

The Role of Virtual Reality in Enhancing the Quality of History Learning: A Systematic Literature Review Based on SDG 4

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Abstract: This study aims to analyze prior research on the application of Virtual Reality in history education and its role in improving educational quality. Furthermore, the analysis linked Virtual Reality's role to the objectives of SDG 4 (Quality Education). A systematic literature review (SLR) was conducted to filter relevant articles using the PRISMA guidelines. After screening, 20 articles that met the inclusion criteria were selected and then analyzed descriptively. The findings indicate that the use of Virtual Reality generally contributed to improving the quality of history learning across the 20 reviewed articles. However, variations were observed in effectiveness and implementation, influenced by the types of VR employed, including the Anne Frank VR House, 360° videos, HMD-based VR, Oculus Quest 2, CloudPano, and VR-based games. The potential of Virtual Reality (VR) to support several targets under SDG 4, particularly SDG 4.1 on improving the effectiveness of learning, SDG 4.3 on access to technology-based higher education, SDG 4.4 on the development of 21st-century digital skills, SDG 4.5 on inclusive and equitable education, and SDG 4.c on improving the competence of educators. This study finds that virtual reality has the potential to enhance the quality of history learning by enabling exploration of visual spaces. However, there are challenges in its implementation that require teacher training and support from schools and the government, as well as adequate funding and infrastructure, to maximize the use of Virtual Reality in history learning. Future research is expected to expand the scope of the database, the types of technologies, and the SDG aspects analyzed, yielding a more comprehensive understanding of the role of immersive technologies in sustainable education.

Keywords: virtual reality, history learning, SDGs4, systematic literature review.

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■ INTRODUCTION

The transformation of learning patterns in the 21st-century education era has changed the conventional learning model. 21st-century learning is a key component of Sustainable Development Goal 4 (SDG 4), which aims to ensure inclusive, equitable, and quality education and to promote lifelong learning opportunities for all. SDG 4 emphasizes the importance of education as a tool for achieving other sustainable development goals, such as poverty eradication, gender equality, and social justice (Miranda Gonçalves, 2023). One of the characteristics of 21st-century learning is

the integration of technology into the learning process as part of efforts to transform education.

The 4.0 Industrial Revolution has brought about major changes in education, driving the integration of technology to meet the need for learning that is more flexible, adaptive, and relevant to the challenges of the times (Lin et al., 2025). The integration of technology into the learning process is supported by several reasons that contribute to the effectiveness and quality of learning. Technology can boost student motivation by creating a more interactive and engaging learning experience (Das & Malaviya, 2025).

Furthermore, Yaseen et al. (2025) explain that the use of technology in the learning process enables learning tailored to individual student needs, such as through adaptive learning tools and personalized feedback. In terms of flexibility, technology removes the constraints of time and place in learning, allowing students to learn anytime, anywhere (Yadav, 2025). In the long term, integrating technology into education helps students prepare for future demands, such as digital literacy and the ability to use technological tools (Pilgrim et al., 2025). Therefore, the integration of technology is also an important aspect of history learning, where teachers are required to develop innovative and interactive learning approaches that are relevant to the characteristics of digital-generation students.

As a subject taught at various levels of education, history aims to develop diachronic and synchronic thinking skills, to understand causality, and to train creative, critical, selective, and synthetic thinking skills for analyzing various historical sources and for narrating history in writing (historiography) (Chapman, 2021). History, as a subject studied in formal educational institutions, not only provides cognitive understanding but also fosters students' character, helping them become responsible citizens and cultivating a sense of love and pride for the nation and country. Furthermore, in practice, the teaching of history in schools still faces various pedagogical challenges that affect the quality of students' understanding. History is often taught through a textual approach and the memorization of chronological events, making it difficult for students to grasp the social, cultural, and emotional contexts of historical events.

A lack of historical empathy is one of the key challenges in modern history education. Students often struggle to imagine the situations, conditions, and human experiences of the past due to the limited availability of educational media that provide contextual learning. When instruction

focuses solely on textbooks and verbal explanations, students tend to absorb information passively, without developing emotional or spatial engagement with the historical events being studied. This situation results in low interest in learning, low classroom engagement, and a reduced ability for students to construct a deep understanding of historical meaning. Additionally, the use of lecture-and-note-taking methods, which certainly cannot fully engage students, makes learning boring (Bonsu et al., 2024).

Efforts to address the challenges of history learning today include maximizing the use of technology, such as Virtual Reality. Virtual Reality is understood as a simulation technology that can load and present a virtual world experience (Puiu & Udri'tioiu, 2024). Howard & Gutworth (2020) explain that the term VR refers to technology that creates a three-dimensional artificial world that stimulates sight and hearing, simulating the real world or imagination (Dechsling et al., 2024). This is consistent with the 4E cognitive framework, specifically the "embodied" dimension, where physical experiences and interactions with the environment contribute to thinking and understanding, and the "extended" dimension, which involves the use of tools, technology, and external resources to support thinking processes (Korte & Körkkö, 2024). The effectiveness of VR in learning is explained by the embodied cognition approach, which emphasizes that cognitive processes occur not solely through mental activity but are also shaped by the body's interaction with the environment. In history education, the visual and spatial experiences provided by VR enable students to construct more concrete mental representations of past events.

Virtual reality creates a learning environment that allows students to interact directly with objects or situations that are difficult to access in the real world, such as exploring historical sites (Kuznetcova & Glassman, 2018). Several studies

indicate that the use of virtual reality positively impacts the educational environment (Kusherbaevna et al., 2025). Virtual Reality provides opportunities for students to maximize their visual thinking skills through advanced visualization technology in both physical and virtual environments (Rodríguez, 2024). The implementation of technology in classroom learning has become a current teaching trend, including in history lessons (Zajda & Whitehouse, 2026). Virtual Reality is ideal for studying historical topics (Serrano-Ausejo & Mozelius, 2025), because it facilitates students' emotional experiences through three-dimensional visualization. A study by G. Zhang (2019) shows that students who use virtual reality are more motivated and achieve better academic results than those using conventional teaching methods.

