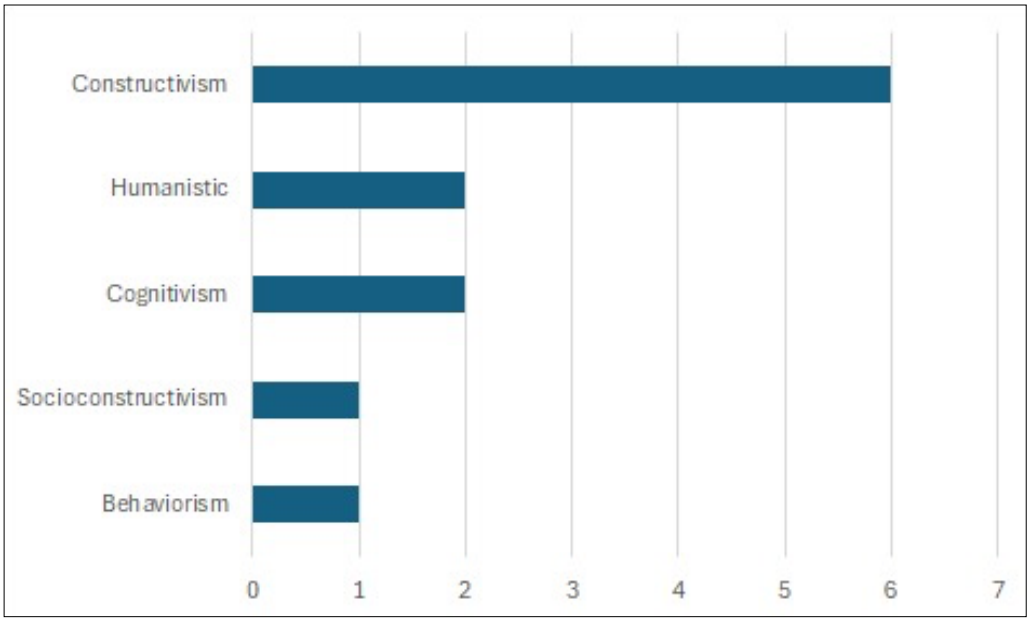
Behaviorism, based on the studies of Skinner and Watson, involves educational practices related to behaviors, positive reinforcement or reward; learning is explained by the stimulus-response relationship (Oliveira; Costa; Moreira, 2001). Behaviorism appeared less frequently, being identified in one study (Al-Karaki; Itradat; Mekonen, 2023). In this case, VR was used within a gamified cybersecurity training environment in which learning progressed through cycles of stimulus, response, and reinforcement. Points, levels, and immediate feedback structured the experience, highlighting a performance-driven approach centered on observable behavioral change.

Only one study was most aligned with socioconstructivism (Wang *et al*., 2024). This work examined a collaborative authoring platform in which learning emerged through social interaction – students coordinated tasks, negotiated meaning, and co-created virtual environments. The platform's reliance on shared spaces and group-based problem-solving reflects the socioconstructivist emphasis on knowledge-building as a collective endeavor. For Vygotsky, a leading figure in socioconstructivism, the learning process is related to the interaction of individuals with the environment in which they are embedded (Oliveira; Costa; Moreira, 2001).

Finally, humanistic principles were identified in two studies (Vashisht; Sharma, 2024; Ang *et al*., 2024), both of which highlighted learner autonomy, personalization, and

emotional–developmental support. These platforms enabled individualized pathways – whether through tailored historical narratives or adjustable VR social stories – affirming the humanistic concern with agency, self-direction, and the uniqueness of each learner. Figure 3 clearly illustrates this predominance by comparing the frequency of the different learning theories associated with the analyzed platforms:

Figure 3 ▶
Learning theories associated with VR platforms.
*Source: prepared by the authors*




d) **How do the analyzed platforms enable the authorship of immersive experiences by educators and/or students?**

Across the twelve selected studies, different levels of authorship emerged, ranging from full content creation to restricted interaction with predefined environments. Eight studies provided mechanisms that enabled educators and/or students to create, edit, or customize immersive content, while four studies did not include authoring features, focusing solely on exploration or guided interaction.

Among the creation-oriented platforms, several studies described environments that enabled users to design their own immersive experiences. In Hensen and Klamma (2022), higher education students used Unity 3D, the Mixed Reality Toolkit (MRTK), and Vuforia to build mixed reality prototypes, exercising skills in interactive design and content creation. Similarly, in Southgate *et al*. (2022), elementary school learners used VRTY to create VR learning resources enriched with personalized media.

