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Museum-Based Virtual Reality in Chinese Higher History Education: A Scoping Review of Research and Curriculum Design Innovations

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ABSTRACT

This scoping review examines how museum-based virtual reality (VR) is used in history education in Chinese higher education. As immersive technologies continue to grow in popularity worldwide, VR offers exciting new ways for students to engage with historical content through interactive and sensory-rich experiences. In China, efforts to reform education and digitize cultural resources have sped up the use of VR in classrooms, though research in this area is still scattered. Using the PRISMA-ScR framework and Arksey and O'Malley's methodology, this review analyzes 20 studies published from 2020 to 2024, looking at how they were conducted, the research goals, and the results in various learning settings—formal, non-formal, and informal. The findings show that museum VR enhances academic performance, increases student engagement, fosters historical empathy, and promotes socio-emotional growth, but also points out challenges like usability issues, design flaws, and problems with implementation. This review provides valuable insights for educators, museum professionals, and curriculum developers who want to incorporate immersive heritage learning into higher education

1. INTRODUCTION

Higher education around the world is moving away from traditional lectures and toward more interactive learning experiences that put students at the heart of their learning process. Virtual reality (VR) has become an important tool in this shift, providing a highly immersive, interactive, and engaging experience for students (Freina & Ott, 2015). By enveloping learners in richly simulated settings, VR can make study more motivating and emotionally compelling than

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traditional classroom delivery (Freina & Ott, 2015; Slater & Sanchez-Vives, 2016). Recent advances—most notably lightweight, affordable head-mounted displays and user-friendly development platforms—have lowered technical and financial barriers, positioning VR as a realistic tool for intensifying learning across disciplines (Jangra et al., 2025). Consequently, educators increasingly view VR not as a novelty but as a means of converting students from passive recipients of information into active participants in experiential tasks, a shift that aligns with wider constructivist and student-centered pedagogies (Jangra et al., 2025; Radianti et al., 2020).

While the potential of VR in education is exciting, early studies show mixed results, with some findings even contradicting each other. This shows that we need to be careful when analyzing this technology. Many reviews and studies suggest that VR research is still in the early stages, facing problems like small sample sizes, weak control groups, and short study durations (Jensen & Konradsen, 2018; Radianti et al., 2020). For example, Jensen and Konradsen (2018) found only small improvements in learning with head-mounted VR compared to less immersive methods. Likewise, Radianti et al. Radianti et al. (2020) noted that most university-level VR projects are still in the experimental stage and haven't been fully woven into the curriculum yet. Some surprising results make things even more complicated. In one study, students who learned physics with a regular slideshow actually did better than those using VR, even though the VR group felt more interested and engaged (Parong & Mayer, 2018). This shows that VR doesn't always do what we think it will. It works best when the lessons are simple, easy to follow, and really match what students need to know (Paolanti et al., 2023). In the end, VR can be a powerful tool, but it needs to be carefully thought out and backed by solid research to truly make a difference in education.

Virtual reality (VR) offers exciting possibilities for history education, especially in museums where learning and cultural heritage intersect. Research has shown that the design of museum exhibitions—the space, the materials, and the overall experience—plays a huge role in how visitors connect with what they see and understand (Tzortzi, 2016). Museums, in a way, act as quiet guides, shaping how we perceive history through their layout, the order of objects, and the sensory experiences they offer (Tzortzi, 2016). VR takes this a step further, creating virtual museum environments that not only mimic but often enhance the depth of real-life museum experiences. Over the past five years, museums worldwide have started using VR, augmented reality (AR), and mixed reality (MR) to offer new ways for people to engage with artifacts and historical narratives (Jangra et al., 2025). With virtual tours, 3D reconstructions of lost heritage sites, and interactive digital replicas, visitors can explore history in a much more detailed and personal way, whether they are at the museum or enjoying the experience from afar. Early reports show that these immersive experiences increase visitor satisfaction, interest, and even understanding, indicating that VR in museums can create deeper, more independent connections to the past (Jangra et al., 2025). On a larger scale, educators see these technologies as a powerful way to make history come alive, turning abstract concepts into vivid, emotional experiences that feel meaningful to everyone.

