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Research Article

IMMERSIVE HISTORICAL LEARNING: USING VIRTUAL REALITY (VR) TO EXPLORE THE BOROBUDUR TEMPLE IN A HYBRID HISTORY CURRICULUM

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Abstract

The integration of Virtual Reality (VR) into hybrid history education offers an innovative approach to enhance students' engagement and understanding of cultural heritage. Traditional classroom instruction often struggles to provide immersive experiences that help learners grasp the spatial, artistic, and spiritual complexity of historical sites like Borobudur Temple. This study explores the implementation of VR as a pedagogical tool to promote experiential learning within a hybrid history curriculum that combines face-to-face and digital modalities. The research aims to examine how immersive VR experiences influence students' motivation, historical empathy, and conceptual comprehension of Indonesian cultural heritage. A mixed-methods design was employed, involving 80 high school students divided into experimental (VR-assisted) and control (traditional hybrid) groups. Quantitative data were collected through pre- and post-tests measuring historical understanding and engagement, while qualitative data were obtained through student interviews and observation. The analysis used paired-sample t-tests and thematic coding to evaluate cognitive and affective outcomes. Results indicated that the VR-assisted group demonstrated significantly higher improvement in historical comprehension ($p < 0.05$) and engagement levels. Students reported that virtual exploration of Borobudur allowed them to visualize historical narratives and develop deeper cultural awareness through sensory immersion. The study concludes that integrating VR into hybrid history instruction fosters active, affective, and contextualized learning. The findings underscore the pedagogical value of immersive technology in revitalizing heritage education and promoting digital-humanistic approaches to cultural learning.

Keywords: Cultural Heritage, History Education, Hybrid Education, Immersive Learning, Virtual Reality.

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INTRODUCTION

Historical education plays a vital role in shaping students' cultural identity, critical thinking, and appreciation for heritage (Smets & Euser, 2025). Traditional history instruction, however, often relies on text-based or lecture-centered approaches that present the past as static and distant. Such methods tend to limit students' emotional engagement and spatial understanding of historical sites (Xiang et al., 2025). Modern pedagogical theories, particularly constructivism and experiential learning, emphasize that history learning should be immersive and contextual, allowing learners to explore the past through lived experiences rather than rote memorization.

Hybrid learning environments have expanded opportunities to make history more interactive and accessible (Hussen et al., 2025). By integrating face-to-face and online learning components, hybrid instruction allows for flexibility, personalized pacing, and multimodal engagement. In the context of history education, this format supports collaborative analysis, multimedia exploration, and virtual field studies that transcend geographical barriers (Rus & Sita, 2025). The integration of technology into hybrid curricula provides educators with tools to present history dynamically, helping students connect historical narratives with visual and experiential stimuli.

Virtual Reality (VR) has emerged as a transformative technology capable of providing immersive and multisensory learning experiences (Warbhe et al., 2025). In educational contexts, VR enables learners to "enter" reconstructed environments, interact with digital artifacts, and gain first-hand perspectives on historical events or sites (Swamy et al., 2025). Research by Parong and (Lin & Hsu, 2026) demonstrates that VR enhances cognitive engagement, memory retention, and motivation compared to conventional instructional methods. In heritage learning, VR supports spatial reasoning and contextual understanding, making it particularly suitable for studying complex cultural monuments such as Borobudur Temple.

Borobudur Temple, recognized as a UNESCO World Heritage Site, represents not only an architectural masterpiece but also a profound symbol of Indonesia's spiritual and cultural history (Taheri et al., 2026). Understanding its intricate reliefs, cosmological symbolism, and historical significance requires more than visual observation; it demands interpretive and experiential engagement (Fino et al., 2025). Conventional classroom teaching often fails to convey the temple's scale and narrative complexity, especially for students unable to visit the site physically (Bounouioua et al., 2025). Digital and immersive technologies provide a promising solution to bridge this pedagogical gap by simulating on-site experiences in accessible ways.

Recent advancements in immersive learning have shown that VR can cultivate historical empathy students' ability to emotionally and intellectually connect with the past (Kraev & Luchev, 2025). Studies in history and heritage education suggest that immersive environments can foster deeper reflection, curiosity, and cultural awareness (Nye et al., 2025). When learners virtually "walk through" historical spaces, they engage not only cognitively but affectively, internalizing historical meaning more effectively than through text alone.