Teacher authorship also appears prominently. Müser *et al*. (2023) report the use of a VR authoring environment that allowed university instructors to assemble and modify immersive scenarios without requiring programming skills, lowering the technical threshold for educational creation. Eloy *et al*. (2022) highlight how middle and high school students employed CoSpaces Edu to design AR/VR projects addressing real-world school challenges, reinforcing the pedagogical potential of accessible authoring tools.

Two studies focused specifically on advanced content-creation platforms supported by learning analytics. In Wang *et al*. (2022), users created and customized VR environments through a visual authoring interface, while Wang, Ng and Hu (2024) expanded this approach to collaborative settings, in which multiple participants co-created immersive

content and received analytics-based feedback on collaborative quality. Authorship also appears in Ang *et al*. (2024), where parents and educators customized Social Stories VR environments to support children's socioemotional development. Furthermore, Aresh *et al*. (2023) describe the development of a Unity-based XR system that enables undergraduate students to engage in CAD-related creation tasks, positioning the platform within the category of authoring-oriented educational tools.

In contrast, four studies did not provide mechanisms for learners to create or modify immersive content, instead focusing on engagement with predefined environments. The Adaptive VR Education System (AVRES), analyzed by Cibuļska and Boločko (2022), offers adaptive feedback and multiuser interaction but does not include tools for user-generated content. Likewise, Waidyaratne *et al*. (2024) present the Wat Arun Metaverse, a cultural heritage experience in which students explore interactive 3D environments without altering or authoring scenarios. A similar pattern appears in Al-Karaki, Itradat and Mekonen (2023), whose cybersecurity training metaverse relies on scripted challenges and gamified tasks but does not allow modification of the underlying virtual space. Finally, Vashisht and Sharma (2024) describe the development of an AR/VR history learning application with interactive elements but no authoring capabilities for students or educators.

e) **What challenges and limitations are identified in the studies regarding the educational use of these platforms?**

One of the most recurrent challenges was access to appropriate equipment, such as VR headsets, powerful computers, and stable internet connections – especially in school contexts with limited infrastructure (Cibuļska; Boločko, 2022; Aresh *et al*., 2023; Waidyaratne *et al*., 2024; Al-Karaki; Itradat; Mekonen, 2023; Ang *et al*., 2024). Additionally, Hensen and Klama (2022) emphasize that even when resources are available, there are barriers related to the need for specialized hardware and the adaptation of physical spaces for immersive technology use.

Another frequently mentioned issue in multiple studies refers to the initial learning curve for using the platforms, affecting both students and educators. Wang *et al*. (2022) and Müser *et al*. (2023) point out that mastering these tools requires time and specific training, making it necessary to invest in technical support and teacher professional development to ensure effective pedagogical integration (Eloy *et al*., 2022).

Aspects related to the quality of the immersive experience were also discussed. Southgate *et al*. (2022) notes that limited time for developing the experiences may compromise the pedagogical depth of students' projects. Wang *et al*. (2022) and Ang *et al*. (2024) also highlight limitations concerning collaboration and personalization, such as difficulties in balancing autonomy with effective interaction in collaborative environments and in tailoring virtual settings to users' specific needs.

Additionally, Al-Karaki, Itradat and Mekonen (2023) emphasize the challenge of scalability and technological integration of VR solutions on a large scale, considering the diversity of educational systems and learning environments, while Waidyaratne *et al*. (2024) point to issues of digital inclusion and the technical complexity of maintaining high-quality immersive applications over time.

## 4 Discussion

The analysis of the twelve selected studies revealed not only the diversity of platforms used but also the ways in which these technologies have been mobilized for pedagogical purposes, with varying levels of technical sophistication, authoring possibilities, and theoretical foundations. This panorama aligns with previous reviews (Freina; Ott, 2015; Radianti *et al*., 2020), which had already highlighted the potential of VR to promote experiential learning and student motivation, but advances by emphasizing the expansion of authorship opportunities and integration with approaches such as project-based learning, gamification, and interdisciplinary teaching.

The recurrent use of engines such as Unity 3D and more accessible platforms like CoSpaces Edu and VRTY reflects a trend toward expanding VR beyond passive simulation, with an increasing focus on the active construction of knowledge. The predominance of constructivism across the analyzed studies is not accidental; rather, it reflects the intrinsic nature of VR as a technology that privileges active manipulation, exploration, and experiential meaning-making. VR fundamentally requires a pedagogical shift from transmissive instruction toward learner-centered approaches, as students must navigate, interpret, and transform immersive environments rather than merely receive information. Students who act as creators, rather than passive viewers, engage in deeper cognitive processing and develop more robust conceptual understanding. Compared with earlier studies, there is also evidence of a rise in the development of customized educational platforms, which may indicate stronger collaboration among researchers, developers, and educators in designing meaningful immersive experiences.