China is really embracing this shift. In the past, university history classes in China, especially in the humanities, were often very textbook-focused, which made history feel distant and hard to connect with (Zhuang et al., 2025). To change this, the government has been encouraging digital and immersive learning. In 2020, the Ministry of Education introduced a program that approved over 700 VR courses across 41 subjects, including history, architecture, and archaeology (Zhuang et al., 2025). These courses help students understand tough topics by using VR, like stepping inside the walls of ancient cities, looking at inscriptions closely, or experiencing important historical events from different points of view. Early classroom studies show that this kind of learning makes students more engaged, helps them understand better, and improves memory, suggesting that VR can teach history better than traditional methods (Zhuang et al., 2025).

As formal education evolves, Chinese museums and cultural heritage institutions are embracing VR in a big way, using it both to protect history and to bring it to a wider audience.One standout example is the digital Forbidden City, where visitors can explore the imperial halls, admire restored frescoes, and hear expert insights—all within a single immersive space (Chen, 2024). These projects serve two important purposes: they protect delicate artifacts through digitization, ensuring their survival for future generations, while also making cultural treasures available to young, tech-savvy people who may not have the opportunity to visit these historical sites in person. Combined with classroom use, they create a multi-context ecosystem—formal, non-formal, and informal—where VR mediates historical understanding in complementary ways. Nevertheless, these impressive practices have outpaced scholarly synthesis; research remains fragmented across educational technology, museology, and heritage-informatics journals, with varying goals and methods.

This fragmentation highlights a notable gap in systematic understanding. Individual case studies document positive experiences or technical challenges, yet they rarely connect to a larger framework of best practices, design principles, or outcome measures. Consequently, educators, museum practitioners, and policymakers struggle to see the “big picture” of how and why VR succeeds or fails in teaching history. Moreover, China’s uniquely large-scale investment has not been assessed through a consolidated academic lens, limiting global awareness of transferable lessons and persistent obstacles.

To address this knowledge deficit, the present study conducts a scoping review of empirical research on museum-based VR in Chinese higher history education. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) and Arksey and O’Malley’s five-stage methodology, we systematically map literature published from 2020 through 2025. This review looks at four main questions: (1) What educational goals, like building historical empathy, critical thinking, or deepening knowledge, do museum VR programs aim to achieve? (2) What VR tools, design features, and teaching methods are used? (3) What types of research, participants, and learning settings are involved in these studies? And (4) What results, benefits, and challenges have been found? By gathering findings from different settings—formal courses, museum programs, and even home learning—the review highlights key patterns, gaps, and the quality of the evidence.

This review offers several key takeaways. First, it helps clarify where current research stands, making it easier to separate solid evidence from more casual, anecdotal reports. Second, it highlights design features—like storytelling, interactivity, and collaboration—that are linked to better learning outcomes, offering practical advice for future curriculum development. Third, it identifies common hurdles—such as usability problems, cybersickness, and lack of resources—that need to be addressed to make VR more widely accessible. Finally, by placing China’s efforts in the larger global conversation on immersive heritage education, the review encourages cross-cultural learning and helps shape best practices worldwide.

The combination of VR with museum pedagogy looks like it may lead to better ways of teaching history. Students will be able to explore ancient worlds, question objects, and make sense of things via their own experiences. China's large-scale utilization is a great setting for looking into the teaching benefits and challenges of using VR in museums. But if it doesn't become a part of the system, the field could miss chances and learn from its failures. This scoping review therefore provides up-to-date, evidence-based outcomes that will be useful to educators, museum professionals, and policymakers towards better, inclusive, and interactive history learning in the age of virtual immersion.

2.METHOD

This scoping review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and was conducted following Arksey and O'Malley's methodological framework: (i) identifying research questions, (ii) identifying relevant studies, (iii) selecting eligible studies, (iv) charting the data, and (v) collating, summarising, and reporting the results. Despite growing enthusiasm for museum-based virtual reality (VR) as a means to invigorate history education, existing studies have produced mixed and often inconclusive findings. Accordingly, the guiding inquiry for this review was framed as: "What empirical insights can be gleaned from the existing body of literature regarding the effectiveness of museum-based VR in history education?" Table 1 presents the core research questions aligned with their corresponding objectives under the Population–Concept–Context (PCC) framework.