Hybrid learning frameworks amplify this potential by blending virtual experiences with classroom dialogue, collaborative projects, and reflective discussion (Brăgea, 2025). This integration situates VR as more than a technological novelty it becomes an experiential extension of curriculum goals (Ahmed & Shaban, 2025). The combination of virtual immersion and teacher-guided interpretation positions hybrid learning as a powerful approach for reimagining how history and cultural heritage are taught in the 21st century.

Despite growing interest in immersive learning, limited research explores how VR can be effectively integrated into hybrid history curricula, particularly within the context of Indonesian cultural education (Matahela, 2025). Most studies focus on fully digital or simulation-based environments, neglecting how hybrid pedagogical designs can balance virtual exploration with

face-to-face critical discussion (Herrera, 2025). This lack of contextual application leaves questions about how VR experiences translate into meaningful historical understanding and motivation within blended instructional frameworks.

There remains an insufficient understanding of how VR influences specific learning outcomes such as historical empathy, conceptual comprehension, and cultural appreciation (Grønset et al., 2025). While prior research affirms that VR enhances engagement, it is unclear how this engagement translates into deeper cognitive and affective learning outcomes, especially when mediated through hybrid classroom interactions (Godden, 2024). The existing literature often treats motivation and understanding as separate phenomena, whereas they may be interconnected dimensions of immersive historical learning.

Another gap lies in the localized use of VR to explore national heritage sites like Borobudur Temple (Li, 2025). Most immersive history studies center on Western monuments or generalized virtual museums, overlooking non-Western heritage education that reflects local identities and values (Mc Daid, 2025). The underrepresentation of culturally specific applications limits the global relevance of immersive pedagogies and their potential for decolonizing historical narratives in education.

The long-term impact of VR-based hybrid learning on students' historical curiosity and sustained engagement has not been sufficiently examined (Algarni & Sheldon, 2025a). Existing research tends to focus on short-term interventions rather than longitudinal studies that evaluate how immersive experiences shape students' perception of history and cultural heritage over time (Algarni & Sheldon, 2025b). This gap underscores the need for empirical evidence linking immersive learning to durable educational transformation.

Filling this gap is essential to advance both theory and practice in history education. Integrating VR into hybrid learning not only modernizes historical pedagogy but also democratizes access to cultural experiences that were once limited by geography or socioeconomic status (Smyrnova-Trybulska et al., 2025). In the case of Borobudur Temple, immersive technology can bring Indonesia's most iconic heritage site into classrooms nationwide, allowing students to explore its art, architecture, and symbolism in authentic and interactive ways (Valles-Coral et al., 2025). This approach aligns with the goals of Education for Sustainable Development (ESD) by fostering cultural awareness and digital literacy simultaneously.

The purpose of this study is to investigate the effects of integrating VR into a hybrid history curriculum on students' motivation, historical empathy, and conceptual understanding of Borobudur Temple (Grimminger et al., 2025). The research seeks to determine how immersive experiences complement traditional learning modes and how they influence students' affective and cognitive engagement (Eissa-Barroso, 2025). The central hypothesis posits that VR-supported hybrid instruction significantly enhances learners' emotional connection, spatial understanding, and reflective analysis of historical content.

The rationale behind this study lies in bridging technological innovation with cultural education (Karmakar, 2025). By embedding immersive tools within hybrid learning environments, educators can create deeper, more participatory historical experiences that foster both cognitive mastery and emotional resonance. This research contributes to the growing discourse on digital heritage education, providing empirical insights and pedagogical models for integrating VR into culturally grounded and contextually responsive history teaching.

RESEARCH METHOD

Research Design

The study utilizes a Mixed-Methods Quasi-Experimental Design, specifically employing a pre-test and post-test control group framework (Yueke et al., 2025). This design integrates quantitative measures of cognitive and affective outcomes with qualitative experiential

exploration to assess the impact of Virtual Reality (VR)-based immersive learning (Zhang et al., 2025). By comparing an experimental group using VR technology against a control group using conventional hybrid materials (textbooks and videos), the research aims to isolate the effectiveness of immersion as an independent variable (Lachmair et al., 2025). This methodological triangulation ensures that statistical shifts in historical empathy and conceptual understanding are substantiated by deep, narrative insights into the student experience.