Virtual Reality technology is now specifically designed for museums and historical sites, offering innovative ways to explore and interact with heritage (Villena-Taranilla & Diago, 2025). The use of Virtual Reality in Indonesia has so far been implemented in several museums and through websites such as Indonesia Virtual Tour and Museum Nasional Indonesia Virtual Tour. Learning about historical events through three-dimensional visualizations in Virtual Reality makes it much more interesting. However, virtual reality technology cannot be viewed solely in terms of innovation and technological sophistication. The use of technology in education needs to be evaluated more comprehensively to determine the extent to which it truly contributes to the goals of sustainable education. In this context, SDG 4 (Quality Education), established by the United Nations, can serve as an evaluative lens to understand the impact of VR use in education more holistically. SDG 4 not only emphasizes improving the quality of learning but also accessibility, inclusivity, and educational equity for all students.

Through SDG 4 (Quality Education), the United Nations emphasizes the importance of

providing inclusive, equitable, and quality education for all through a series of interrelated targets. Target 4.1 highlights the importance of effective, high-quality primary and secondary education. At the same time, Target 4.4 emphasizes mastery of 21st-century skills, including digital literacy and technological competencies relevant to the demands of the modern world. Additionally, Target 4.5 underscores the importance of equitable, nondiscriminatory access to education, while Target 4.7 positions education as a means of fostering global awareness, tolerance, and sustainable development. On the other hand, Target 4.c emphasizes the importance of enhancing teacher competencies as key actors in educational transformation. Overall, SDG 4 focuses not only on expanding access to education but also on improving the quality of learning, strengthening digital skills, promoting inclusivity, and ensuring education is prepared to face the challenges of the digital age and the ever-evolving global landscape.

From the perspective of SDG 4, the implementation of VR in education is analyzed not only for its effectiveness in improving learning outcomes but also for the extent to which this technology is equitably accessible, supports inclusive learning, and reduces educational disparities in the digital age. Quality education emphasizes equal access, effective learning outcomes, and the use of digital learning resources to support lifelong learning by providing high-quality materials accessible anytime, anywhere (Huzooree & Yadav, 2025). The UN's 2030 Agenda emphasizes the importance of efforts to ensure inclusive, equitable, and quality education and promote lifelong learning for all (Fuentes-Penna et al., 2025). Therefore, studies on the use of VR in education should not focus solely on aspects of learning effectiveness, such as increased motivation, engagement, or student learning outcomes. Rather, the use of VR in history education needs to be understood within the

framework of sustainable educational development.

Several previous Systematic Literature Reviews have shown that VR has the potential to improve the quality of learning through interactive, immersive experiences. Research by Villena-Taranilla and Diago (2025) discusses the challenges and implications of using VR in history education, particularly regarding the technical, economic, psychological, and social aspects of its implementation. Meanwhile, research by Hamilton et al. (2021) highlights that VR can increase student engagement and provide a more immersive learning experience compared to conventional learning. Other studies also indicate that VR has the potential to support innovation in learning and digital educational transformation across various fields of study (Lampropoulos & Kinshuk, 2024; Rojas-Sánchez et al., 2023). However, most previous research has primarily focused on the effectiveness of the technology, learning experiences, and the technical aspects of VR implementation. These studies have not specifically used SDG 4 (Quality Education) as an analytical framework for examining the impact of VR on sustainable education, particularly in supporting Target 4.4 which focuses on strengthening relevant 21st-century skills and digital literacy and Target 4.5, which emphasizes the importance of inclusive, equitable, and accessible education for all learners without discrimination.

Based on a review of previous research, the integration of the SDG 4 perspective into VR studies in history education represents both a research gap and an important area of novelty that warrants further development to yield a more comprehensive understanding of VR technology's role in supporting sustainable educational development in the digital age. The authors view this as an opportunity to conduct a systematic literature review on the role of Virtual Reality in improving the quality of history learning, aligned

with SDG 4. To make this research more focused, the researchers formulated the following research questions:

- RQ1: What is the role of Virtual Reality (VR) in history learning?
- RQ2: What are the challenges faced in applying Virtual Reality in history learning?
- RQ3: How does Virtual Reality contribute to the achievement of Sustainable Development Goal 4 (SDGs 4) on quality education?

■ METHOD

Research Design

This study employed a Systematic Literature Review (SLR) design consisting of four stages: research design, search strategy, development of inclusion and exclusion criteria, and data analysis. This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure that the Systematic Literature Review (SLR) process was conducted in a systematic, transparent, and reproducible manner (Page et al., 2021). The research design stage was conducted to determine the focus and procedures of the systematic review. Next, the search strategy was implemented using scientific databases, using keywords relevant to the research topic. The retrieved articles were then screened based on inclusion and exclusion criteria to ensure the suitability and quality of the data sources. In the final stage, the data were analyzed using thematic analysis and narrative synthesis to identify patterns in the findings, as well as VR's contribution to history learning and the achievement of SDG 4. A systematic review is defined as the process of identifying literature that meets specific search and inclusion criteria within a particular field of study (Burgos, 2024). The SLR research process began with clear and focused research questions (Lefavre & Slobogean, 2013). Next, a detailed research

design was created, outlining the inclusion and exclusion criteria, search strategy, and methods for data extraction and analysis (Višič, 2022). The SLR process follows a structured process that enhances transparency and productivity, thereby making the findings more credible (García-Peñalvo, 2022). The use of the Scopus and Garuda databases in this study was based on considerations of quality, credibility, and the scope of literature relevant to the research topic. Scopus was selected because it is a reputable international database that provides peer-reviewed scientific articles with high publication standards and has a broad multidisciplinary scope, enabling researchers to access the latest references on Virtual Reality (VR), history education, and SDG 4 from a global perspective. Meanwhile, Garuda was used to supplement national literature relevant to Indonesia's educational context, particularly research on the implementation of VR in history education in local educational settings. The combination of these two databases allows the study to access more comprehensive, credible, and contextually relevant data sources, thereby strengthening the validity of the research findings. The search was limited to the period 2020 to 2025 due to its relevance to the current modern educational context.