Table 1. Research questions created based on PCC

Research Questions	Specific Objectives
1. How are past studies on Museum VR applications in history courses distributed?	1. To explore the geographic distribution, target age groups (primary, secondary, higher education), and participant profiles in past Museum VR studies.
2. What research designs were commonly used in past studies on Museum VR in history education?	2. To determine the prevalent research methods (quantitative, qualitative, mixed) in previous studies related to Museum VR in history education.
3. What specific educational purposes have past Museum VR studies targeted in history education?	3. To analyze the educational goals such as enhancing historical empathy, historical thinking, student engagement, motivation, accessibility, and inclusion within Museum VR studies.
4. What specific Museum VR elements and design features were investigated in past studies on history education?	4. To identify specific technical design elements, pedagogical integration approaches, immersive technology types, and interactive features used in Museum VR studies.
5. What were the key findings regarding the effectiveness of Museum VR technology in history education?	5. To summarize and report findings concerning Museum VR's impact on learning effectiveness, student motivation, empathy, historical thinking, and accessibility and inclusion.

The search strategy was designed to capture all relevant studies as broadly as possible. This entailed using precisely formulated keywords and Boolean operators that reflected the intersection of virtual reality, museum contexts, history education, and learning outcomes, as detailed in Table 2. The study inclusion criteria are summarised in Table 3. Scoping-review protocols cannot be registered in PROSPERO; nevertheless, the review adhered to PRISMA guidelines [17] to ensure methodological transparency. Two members of the research team independently screened all retrieved titles and abstracts against the predefined inclusion and exclusion criteria, resolving discrepancies through discussion and consensus.

Table 2. Search string

Search directory	Search string
WOS	((((TS=("VR") OR TS=("Virtual Reality"))) AND (TS=("history") OR TS=("historical learning"))) OR TS=("museum")) AND TS=(“education”)

Table 3. Inclusion and Exclusion Criteria

Inclusion Criterion	Exclusion Criterion
Article published from 2019–Recent	Article published before 2019
Focused on museum-based or heritage-related VR applications	Not related to museum VR or heritage education
Targeting tertiary/higher education learners or educators	Not involving college/university-level participants
Focused on history education or historical learning outcomes	Focused on non-historical or general VR education
Text in the English or Chinese language	Written in other languages
Full text accessible	Without full-text access

The research team determined a set of study attributes to be extracted for synthesis after piloting a Microsoft Excel–based data-charting form on a representative sample of articles. The final charting template captured the following elements: author, year of publication, country or region, source title, study purpose, research design, VR technology and pedagogical features, and key findings. Charted data were then coded and refined iteratively; keywords and thematic labels were applied to condense the information into meaningful categories aligned with the review objectives.

3. RESULTS AND DISCUSSION

The search yielded 317 records from the Web of Science (WoS) database during the identification stage. After automatic and manual checks for redundancy, 17 duplicate entries were300 unique titles for screening. Title-and-abstract screening excluded 251 records that were unrelated to museum-based VR, lacked a history-education focus, or targeted non-tertiary populations. The remaining 30 articles proceeded to full-text assessment. During data-extraction eligibility checks, 10 articles were excluded for reasons such as insufficient empirical data, absence of museum contexts, or methodological limitations. Consequently, 20 studies met all inclusion criteria and were incorporated into the review, as summarised in Table 4 .

3.1 Distribution of Past Studies

The twenty studies included in this scoping review were published between 2020 and 2024, with a noticeable increase in publication frequency beginning in 2021. Only one study was published in 2020 (Fransson, 2020), while six studies appeared in 2021 (Hernandez, 2021; Lanzieri, 2021; Puggioni, 2021; Escribano-Miralles, 2021a; Escribano-Miralles, 2021b; Lee, 2021). The year 2022 saw three relevant publications (Villena-Taranilla, 2022; Chan, 2022; Castro, 2022), followed by another surge in 2023 with six studies (Leinonen, 2023; Shanti & Al-Tarazi, 2023;

Smutny, 2023; Toktamysov, 2023; Wu, 2023; González-Sanz, 2023). In 2024, four additional studies were published (Xu, 2024; Donegan, 2024; Jeon, 2024; Liu & Sutunyarak, 2024). Geographically, research in this area is largely centered in Europe, which accounts for 13 out of the 20 studies. Spain leads with six contributions (Leinonen, 2023; Lanzieri, 2021; Villena-Taranilla, 2022; Escribano-Miralles, 2021a; Escribano-Miralles, 2021b; González-Sanz, 2023), followed by other European nations like Greece, the Czech Republic, Italy, Sweden, Russia, Ireland, and the United Kingdom. Asia contributed six studies, with research from Jordan, Hong Kong, China (two studies), South Korea, and Thailand. North America is represented by a single study from the United States (Liu & Sutunyarak, 2024). This distribution shows a clear regional and temporal trend, with a noticeable increase in empirical research on museum-based VR for history education after 2020, especially in European and East Asian higher education contexts, reflecting the global rise of immersive learning technologies in teaching.