Despite the relevant contributions of the analyzed studies, some limitations were identified. First, most of the evidence comes from conference papers (12 out of 15 studies), which may indicate a lower degree of scientific maturity in some of of the publications and reduced methodological detail. Moreover, many of the reported experiences were still in pilot or prototyping stages, limiting the generalizability of the results. A predominance of studies in higher education and in Northern Hemisphere contexts was also observed, which reduces the representativeness of more diverse educational realities.

It should be noted that none of the studies discussed accessibility or inclusivity. Accessibility within VR is limited, with many developers struggling to understand how to best implement assistive tools and features (Ji *et al*., 2023), and users with disabilities are often unable to utilize this technology (Mott *et al*., 2020). This can be especially damaging when students with disabilities will not be able to utilize VR, hindering their learning experience. Additionally, other ethical aspects of VR use, such as sustainability and data privacy, were not addressed directly (Peña-Acuña; Rubio-Alcalá, 2024).

Furthermore, it is important to recognize that these interpretations are influenced by the restricted temporal scope of the review (2022–2024) and the reliance on only two databases (IEEE Xplore and ERIC). While this strategy ensured methodological focus, it may have limited the breadth of perspectives captured, especially studies published in other repositories or emerging journals. These limitations, however, do not invalidate the findings, but suggest a cautious interpretation and highlight the importance of future reviews expanding the evidence base by including more diverse sources.

Regarding the review procedures, it is acknowledged that, although the PRISMA 2020 methodology and the PICOC model were rigorously followed, only two databases (IEEE Xplore and ERIC) were used, which may have restricted the scope of the search. Nevertheless, the findings of this review provide relevant contributions for different audiences. For pedagogical practice, the results indicate that VR platforms

can be successfully integrated into active methodologies, provided there is adequate infrastructure, teacher training, and pedagogical intentionality. For educational managers and policymakers, the data reinforce the importance of investing in technological infrastructure and accessibility, as well as in teacher training for the critical and creative use of these technologies. For the research field, the need for long-term studies with greater geographical and educational diversity is highlighted, along with investigations exploring the impact of VR on deep learning, digital inclusion, student authorship, and competency-based assessment. Expanding studies that articulate VR with other emerging technologies, such as artificial intelligence and the educational metaverse, is also recommended.

## 5 Final considerations

This SLR aimed to analyze the use of VR platforms applied to education between 2022 and 2024, with emphasis on the functionalities offered, reported pedagogical uses, authorship possibilities for teachers and students, and the learning theories underpinning these practices. From the analysis of twelve studies considered high quality, it was possible to identify relevant trends, as well as recurrent challenges and opportunities for future investigations.

The results revealed that VR has been increasingly incorporated into educational contexts, with a focus on promoting active learning, personalized experiences, and collaborative environments. The predominance of pedagogical approaches such as project-based learning and gamification, together with the strong presence of constructivist and socioconstructivist foundations, reinforces VR's potential as a tool for meaningful knowledge construction. Furthermore, the advancement of creation possibilities in the analyzed platforms stands out, enabling students and educators not only to explore content but also to become creators of immersive experiences with pedagogical intentionality.

On the other hand, the review also highlighted important limitations, such as the need for adequate infrastructure, specialized teacher training, the complexity of certain tools, and the difficulty of scalability in diverse educational realities. These challenges point to the urgency of public policies and institutional investments that ensure equitable and sustainable use of these technologies in different contexts.

For future studies, long-term empirical investigations are recommended, with a focus on learning assessment, digital inclusion, competence development, ethics, accessibility, and integration with other emerging technologies such as artificial intelligence, the educational metaverse, and spatial computing.

In summary, the findings of this review indicate that VR platforms represent not only a technological innovation but also a paradigmatic transformation in how education is conceived, organized, and experienced. Their conscious, ethical, and pedagogically grounded use can contribute to more meaningful, creative, and inclusive educational experiences in both the present and the future.

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## Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

## Ethics statement

This study is a systematic literature review based exclusively on previously published studies and did not involve human participants or animals. Therefore, ethical approval was not required.

## Author contributions

**VALE, L. M. A.; ARRUDA, D. D.; AMARAL, P. D. A.; JALIL, S. M.:** conceptualization; methodology; data curation; formal analysis; writing – original draft; writing – review and editing. **ANDRADE, A. F.:** supervision; validation; critical revision of the manuscript; intellectual contribution to the study design and theoretical framework.

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