Search Strategy

The literature search strategy was conducted using search terms tailored to the characteristics of the Scopus and Garuda databases. In the Scopus database, the search used the following combination of keywords: (“virtual reality” OR VR OR “immersive learning”) AND (“history education” OR “history learning” OR “history teaching”) AND (“quality education”

OR “SDG 4” OR “sustainable development goal 4”). Meanwhile, in the Garuda database, the following keywords were used: (“virtual reality”, “pembelajaran sejarah”, “pendidikan sejarah”, “SDG 4”, “pendidikan berkualitas”). The use of Boolean operators such as AND and OR aims to both broaden and narrow the search results so that the articles obtained align with the research topic regarding the role of Virtual Reality in improving the quality of history learning from the perspective of SDG 4. The initial search yielded 284 articles relevant to the keywords. The articles obtained were then screened using inclusion and exclusion criteria. The inclusion and exclusion criteria for the screening process in this study are presented in Table 1.

Inclusion and Exclusion Criteria

Selecting appropriate and inappropriate articles is important during the research planning phase (Torsello et al., 2012). The author set preset criteria. Then, articles were selected for further review in selecting articles suitable for this study (Spolarich, 2023). Exclusion criteria were developed to exclude sources that were ineligible or not permitted to participate in the study (Finnegan & O'Donoghue, 2019).

The criteria defined in this study serve to filter the literature sources, ensuring that those included in the requirements fulfill academic standards and are relevant to the issue under consideration. These criteria narrow the study's scope and align it with the objectives of this research. By systematically applying inclusion and exclusion criteria, the credibility and transparency of this research may be enhanced, and the review process can be more readily repeated. An overview of these criteria is shown in Table 1.

Table 1. Inclusion and exclusion criteria

| Criteria Type | Inclusion Criteria | Exclusion Criteria |
|---------------|---|---|
| Document Type | Peer-reviewed scientific journal articles | Books, book chapters, proceedings, editorials, or gray literature |

| | | |
|----------------------|---|---|
| Method | All types of empirical methods that conduct field research. | Conceptual/theoretical articles without empirical data. |
| Topic Focus | Focus on the use of Virtual Reality and its impact on the quality of history education. | Does not discuss virtual reality and its connection to history learning |
| Level of education | Formal education levels include elementary school, junior high, high school, and college. | Informal education or general training. |
| Source accessibility | Articles are available in full text | Not accessible in full text |

Data analysis

The systematic literature review process in this study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The PRISMA guidelines were used to identify and select articles for analysis. A search of various databases (Scopus and GARUDA) yielded 284 articles. After removing 54 duplicate articles, 230 articles remained for selection. At the title and abstract screening stage, 150 articles were eliminated because they were not relevant to the theme of Virtual Reality-based history learning. A total of 80 articles were then read in full, but 60 were excluded because they did not meet the criteria: some did not discuss history education, did not use VR directly, or were not based on empirical methods. Finally, only 20 articles met all the criteria and were used in the final analysis of this study. The stages of the selection process, as outlined in the PRISMA guidelines, are shown in Figure 1.

The data analysis step focused on articles that passed the screening process. The approach yielded 20 papers, which were rigorously evaluated. The Data analysis was conducted using an integrated deductive and inductive approach to improve transparency and analytical rigor. The deductive analysis was based on predetermined categories derived from the research framework, including the use of Virtual Reality (VR), history learning outcomes, and SDG 4 indicators related to quality education. Meanwhile, the inductive approach was employed to identify emerging

themes in the reviewed articles, including critical thinking, historical awareness, student engagement, immersive learning experiences, and digital literacy. Open coding was conducted independently by two researchers during the article selection and evaluation process in this study to minimize subjectivity in determining article eligibility for analysis. Each researcher conducted the identification, screening, and evaluation of articles using pre-established inclusion and exclusion criteria. To ensure consistency in assessment between researchers (inter-rater reliability), the level of agreement was analyzed using Cohen's Kappa (κ). The results showed strong agreement in the Cohen's Kappa category ($\kappa > 0.80$), indicating that the article selection process was conducted consistently and reliably.

In cases where discrepancies in assessment were found during the article selection process, both researchers engaged in in-depth discussions by re-examining the articles' alignment with the established inclusion and exclusion criteria. This process involved a re-examination of the title, abstract, research methods, and the relevance of the article's content to the research focus. Disagreements that arose were not resolved individually but were addressed through discussion and academic argumentation until a consensus was reached. This approach was adopted to minimize potential subjective bias in the selection process and to ensure that the selected articles met the standards of research quality and relevance.