Table 4. Literature Matrix

Distribution (Author & Country)	Research design	Focus variables / skills
Leinonen et al. (2023) – Spain	Quantitative · SEM	Intention to use VR (Extended TAM)
Hernandez et al. (2021) – Greece	Quantitative experiment (multisensory VR)	Presence; educational experience
Shanti & Al-Tarazi (2023) – Jordan	Mixed (quasi-exp. + focus groups)	Learning experience; knowledge retention
Smutny (2023) – Czech Rep.	Quantitative market analysis	App trends; user ratings; content distribution
Lanzieri et al. (2021) – Spain	Quantitative pre/post pilot	Community knowledge; learner perceptions
Fransson et al. (2020) – Sweden	Qualitative (interviews & obs.)	Teacher challenges; implementation barriers
Puggioni et al. (2021) – Italy	Mixed experiment (ScoolAR)	Knowledge & competencies gain
Villena-Taranilla et al. (2022) – Spain	Quantitative experiment	Academic performance; motivation
Chan et al. (2022) – Hong Kong, China	Quantitative (two assessments)	Architectural-history learning; presence
Toktamysov et al. (2023) – Russia	Quantitative survey	Academic performance with digital tools
Wu et al. (2023) – China	Quantitative experiment (SRS-SVVR)	Learning performance; self-regulation
Xu (2024) – China	Quantitative psychodiagnostic test	Emotional intelligence; self-esteem
Donegan et al. (2024) – Ireland	Mixed (surveys + interviews)	Attitudes; confidence; science skills
Escribano-Miralles et al. (2021a) – Spain	Quantitative survey	Activities & resources in museum visits
Escribano-Miralles et al. (2021b) – Spain	Quantitative survey	Perceived educational value of museum visits
Lee et al. (2021) – South Korea	Mixed AR-blended learning	Flow; interest; learning experience

González-Sanz et al. (2023) – Spain	Mixed (surveys + interviews)	Pupils' learning preferences (VTS)
Jeon et al. (2024) – Thailand	Mixed (usability & cybersickness tests)	Usability; empathy education; cybersickness
Liu & Sutunyarak (2024) – USA	Mixed (TAM + Flow)	Visitor attitudes; satisfaction; behavior intention
Castro et al. (2022) – UK	Mixed (ANOVA; pre/post)	Motivation; learning performance (zoology)

3.2 Research Designs Used in Past Studies

Across the 20 studies synthesised from Web of Science, quantitative designs dominated (n = 11), including structural-equation modelling (Leinonen,, controlled or pre/post experiments (Hernandez, 2021; Villena-Taranilla, 2022; Chan, 2022; Wu, 2023), surveys (Toktamysov, 2023; Escribano-Miralles, 2021a, 2021b) and market-analysis techniques (Sad, 20. Mixed-methods approaches accounted for eight studies—typically combining experiments with focus groups or interviews (Shanti & Al-Tarazi, 2023; Puggioni, 2021; Donegan, 2024; Lee, 2021; González-Sanz, 2023; Jeon, 2024; Liu & Sutunyarak, 2024; Castro, 2022)—while only one purely qualitative study relied on interviews and classroom observation to capture implementation barriers (Fransson, 2020). Within these broad categories, the most common specific techniques were laboratory or classroom experiments (n = 7) and questionnaire-based surveys (n = 5), signalling a strong preference for measuring learning effects and user perceptions through standardised instruments.