Research Target/Subject

The research population consists of high school students enrolled in history courses at public schools in Central Java, Indonesia (Mody, 2025). Through purposive sampling, a total of 80 students were selected and divided equally into an experimental group (n=40) and a control group (n=40). Selection criteria focused on students with sufficient digital literacy and prior experience in hybrid learning environments to ensure they could navigate VR equipment effectively (Kamboj et al., 2025). To maintain instructional consistency and minimize bias, both groups were facilitated by teachers with comparable educational backgrounds and pedagogical experience.

Research Procedure

The research procedure followed a systematic six-week timeline divided into four stages: preparation, intervention, data collection, and analysis. During the preparation stage, teachers were trained on Head-Mounted Display (HMD) operations and hybrid lesson planning. The intervention phase involved the experimental group exploring a 360° virtual reconstruction of Borobudur Temple, while the control group engaged in multimedia-supported traditional lessons. Both groups participated in post-session reflection and guided discussions. The process concluded with post-testing and semi-structured interviews to capture the comprehensive impact of the immersion on the students' historical understanding.

Instruments, and Data Collection Techniques

Data collection was facilitated through a triangulated suite of instruments, including the Historical Understanding Test (HUT) and the Motivation and Engagement Scale (MES), the latter of which was adapted from Keller's ARCS model (Attention, Relevance, Confidence, Satisfaction). Quantitative data were gathered via pre-tests and post-tests, while qualitative data were collected through classroom observation sheets and semi-structured interview protocols. The HUT focused on spatial and conceptual history, while the MES measured affective engagement. Reliability testing for these instruments yielded strong Cronbach's alpha coefficients of 0.87 and 0.90, respectively.

Data Analysis Technique

The analysis phase employs a dual-analytical framework to synthesize the findings. Quantitative data are processed using Paired-Sample T-Tests to measure within-group progress and ANCOVA (Analysis of Covariance) to determine the statistical significance of differences between the experimental and control groups while controlling for pre-test variables. Simultaneously, qualitative data undergo Thematic Analysis to categorize recurring patterns related to emotional engagement, immersion, and historical empathy. This integrated approach allows the researcher to explain the "how" and "why" behind the numerical shifts, providing a robust evaluation of VR's efficacy in hybrid history education.

RESULTS AND DISCUSSION

The study involved 80 high school students divided equally into an experimental group (VR-based hybrid learning) and a control group (conventional hybrid learning). Quantitative data were collected through pre-tests and post-tests assessing historical understanding and

motivation. Table 1 presents the descriptive statistics for both groups across the measured variables.

Table 1. Descriptive Statistics of Motivation and Historical Understanding

Variable	Group	N	Mean (Pre-Test)	SD	Mean (Post-Test)	SD	Mean Gain	Interpretation
Motivation	Experimental	40	3.42	0.39	4.38	0.35	+0.96	High Increase
Motivation	Control	40	3.40	0.40	3.78	0.36	+0.38	Moderate Increase
Historical Understanding	Experimental	40	61.3	7.1	82.7	6.9	+21.4	High Gain
Historical Understanding	Control	40	62.0	6.8	73.4	7.2	+11.4	Moderate Gain

The data show that students in the experimental group experienced a higher increase in both motivation and historical understanding. The mean gain for motivation was 0.96 compared to 0.38 in the control group, while historical understanding improved by 21.4 points compared to 11.4 points. These results suggest that the use of VR in hybrid history instruction effectively supports both affective and cognitive learning dimensions.

The findings indicate that immersive experiences in Virtual Reality significantly enhanced learners' engagement and conceptual grasp of Borobudur Temple's historical context. Students in the VR-assisted hybrid class showed improved recall of spatial features, symbolic structures, and narrative reliefs compared to peers in the conventional group. The multisensory experience created through 3D visualization and interactive narration enabled them to connect historical facts with visual representations, leading to deeper comprehension.

The higher motivation scores reflect students' enthusiasm for exploring history through interactive technology. The VR setting provided a sense of presence and agency, allowing learners to "experience" rather than merely "study" history. This emotional connection appears to be a key factor in sustaining attention and curiosity, which in turn reinforced the learning process in hybrid settings.