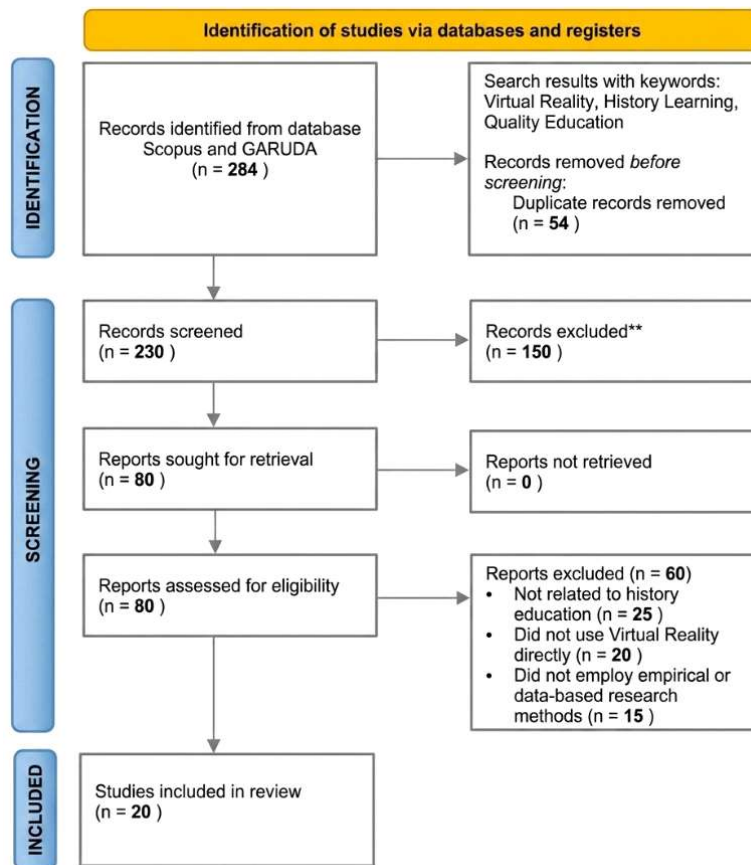


Figure 1. PRISMA flow diagram

■ **RESULT AND DISCUSSION**

After going through a rigorous screening process based on predetermined criteria, 20

articles were included and deemed suitable for further analysis. The articles that will be analyzed in this study are listed in Table 2.

Table 2. Article data extraction results

| (Author's, Year) | Country | Education Level | Sample Size | Type of VR Technology Uses | Summary Result |
|---|---------|----------------------|-------------|--|--|
| (Mulders, Träg, Kaninski, & Rahner, 2025) | German | Undergraduate School | 74 | Fully Immersive VR (HMD VR and Controller – Anna Frank VR House application) | VR environments are more effective at fostering emotional engagement than at promoting cognitive learning, especially in educational settings where the focus is not on conveying facts but on empathizing with the otherwise unfamiliar reality of another person's life. |
| (Villena-Taranilla et al., 2025) | Spain | Pre-Service | 73 | Fully Immersive VR (VR Glasses – Virtime place application) | This study highlights the potential of VR to enhance teacher training, motivation, digital competencies, and innovative methodologies, while underscoring the need for effective pedagogical design to optimize its educational impact |

| | | | | | |
|---|--------------|---|-----|--|---|
| (Li et al., 2025) | China | Undergraduate School | 102 | Fully Immersive VR (HMD VR and Controller – Dule Temple) | The study emphasizes that VR should not entirely replace traditional teaching methods. Instead, combining the strengths of VR and conventional techniques offers a balanced and effective strategy for architectural education. |
| (Gonzales, 2025) | Philippines | Pre-Service | 41 | Fully Immersive VR (HMD VR- The National Geographic Explore VR and Blueplanet VR apps) | The results highlight the positive impact of VR on perceived competence, the strong recommendation to incorporate VR experiences into the curriculum, and the significance of perceived usefulness in shaping students' experiences and outcomes. |
| (Mulders, Träg, Kaninski, Kirner, et al., 2025) | German | Undergraduate School | 75 | Fully Immersive VR (HMD VR and Controller – Anna Frank VR House application) | The study results show that VR can convey highly emotionally engaging testimonies and enable role-taking, which suggests that VR is particularly suitable for affective learning. |
| (Ali, 2024) | Saudi Arabia | Secondary school, Undergraduate School, Post-Graduate | 59 | Fully Immersive VR (HMD VR and Controller – Almusukaf market) | Results indicate positive participant experiences, increased interest in Saudi cultural heritage and appreciation for VR technology. |
| (Shanti & Al-Tarazi, 2023) | Yordania | Undergraduate School | 75 | Fully Immersive VR (HMD VR and Controller- Virtual tour 360 ° Hagia Sophia Church) | The findings of the research show an increase in student learning experience and knowledge recollection when using VR in comparison to conventional teaching methods. |
| (Agustini et al., 2023) | Indonesia | Undergraduate School | 20 | Non-Immersive VR (Smartphone based VR-Game Penjelajah) | The result showed that the average response of the 20 users was 91.81%, which could be categorized as very positive. The effect score was 0.80, which could be categorized as very effective. |
| (X. Zhang et al., 2023) | China | Undergraduate School | 36 | Non-Immersive VR (Smartphone-based VR- Shang Dynasty city wall site) | The virtual reality simulation world can provide strong multisensory interaction and offer new experiences to educators and students. The application of virtual reality technology can help improve the teaching design of deep learning |
| (Nachtigall et al., 2022) | German | Secondary School | 164 | Fully Immersive VR (HMD VR - Shang Dynasty city wall site) | That students who practiced analyzing 360° videos within an explicit SRL training used more cognitive strategies than students who received an implicit SRL training on how to analyze these videos. |