3.3 Research Aims of Past Studies

The studies included in this review addressed a range of research aims related to the application of museum-based virtual reality (VR) in history education, which can be broadly grouped into six categories. The most common goal across the studies was to improve academic performance and learning effectiveness, as highlighted in eight studies (Hernandez, 2021; Shanti & Al-Tarazi, 2023; Lanzieri, 2021; Puggioni, 2021; Villena-Taranilla, 2022; Chan, 2022; Wu, 2023; Castro, 2022). In these studies, VR was used to enhance knowledge acquisition, retention, and understanding of historical concepts. A total of five studies focused on increasing learner motivation and engagement through immersive and interactive experiences (Villena-Taranilla, 2022; Lee, 2021; Castro, 2022; Shanti & Al-Tarazi, 2023; González-Sanz, 2023). Four studies aimed to investigate user attitudes, satisfaction, and adoption intentions, often within the framework of the Technology Acceptance Model or user-experience analysis (Leinonen, 2023; Donegan, 2024; Liu & Sutunyarak, 2024; Smutny, 2023). Another four studies concentrated on experiential and ergonomic factors such as presence, usability, and cybersickness, which are critical for evaluating the quality and comfort of immersive VR environments (Hernandez, 2021; Chan, 2022; Jeon, 2024; Lee, 2021). Two studies also looked at how VR impacts emotional and social growth, exploring outcomes like empathy, emotional intelligence, and self-esteem (Xu, 2024; Jeon, 2024). Additionally, three studies tackled practical challenges, such as teacher-related obstacles and how effective museum-based educational resources really are (Fransson, 2020; Escribano-Miralles, 2021a; Escribano-Miralles, 2021b).

3.4 Factors Investigated

Among the 20 studies examined, researchers explored a range of cognitive, emotional, and hands-on learning aspects tied to how museum-based virtual reality (VR) is used in history classrooms. Of all the themes that surfaced, student learning outcomes and academic performance were the ones that came up most often, being the focus of eight studies. Additionally, five investigations concentrated on learner motivation and engagement, assessing variables such as interest, immersion, and behavioral intention (Villena-Taranilla et al., 2023).Some studies focused more specifically on how students interacted with the VR systems themselves. Research by Hernandez (2021), Chan (2022), Jeon (2024), and Liu and Sutunyarak (2024) looked into how easy the platforms were to use and how responsive or intuitive the interfaces felt during learning.Emotional and psychological outcomes—such as empathy, emotional intelligence, and self-esteem—were examined in three studies, highlighting the personal dimensions of immersive learning. Furthermore, three additional studies focused on students' attitudes toward VR adoption, often interpreted through the lens of established behavioral models, particularly the Technology Acceptance Model (Leinonen, 2023; Donegan, 2024; Smutny, 2023). Learning preferences and perceptions of museum-based resources were documented in three studies(Writeteaching challenges and implementation barriers were the focus of a single qualitative study (Fransson, 2020). This distribution illustrates the diversity of variables used to evaluate VR-enhanced history learning, spanning measurable learning gains, motivational states, emotional growth, and institutional or pedagogical constraints.

3.5 Findings of Past Studies

After going through the 20 studies included in this scoping review, a few clear patterns began to stand out. Among them, one of the most frequently mentioned was the boost in students' academic achievement and learning results, which was noted in four separate studies. Another important area involved student motivation and engagement—especially in VR settings that were emotionally immersive and designed to draw learners in (Villena-Taranilla et al., 2023). What's more, studies by Jeon (2024), Xu (2024), and Donegan (2024) pointed to meaningful emotional and social effects. These included improved empathy, stronger emotional intelligence, and a rise in students' confidence while learning through VR. In terms of user attitudes and satisfaction, three studies (Leinonen, 2023; Liu & Sutunyarak, 2024; Donegan, 2024) found that learners reported high levels of satisfaction, intention to use, and behavioral alignment with VR-based museum learning. Another set of three studies (Hernandez, 2021; Chan, 2022; Jeon, 2024) emphasised the importance of presence and usability, aret(Fromcontextual and implementation-related challenges, such as educator readiness, technological constraints, and the need for enhanced museum resources. Together, these findings support the potential of museum VR in history education, while also underscoring areas for further pedagogical and infrastructural refinement.

3.6 Comparisons between Formal, Non-Formal, and Informal Learning

3.6.1 Formal Learning (Classroom-Embedded VR)

When used in formal classroom settings, VR-based learning is usually the result of thoughtful planning, guided by institutional standards and focused on clear learning goals. It happens in accredited schools and is embedded directly into the official curriculum. In science education, for instance, students taking part in VR-enhanced lessons have shown better academic results and reduced mental strain—likely because these activities are aligned with lesson objectives and led by trained instructors (Liu et al., 2022). Teachers often organize VR experiences—like 3D simulations or spatial exploration—in ways that help students gradually build understanding, moving from simple to more complex concepts (Villena-Taranilla et al., 2023). Both students and teachers tend to see this kind of learning as part of their scheduled class time, guided by specific goals and expectations. What sets formal VR learning apart is that it counts toward academic credit. Take architectural history students, for example—they use immersive design modules in VR and are formally evaluated, with the results included in their transcripts (Shanti & Al-Tarazi, 2023). In another example, engineering students use VR systems with haptic feedback to reconstruct historical spaces. Their work is graded and directly contributes to their course results, just like any other core assignment (Chrysanthakopoulou et al., 2021). Rather than serving as a supplementary feature, VR in these cases plays a central instructional role. Unlike informal learning, which tends to be voluntary and rarely linked to official assessments, this kind of VR use is tightly integrated into the academic process and carries real weight in terms of credit and evaluation.