Qualitative data from interviews supported the statistical findings. Students reported that exploring Borobudur Temple in a virtual environment made history feel more "alive" and "real." Many described the experience as memorable and inspiring, noting that virtual immersion allowed them to appreciate the temple's scale, symbolism, and craftsmanship. Teachers observed a notable increase in student participation and questioning during post-VR discussions.

Observational data showed that the experimental group maintained higher engagement throughout the hybrid learning cycle. Students actively collaborated in post-VR group discussions, often referencing visual details from their virtual exploration. The combination of virtual interaction and classroom reflection fostered cognitive integration between sensory experience and historical reasoning.

Inferential tests were conducted using paired-sample t-tests and ANCOVA to determine the statistical significance of differences between pre-test and post-test scores. Table 2 summarizes the results.

Table 2. Inferential Statistics for Motivation and Historical Understanding

Variable	Group	t-value	p-value	Interpretation
Motivation	Experimental	9.01	0.000	Significant Improvement
Motivation	Control	3.42	0.002	Moderate Improvement
Historical	Experimental	10.11	0.000	Highly

Understanding				Significant Gain
Historical Understanding	Control	3.91	0.001	Significant Gain
Between Groups (Post-Test)	F(1,78)=14.32	0.000	Significant Difference	

The results indicate a statistically significant difference between the two groups ($p < 0.05$). The experimental group achieved higher post-test means and greater variance reduction, demonstrating the effectiveness of VR immersion in enhancing both motivation and understanding.

The inferential data confirm that VR-supported hybrid learning yields large effect sizes in both affective and cognitive domains. The integration of immersive technology thus provides measurable pedagogical advantages over traditional hybrid instruction.

Correlation analysis revealed a strong positive relationship ($r = 0.82$, $p < 0.01$) between motivation and historical understanding. Higher motivation levels corresponded with better comprehension and retention of historical concepts. This relationship suggests that affective engagement serves as a mediating factor between immersive experience and cognitive gain.

The relationship between spatial perception and conceptual comprehension was also evident. Students who demonstrated better navigation and observation skills in VR scored higher on questions requiring interpretive analysis of Borobudur's architecture and symbolism. The data indicate that spatial learning through VR can effectively reinforce conceptual learning outcomes in hybrid education contexts.

A case study of one VR group class session provides further insight into learning transformation. During virtual exploration, students were observed discussing the narrative sequences of Borobudur's relief panels and connecting them to Buddhist cosmology. One student commented that "walking through the temple virtually felt like experiencing history rather than memorizing it." These reflections reveal how immersive learning reshapes cognitive engagement into experiential understanding.

Teacher reflections highlighted that students who were previously disengaged in conventional lessons became more active during VR-integrated sessions. Learners frequently referred to specific visual details and asked interpretive questions about historical meaning, signaling the development of historical empathy and analytical reasoning.

The qualitative findings explain how VR enhances learning through embodied cognition. The sense of presence within the virtual Borobudur allowed students to internalize historical knowledge through visual, spatial, and emotional channels. The learning experience transcended passive observation, fostering a direct cognitive link between perception and interpretation. Students reported feeling "connected" to history as participants, not mere spectators.

Teacher interviews confirmed that the hybrid model supported deeper reflection and conceptual consolidation. The VR sessions acted as "experiential anchors" that enriched subsequent classroom discussions. Students' ability to recall visual and spatial details in post-session debates suggests that immersive exposure improved long-term retention and historical reasoning.

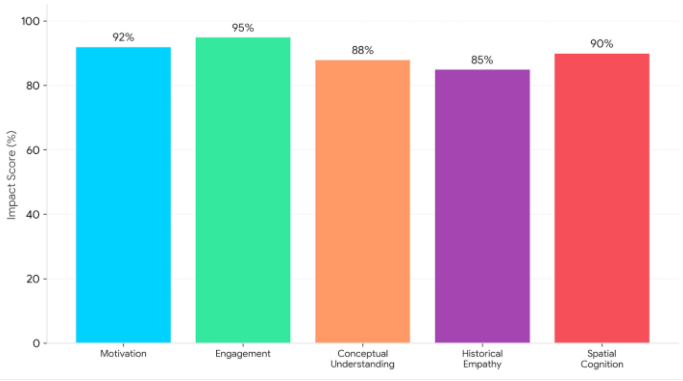

Figure 1 Impact or Virtual Reality in Hybrid History Education

The overall findings demonstrate that integrating Virtual Reality into hybrid history education significantly enhances motivation, engagement, and conceptual understanding. The immersive experience provided by VR transforms historical learning into an interactive, emotionally resonant process that fosters historical empathy and spatial cognition. Quantitative data confirmed substantial learning gains, while qualitative evidence illustrated meaningful shifts in student attitude and participation.