| | | | | | |
|------------------------------------|-----------|------------------|----|--|--|
| (Barbara, 2022) | Sweden | Secondary School | 8 | Non-Immersive VR (PC based VR- 360 ° Video). | Re-Live History is a learning tool, designed and developed in collaboration with heritage experts and history teachers, for classroom use to help students achieve several learning outcomes related to prehistory. |
| (Fransson et al., 2020) | Sweden | K-12 School | 22 | Fully Immersive VR (HMD VR and Controller) | The findings of this study indicate that teachers need to be able to: (a) assess their pedagogical usefulness in the situated context, (b) know what the VR experience involves to be able to include it as part of their teaching, and (c) interact with and/or scaffold students in relation to their use of a VR app. |
| (Putri & Ofianto, 2023) | Indonesia | High School | 25 | Fully Immersive VR (HMD VR and Controller) | The results obtained in this needs analysis research are (1) needs analysis for teachers, (2) needs analysis for students. (3) analysis of learning materials in accordance with learning outcomes by using the virtual reality media. |
| (Triyani & Michellia Karima, 2025) | Indonesia | High School | 33 | Non-Immersive VR (Smartphone-based VR- 3D Image) | The researcher provides an offer in the form of virtual reality media based on students' needs, practical, and facilitating the delivery of material by teachers to students, so that students are more interested in learning history and can improve students' understanding related to the material of change and sustainability in events history. |
| (Almada et al., 2024) | Indonesia | High School | 7 | Non-Immersive VR (Smartphone-based VR- 3D Image) | VR allows students to experience historical events firsthand, creating an immersive and interactive learning environment. By using VR, students not only view images or listen to explanations but can also "visit" historical sites and experience the social and cultural context of the time. |
| (Hilda & Ofianto, 2023) | Indonesia | High School | 6 | Non-Immersive VR (Smartphone-based VR- 3D Image) | The process of learning history in the classroom requires facilities and infrastructure that can visualize a building or historical site in the field in real time, so that classroom learning is not monotonous and can increase students' enthusiasm and interest in learning history in the surrounding environment. |

| | | | | | |
|-------------------------------|-----------|--|----|---|--|
| (Mulyani & Ofianto, 2022) | Indonesia | High School | 54 | Non-Immersive VR (Smartphone-based VR- 3D Image) | The results showed that (1) the feasibility of virtual reality media in general was in the very feasible category and was able to improve thinking skills in identifying changes in historical events,(2) the practicality of virtual reality media as a whole was in the very practical category. |
| (Perwira Negara et al., 2025) | Indonesia | High School | 4 | Non-Immersive VR (Smartphone-based VR- 3D Image of the Pagaruyung Kingdom) | The results of the study indicate that the use of Virtual Reality can be an effective and efficient way to introduce cultural heritage to the younger generation through technology-based learning. |
| (Rasyid Ridha et al., 2024) | Indonesia | High School | 23 | Non-Immersive VR (Smartphone-based VR-3D Image of the Tomb of the Deceased Pekan) | The results showed that the use of VR had a positive impact in improving students' understanding of complex and abstract historical concepts. |
| (Ba'in et al., 2024) | Indonesia | In Service (Teacher professional learning community) | 35 | Non-Immersive VR (Smartphone-based VR- World War II 3D Images) | The expected results are the growth of teacher and student creativity and increased student motivation and historical awareness. |

Based on Table 2, research on virtual reality in history learning is spread across the country, education level, sample size, and type of VR used, with a summary of research results. Most articles present outputs aimed at improving the quality of history learning, particularly in critical thinking and historical understanding. In addition, some articles analyze the feasibility of virtual reality technology in history learning.

RA1: The Role of Virtual Reality in History Education

Based on the analysis of 20 articles on the role of virtual reality in history education, the use of virtual reality in history learning employs several types, such as Fully Immersive VR and Non-Immersive VR. VR devices are often used for Fully Immersive VR, such as HMDs (Head-Mounted Displays). The HMD devices used include the Oculus Quest 2 (Meta Oculus Quest), HTC Vive, VR Glasses, and the built-in controller

of the HMD device. Other VR hardware, such as Computers and smartphones, is used for Non-Immersive VR. The software used is also diverse, including the Oculus app, Blender, 3Ds Max, SteamVR, Unity, Unreal Engine, and other Android-based VR applications. Simulations of VR environments in the form of applications such as Anna Frank VR House, Al Musukaf Market, and the Shang Dynasty City Wall Site. Other forms of VR include 360° video and 3D images of historical buildings, such as the Sophia Church and the Murhum Pekan Tomb, as well as other history-themed images. The use of Virtual Reality in history learning. From the 20 articles analyzed, the metasynthesis identified several main roles of virtual reality in history learning, integrating various qualitative research to build new theories, concepts, or understandings. Based on thematic synthesis from various studies, it was found that several key roles of VR in history learning were found, namely:

Improving Immersive Learning Experience

The most dominant theme in the research findings is VR's ability to create immersive learning experiences. Pedagogical strategies such as virtual field trips provide a learning experience through three-dimensional simulations; students can virtually "feel" the atmosphere of historical events, as if they were directly on the site. This strategy can be analyzed from research by Mulders et al. (2025), who used the Anne Frank VR House application with the help of HMD and Controller devices that allowed students to learn about events in World War II through the historical narrative of the massacre of Jews by Nazi German soldiers through the story of Anne Frank. The same was done by Nachtigall et al. (2022), who used 360° videos with historical themes as a cognitive strategy to provide visualization of past events.

Learning with this virtual field trip strategy affects historical empathy. The skill of historical empathy is the most dominant historical thinking skill influenced by Virtual Reality (VR) because VR's main characteristics enable it to present a more personal, emotional, and contextual historical experience than conventional learning media. VR can combine intellectual understanding with emotional experience, so that students not only know the context of historical facts but also empathize with the historical subject through the visualization provided.

The role of VR in history learning, particularly in improving the immersive learning experience, can also be seen from the architectural perspective of a historical building. As is well known, one of the obstacles in learning history is the abstraction of past contexts, such as studying the historical narratives of buildings of historical value, when in the real world students cannot access those places or the buildings have been destroyed or not maintained. The research by Shanti & Al-Tarazi (2023) integrates VR with Moodle and is applied to students to study the

structure of historic buildings, such as the Hagia Sofia church. The results of this study highlight the importance of VR technology for historical perspective-taking. Historical perspective-taking is the ability to understand people's ways of thinking, viewpoints, values, beliefs, and actions in the past, based on the context of their times rather than on the perspective of the present. VR helps concretize space, social environment, cultural and political situation, and geographical conditions. When students can see firsthand the shapes of ancient cities, battlefields, and settlements of previous societies, they can more easily understand how people of the past lived and made decisions.