3.6.2 Non-Formal Learning (Museum-Based VR)

Non-formal learning, as illustrated through museum-based virtual reality (VR) experiences, offers a purposeful yet flexible approach to education that takes place outside traditional school systems. Rather than following fixed curricula or leading to formal qualifications, this type of learning is typically created for specific groups, focusing on immersive, meaningful experiences that encourage exploration and personal connection. For example, VR exhibits that incorporate haptic feedback and physical movement allow participants to engage with historical events through multiple senses, building emotional and cognitive links that often extend beyond what conventional classrooms can offer (Chrysanthakopoulou et al., 2021). Unlike formal education, which tends to be shaped by centralized control, non-formal VR learning gives users more freedom to decide what to explore, how deeply to engage, and at what pace. This learner-centered approach is clearly visible in projects like The Museum of Digital Things, where visitors use extended reality tools to explore, handle, and digitally reconstruct cultural objects in ways that feel personally meaningful (Song & Evans, 2024). These VR environments do more than simply present information. They often combine thought, emotion, and social interaction in ways that feel natural and intuitive to learners. As students move through virtual reconstructions of historical places, they aren't just absorbing facts—they're interpreting what they encounter together, connecting it back to the cultural context embedded in the experience (Castro et al., 2025). Many museum-based VR programs also foster curiosity and inquiry. The RHINO-VR project, for instance, introduces robotics concepts by letting students engage in hands-on experimentation. While the setting feels informal and open-ended, the learning process still follows a clear educational structure and purpose (Schlachhoff et al., 2024). These examples demonstrate how museum-based VR embodies the core qualities of non-formal education—structured with intention and care, yet flexible enough to move beyond the rigid routines and formalities found in traditional academic settings.

3.6.3 Informal Learning (Home & Community Settings)

Informal learning, particularly within home and community settings, refers to voluntary, loosely structured, and often unintentional forms of education that emerge from individual curiosity or everyday social participation. Unlike formal or non-formal learning, informal education is neither institutionally organized nor governed by predefined objectives, and it is rarely assessed or credentialed. In the context of virtual reality (VR), this mode of learning is increasingly facilitated through mobile headsets, home-based applications, and public VR installations, enabling individuals to explore topics of interest at their own pace and initiative. For example, older adults who used VR programs for cognitive screening in home or assisted-living environments demonstrated heightened engagement and well-being without the need for formal instructional oversight (Siette et al., 2024). Community-oriented VR applications for basic life-support training likewise allow participants to practise critical skills in immersive environments outside the classroom, reinforcing essential competencies through self-directed participation (Figols Pedrosa et al., 2023). In environmental education, graduate-student-produced 360° VR forest tours let users traverse virtual landscapes from home or public kiosks, promoting meaningful knowledge acquisition through exploratory interaction (Stone, 2022). Informal VR learning also serves socio-emotional and community goals: virtual environments designed to foster social engagement among older adults bolster emotional well-being and inclusion without structured curricula (Xu et al., 2022), while VR language-learning tours immerse learners in culturally rich settings that nurture intrinsic motivation and personal goal-setting (Figueroa Jr. & Jung, 2025). Collectively, these examples underscore how informal VR learning supports holistic development—cognitive, emotional, and social—through self-guided, context-responsive experiences that arise organically outside institutional systems (see Table 5 for a comparative overview of formal, non-formal, and informal VR learning contexts).