In addition to historical thinking skills such as historical empathy and historical perspective-taking, the role of VR in learning history immersively also enhances understanding of historical context. Context understanding is the ability to interpret a historical event in light of the conditions and circumstances that shaped it at the time, across social, political, economic, cultural, geographical, and temporal dimensions. This can be seen in the locally based approach in the research by Perwira Negara et al. (2025), who developed a 3D video of the Tomb of Marhum Pekan as a medium to introduce local history and architecture, as well as the context of the Islamization process in Indonesia. This innovation is a form of historical context-understanding skills from socio-cultural perspectives and demonstrates VR's potential to support the preservation of cultural heritage.

Overall, Virtual Reality plays a strategic role in history learning as a medium that provides an immersive, interactive, and contextual learning experience. In addition, there are historical thinking skills influenced by immersive VR learning experiences, namely historical empathy, historical perspective-taking, and understanding of historical context. This can be seen in the following Table 3 below.

Table 3. Historical thinking skills that emerge in the immersive VR learning experience of history learning

| Historical Empathy | Historical Perspective Taking | Understanding the Historical Context |
|---|---|---|
| The ability to understand past human experiences and feelings | The ability to understand the point of view and way of thinking of past humans according to their times | The ability to understand the conditions and situations behind a historical event |
| Emotional connection with past humans | Historical ways of thinking, values, and perspectives | Social, political, economic, cultural, space, and time conditions |
| VR amplifies emotional experiences and immersion. | VR helps to see events from a specific point of view | VR visualizes historical environments and situations in concrete terms |

Increase Motivation and Interest in Learning

Interactive visual elements, 3D simulations, and virtual exploration make students more actively engaged in learning history. This theme shows that VR helps reduce boredom in learning and increase students' curiosity about historical materials. The use of gamification-based VR is carried out by Agustini et al. (2023), who developed a VR-based educational game called "Explorers" (Explorers) that incorporates gamification elements into prehistoric learning. This game succeeds in increasing students' motivation and interest in learning through an interactive educational game approach. Overall, the various VR applications and devices used in the study show that VR technology not only serves as a medium for visualizing history but also as a means of creating immersive, interactive, and contextual learning experiences, both at global and local scales.

This technology bridges the gap between historical texts and real experiences, allowing students to virtually "experience" the past. Through VR, students not only learn about historical facts, but also develop conceptual understanding, historical thinking skills, and empathy for past events. These findings suggest

that VR has strong potential to create a more immersive and emotionally engaging history-learning experience, thereby not only supporting content understanding but also increasing students' historical awareness and emotional engagement.

In addition, VR plays a role in cultural preservation and in strengthening local identity, while also serving as an innovative tool to increase motivation to learn and active participation in the classroom. A study by Perwira Negara et al. (2025) provides an example of the use of Virtual Reality as a learning medium: a simulation of visiting historical sites virtually. Students will be able to observe historic buildings firsthand. Local history can be used as a learning resource through virtual reality, providing one way to introduce it to students.

Supporting 21st Century Learning

Various studies reveal that VR integration can create a more innovative, interactive, and student-centered learning process. The use of digital technology in history learning is also in line with the demands of modern education, which emphasizes mastery of 21st-century skills. The needs analysis conducted by Mulyani & Ofianto

(2022) shows that both students and teachers use virtual reality as a learning medium to support the development of key 21st-century competencies, such as critical thinking, creativity, collaboration, communication, and digital literacy. An interactive virtual environment allows students to explore, observe, and analyze historical events in greater depth, thereby encouraging critical thinking to understand cause-and-effect relationships.

Additionally, VR-based learning provides a more active and participatory learning experience. Students not only passively receive information but also engage directly in virtual simulations, discussions, and problem-solving grounded in historical contexts. This condition shows that VR supports the student-centered learning approach, which is a main characteristic of 21st-century learning. Thus, VR not only enriches the history learning process, but also supports the creation of a more meaningful, adaptive, and 21st-century education.

The results of the meta-synthesis show that Virtual Reality (VR) technology plays a strategic role in history learning by improving immersive learning experiences, contextual understanding, motivation to learn, and student interactivity. These findings indicate that VR has the potential to become a history-learning innovation relevant to the needs of 21st-century education.

In addition to meta-synthesis to identify the themes and roles of Virtual Reality (VR) in history learning, this study also uses meta-analysis to strengthen the findings statistically, particularly regarding learning motivation and student learning outcomes. A meta-analysis was conducted by combining quantitative data from relevant studies to provide an overview of the effectiveness of VR in history learning. The results of the effect size calculations for each study are presented in Table 4 below.

Table 4. Effect Size of the role of VR in history learning

| Author, (Year) | Variabel | Effect Size (d) | Category |
|---------------------------------|-------------------|-----------------|----------|
| Mulders et al. (2025) | Motivation | 2.38 | High |
| Villena-Taranilla et al. (2025) | Motivation | 1.75 | High |
| Li et al. (2025) | Motivation | 1.2 | High |
| Gonzales, (2025) | Motivation | 3.02 | High |
| Ali (2024) | Learning Outcomes | 0.95 | High |
| Shanti & Al-Tarazi (2023) | Learning Outcomes | 0.95 | High |
| Nachtigall et al. (2022) | Learning Outcomes | 0.55 | Medium |

Based on the results of the meta-analysis in Table 3, the use of Virtual Reality (VR) in history learning shows that the dominant effect size is in the high category. In the learning motivation variable, all studies reported effect sizes above 1.00, indicating that VR has a very strong influence on increasing student motivation. Meanwhile, for the learning outcome variable, the effect size was also in the medium-to-high category. Overall, these findings show that VR is effective in supporting history learning, particularly by improving student motivation and learning outcomes.