Table 5. Comparison of Formal, Non-formal, and Informal Museum-VR Learning Contexts (derived from the 20-study SLR corpus)

Formal learning	Non-formal learning	Informal learning
Highly structured; embedded in a syllabus or compulsory module	May be partly structured (workshops, field-trip programmes, short courses)	Unstructured or loosely organised self-exploration
Direct instruction, teacher-designed VR tasks, graded assignments	Facilitated or guided by educators / museum staff; learning promoted through indirect activities (e.g., co-designing VR exhibits)	Self-directed; little or no facilitator intervention
Intended jointly by educator and learner (course requirement)	Primarily intended by the learner; educator provides opportunities	May be unintended at the outset—emerges from personal curiosity while using VR apps or kiosks
Recognised by both educator and learner; assessed with marks/credits	Recognised by the learner; sometimes acknowledged with certificates or badges	Often not formally recognised by the learner or any institution
Often extrinsic (grades, credit, graduation requirements)	Mixed: extrinsic (skill certificates) and intrinsic (interest, enrichment)	Predominantly intrinsic (enjoyment, personal interest, leisure)
Classrooms, computer labs, VR studios in schools / universities	Museums, cultural centres, community hubs, outreach venues; may also be run on campus	Anywhere – home VR headsets, public VR stations, mobile apps in museums
Has a mandated dimension (attendance & assessment compulsory)	Voluntary participation; learner opts in	Entirely voluntary and spontaneous
Learning is measured or certified (tests, rubrics, credit hours)	May be measured informally (participation logs, micro-credentials)	Not measured or certified
Emphasis on propositional / disciplinary knowledge (facts, concepts) plus targeted skills	Balances propositional and procedural knowledge (doing history, VR design)	Strong on experiential, procedural, and tacit knowledge (e.g., spatial sense, empathy)
Predominantly cognitive, with planned affective elements (e.g., empathy rubrics)	Integrates cognitive, emotional, social, and behavioural elements	Holistic: cognitive, emotional, social, and behavioural elements arise organically

3.7 Learners’ Cognitive, Motivational, and Socio-Emotional Development

Learning doesn't just happen in one dimension—it's about building how we think, what drives us, and how we relate to others. More and more studies are showing that immersive virtual reality (VR) can help support all of that at once. When VR is designed carefully with students in mind, it seems to make complex ideas easier to understand and helps them stay focused longer. Some research also points out that these kinds of immersive tasks can reduce mental overload and make the information stick better (Huang et al., 2023). On top of that, students often say they feel more involved when using VR—not just mentally, but also emotionally and behaviorally. They focus harder, take part more, and often enjoy it more than using regular classroom materials (Frontiersin Editors, 2024). One thing that really seems to matter is motivation. Some studies have mentioned that students, when immersed in VR and given chances to interact freely, often feel more engaged from the inside. That kind of inner drive doesn't always show up in traditional settings, but here, it seems to make a difference—even after the lesson is over. On the emotional side, a few learners said the experience made them feel surprisingly connected—not just to what they were learning, but to the people around them too. When they shared those virtual moments together, it created something that felt more real. All of this points to how VR, if designed thoughtfully, can blend mental effort, curiosity, and a sense of belonging in a way that's both meaningful and memorable (Makransky & Dahlstrom, 2022; Smith & Lee, 2022).

4. CONCLUSION

Museum-based virtual reality (VR) holds remarkable promise for enriching how students engage with history—whether they're sitting in a classroom, walking through a museum, or exploring on their own at home. In formal settings, like university courses, VR helps make learning more structured and meaningful. Lessons tied closely to the curriculum not only improve academic results but also help students better understand abstract historical concepts, all while maintaining clear expectations and assessment standards. In non-formal environments—such as interactive museum exhibits—VR encourages a more open and exploratory approach. Learners can follow their curiosity, build emotional connections to the past, and make sense of history in ways that go beyond textbooks or lectures. Informal VR learning, on the other hand, tends to unfold in quieter, more personal spaces—like someone trying out a VR app at home, or older adults revisiting cultural memories through digital reconstructions. These moments may be unplanned, but they often spark empathy, deepen historical awareness, and allow for personal growth outside formal instruction.

Beyond enhancing disciplinary knowledge, these VR-based experiences holistically nurture learners' emotional intelligence, intrinsic motivation, and social connectedness. Across contexts, immersive history learning not only supports students in acquiring factual knowledge but also empowers them to emotionally inhabit past events, collaborate meaningfully with peers, and reflect critically on historical narratives. The integration of VR into varied educational ecosystems broadens access to experiential learning and redefines how historical understanding is constructed. Therefore, it is essential for educators, museum professionals, and policymakers to recognize the complementary value of formal, non-formal, and informal VR learning. Supporting diverse immersive learning pathways can foster a more inclusive, empathetic, and engaging historical education landscape—one that bridges cognitive rigor with emotional resonance and empowers learners well beyond the classroom.

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