RA2: Challenges in the application of Virtual Reality in history learning

The application of virtual reality in history learning allows students to understand the narrative of an event or historical building in greater depth. The results of several articles analyzed in this study indicate that virtual reality in history learning has the potential to enhance students' cognitive and affective abilities, particularly in terms of historical understanding, engagement, and perspective-taking. However,

the findings also reveal variations in effectiveness due to challenges such as technological limitations, accessibility, implementation costs, and differences in students' digital competencies. However, the positive results of using virtual reality in history learning also indicate challenges in its implementation in the field. Several studies show that there are still weaknesses in the implementation of virtual reality due to several factors.

The challenge in applying virtual reality to history learning lies in teachers' readiness. Not all teachers have a strong technological background, so using virtual reality can be new and complicated for some of them. The use of virtual reality requires sufficient technological knowledge, thus requiring teachers to be ready to adapt in its implementation. This issue of teacher readiness can be addressed by providing training for teachers, as explained in a study titled "Development of Virtual Reality-Based History Parks for History Teachers of the Pati Regency MGMP." The results of this study reflect training for quality education through improving the skills of history teachers in developing and utilizing innovative technology-based learning media, which will ultimately create a more effective, attractive, and relevant learning environment for students.

The application of Virtual Reality (VR) technology in history learning faces various interrelated challenges, especially in economic, technical, and pedagogical aspects. The study highlights the limited funds available to teachers to purchase VR devices such as HMDs and supporting software, and raises concerns about the reliability of the technology, which is often complex and requires rapid technical support. In addition, teachers and students need time to adapt to the logic of using VR. In contrast, students' focus on learning is sometimes diverted to the visual experience rather than the learning material. From an implementation perspective, the limited

number of devices, class size, space, and rigid schedules are significant practical obstacles. The use of alternatives such as rotation systems or BYOD also raises new issues, such as inequality of access among students. Teachers also face difficulties in linking VR content to the curriculum and measurable learning outcomes, as its benefits are more affective in nature, such as increased motivation and empathy, rather than direct academic improvement. On the other hand, a lack of training and learning time means that many teachers do not yet have sufficient digital competence to make optimal use of VR.

Research conducted by Franson et al. (2020) confirms the findings regarding the challenges in implementing Virtual Reality in history education. The challenges of implementing Virtual Reality (VR) in history education include interrelated technical, economic, psychological, social, and pedagogical aspects. Technically, limitations in system interoperability, format incompatibility, and high hardware and software requirements hinder access in resource-constrained institutions. Economically, the costs of procuring, maintaining, and developing VR content remain relatively high, limiting its adoption by certain institutions. Psychologically and socially, the use of VR can cause disorientation, anxiety, and difficulty distinguishing reality from simulation, raising ethical issues in learning design. Meanwhile, pedagogically, the lack of VR integration in the curriculum and minimal teacher training hinder the effective implementation of this technology in the classroom.

The successful application of VR in history learning depends heavily on funding support, infrastructure, ongoing training, institutional flexibility, and teachers' ability to balance technological and pedagogical aspects so that this technology truly adds value to the teaching and learning process. Therefore, technology standardization, sustainable funding, the development of ethical, user-friendly content, and

the improvement of educators' competencies are needed to effectively integrate VR into history learning.

RA3: The Contribution of Virtual Reality to Sustainable Development Goal 4 (SDG 4) Quality Education

The Sustainable Development Goals are a comprehensive framework established by the United Nations in 2015 that aims to address global challenges and achieve a better, more sustainable future by 2030. One of the 17 agreed goals is achieving quality education. Quality education is one of the Sustainable Development Goals, or SDGs, specifically in the fourth point, which focuses on inclusive and equitable quality education and lifelong learning opportunities for all. Sustainable Development Goal 4 specifically aims to ensure inclusive, equitable, and quality education and promote lifelong learning opportunities for all by 2030. This goal is

fundamental to sustainable development, as education is a powerful tool for changing lives, reducing poverty, promoting gender equality, and building sustainable communities.

In the context of this study, the implementation of Virtual Reality (VR) is analyzed in relation to several SDG 4 targets, specifically SDGs 4.1 on improving the quality and effectiveness of learning, SDGs 4.3 on access to quality higher education, SDGs 4.4 on the development of technological and digital skills, SDGs 4.5 on inclusive and equitable education, SDGs 4. a regarding safe and effective technology-based learning environments, and SDGs 4.c regarding the enhancement of educators' capacity and competencies. Therefore, the analysis of the research findings focuses not only on the impact of VR on history learning but also on its contribution to achieving various targets within SDG 4, as presented in Table 4 below.

Table 4. Virtual reality (VR) research analysis in the context of SDG 4 (quality education)

| Author & Year | Research Focus | SDGs 4 Targets | SDGs 4 Aspects Achieved | Key Findings |
|--------------------------|--|----------------|---|--|
| Mulders et al. (2025) | Implementation of VR in European history learning | SDGs 4.1 | Improvement of students' conceptual understanding and participation | VR improves students' conceptual understanding and active participation through immersive learning experiences. |
| Almada et al. (2024) | VR as a collaborative learning medium at universities | SDGs 4.3 | Access to collaborative and technology-based higher education | VR expands collaborative learning opportunities and improves academic outcomes in higher education. |
| Agustini et al. (2023) | The effect of VR on high school students' motivation and learning outcomes | SDGs. 4.1 | Enhancement of student motivation and learning effectiveness | VR increases student motivation and learning outcomes by creating contextual and enjoyable learning experiences. |
| Nachtigall et al. (2022) | The use of VR in teacher training | SDGs 4.c | Development of teacher pedagogical competence | VR helps prospective teachers develop pedagogical skills and reflective learning experiences. |
| Li et al. (2025) | The effectiveness of VR in increasing student engagement | SDGs 4.1/4.4 | Student engagement and digital competency | Immersive technology increases emotional engagement, active participation, and digital interaction in learning. |
| Fransson et al. (2020) | Barriers to VR implementation in elementary schools | SDGs 4.5/4.a | Inclusive and technology-supported learning environment | Infrastructure limitations, costs, and teacher readiness hinder equitable implementation of VR. |
| Putri & Ofianto (2023) | Teachers' perceptions of VR implementation in Indonesia | SDGs 4.c | Strengthening teachers' professional capacity | Teachers require training and technical support to effectively integrate VR into learning activities. |

Sustainable Development Goal 4, which is part of the 2030 global agenda, focuses on ensuring quality education and opportunities for everyone to receive a proper education throughout their lives. Technology plays an important role in achieving this vision in various ways, including the use of Virtual Reality. Assistive technologies, such as immersive virtual reality systems, enable learning through the visualization of space and time and semantic conversation, enhancing the learning experience for students, including those with disabilities, such as children with autism. This technology can motivate, educate, and train students in a more inclusive environment, while also providing educational, psychological, and social benefits.

The results of a systematic review of several studies indicate that Virtual Reality (VR) has the potential to improve the quality of education, as reflected in SDG 4, which aims to ensure that all students receive equitable, quality education. However, this contribution is heavily influenced by educational institutions' ability to overcome implementation challenges, including infrastructure limitations, access to technology, costs, and educators' readiness to use VR effectively. Based on findings from various studies, the implementation of Virtual Reality (VR) in education not only contributes to the general aspects of quality education but is also linked to several specific targets within SDG 4. Research by Mulders et al. (2025), Agustini et al. (2023), and Li et al. (2025) indicates that VR can enhance students' conceptual understanding, motivation, emotional engagement, and active participation through immersive learning experiences. These findings align with SDG 4.1, which emphasizes improving the quality of learning outcomes and the effectiveness of education.

Furthermore, the study by Almada et al. (2024) relates to SDG Target 4.3 because it demonstrates that integrating VR into higher education can expand access to collaborative

learning and improve its quality. Meanwhile, the studies by Nachtigall et al. (2022) and Putri & Ofianto (2023) support SDG Target 4.c, which focuses on enhancing educators' capacity and competencies. Both studies confirm that the use of VR aids in developing teachers' pedagogical skills, but its implementation still requires adequate training and technical support.

In addition, the study by Fransson et al. (2020) shows that the use of VR is also linked to SDG targets 4.5 and 4.a, which emphasize inclusive education and safe and effective learning environments. The study found that infrastructure limitations, technology costs, and teacher readiness remain the main barriers to the equitable implementation of VR in schools. Thus, these findings indicate that VR's contribution to SDG 4 is multidimensional, encompassing improved learning quality, access to higher education, the development of teacher competencies and digital skills, and the challenge of ensuring equitable access to educational technology.

■ CONCLUSION

This study aims to synthesize findings from previous research articles that have used Virtual Reality technology in history education. Several of these articles identified various Virtual Reality applications or software, including the Anne Frank VR House, 360° history-related videos, Moodle, 3D videos of the Mahrum Tomb in Pekan, the Oculus Quest 2 with 3D Max software, National Geographic Explore VR, and the Blueplanet VR app, CloudPano, VR HMDs (head-mounted displays), and the VR-based game "Explorer." Based on the analysis, history learning using Virtual Reality has the potential to enhance students' cognitive knowledge, as students can virtually visit historical sites, thereby yielding a more comprehensive understanding of history than conventional learning. Additionally, learning with Virtual Reality can enhance students' emotional responses because they feel as though

they are actually present in the historical setting or event depicted in the experience.

Overall, the review findings indicate that Virtual Reality (VR) has the potential to support several targets within SDG 4, particularly SDG 4.1 regarding the improvement of learning effectiveness, SDG 4.3 concerning access to technology-based higher education, SDG 4.4 regarding the development of 21st-century digital skills, SDG 4.5 on inclusive and equitable education, and SDG 4.c regarding the improvement of educators' competencies. Through immersive and interactive learning experiences, VR can enhance student engagement, conceptual understanding, and motivation to learn. However, these contributions are still hindered by various implementation challenges, such as infrastructure limitations, technology costs, and teachers' readiness to effectively integrate VR into learning.

This study contributes by formulating a conceptual relationship between Virtual Reality (VR), history education, and the achievement of SDG 4 targets through an immersive learning approach. The study demonstrates that implementing VR serves not only as an innovative learning medium but also as a means of developing 21st-century skills, historical awareness, and students' emotional engagement, all of which are relevant to sustainable education. Based on these findings, this study proposes a conceptual model that positions VR as a bridge between immersive learning experiences, the enhancement of historical competencies, and the achievement of SDG 4 indicators, particularly regarding the quality of learning, digital skills, and the capacity development of educators. Additionally, this study offers a more specific agenda for further research, including exploring the effectiveness of VR in fostering historical empathy, digital literacy, and cross-cultural collaborative learning in history education.

This study has several limitations that should be taken into account when interpreting the

findings. First, the literature sources used were limited to the Scopus and Garuda databases, so relevant studies from other databases may have gone unidentified. Second, this study focuses solely on the use of Virtual Reality (VR) in history education and thus does not cover other immersive technologies, such as Augmented Reality (AR), Mixed Reality (MR), or artificial intelligence-based technologies that also have the potential to support educational innovation. Third, the research analysis is limited to the relationship between VR implementation and SDG 4 (Quality Education), and has not yet explored its potential contributions to other sustainable development goals, such as SDG 9 on innovation and infrastructure or SDG 10 on reducing disparities in educational access. Therefore, future research is expected to expand the scope of the database, the types of technologies, and the SDG aspects analyzed to yield a more comprehensive understanding of the role of immersive technologies in sustainable education.

■ **DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS**

During the drafting of this manuscript, the author(s) employed [DeepL Translate and Grammarly] to assist with [translating text and refining sentence structure]. The author(s) have reviewed and edited the content generated by this tool and assume full responsibility for the content of the published article.

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