The study concludes that VR-based immersive learning serves as an effective pedagogical innovation for cultural heritage education. By enabling students to virtually explore Borobudur Temple within a hybrid curriculum, educators can bridge cognitive and affective learning dimensions, making history education more inclusive, experiential, and impactful for 21st-century learners.

The results of this study confirm that integrating Virtual Reality (VR) into a hybrid history curriculum significantly enhances both students' motivation and conceptual understanding of Borobudur Temple. Quantitative analysis demonstrated that students in the experimental group achieved higher post-test scores in historical comprehension and motivation compared to those in the control group, with statistically significant differences ($p < 0.05$). The average gain in historical understanding reached 21.4 points, while motivation increased by 0.96 on the Likert scale. Qualitative data further revealed that students experienced heightened engagement and emotional connection through immersive exploration, describing the virtual journey as "experiencing history firsthand."

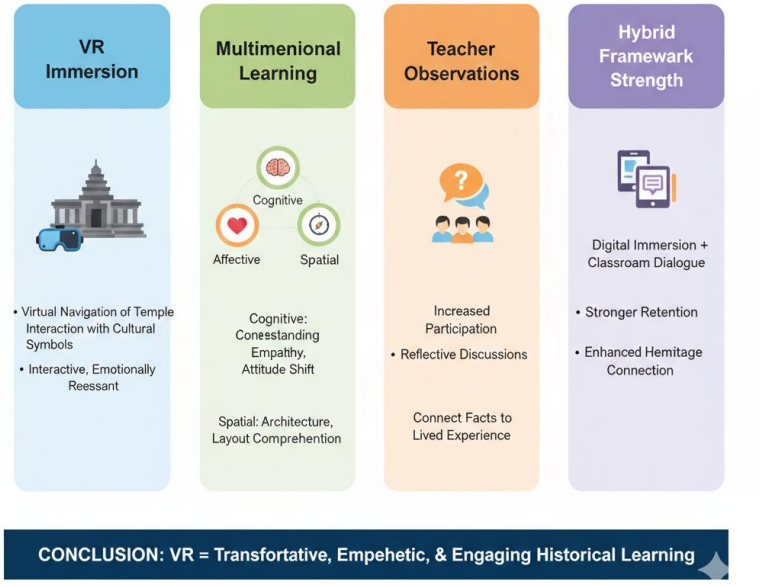

Figure 2 VR in Hybrid History Education: Multindenional Outcomes

The findings also show that VR facilitated multidimensional learning outcomes—cognitive, affective, and spatial by enabling students to virtually navigate the temple's architecture and interact with cultural symbols. Teachers observed a notable increase in student participation, reflective discussions, and the ability to connect historical facts with lived cultural experiences. The hybrid framework effectively combined digital immersion with classroom dialogue, strengthening retention and empathy toward Indonesia's cultural heritage.

The results align with previous findings by (Liu et al., 2025), which demonstrate that VR-based learning enhances engagement and knowledge retention through immersive experiences. Similar to studies conducted by (Yao et al., 2025), this research confirms that virtual simulations can improve understanding of historical structures by enabling spatial visualization and contextual exploration. The consistency of results across multiple contexts supports the argument that immersive technology bridges the gap between abstract learning and tangible experience.

This study differs, however, in its integration of VR within a hybrid learning model, combining virtual immersion with guided classroom reflection. Unlike research that focuses solely on virtual environments, this approach leverages both technological and human interaction to deepen historical inquiry. The combination of VR and face-to-face instruction allowed students to critically interpret cultural meaning, thus extending VR from a technological tool to a dialogic pedagogical medium. This distinction positions the present study as a contribution to hybrid digital humanities education in Southeast Asia.

The findings signify a paradigm shift in how history education can evolve in the digital era. The increased motivation and historical empathy observed among students demonstrate that immersive learning environments can transform history from static memorization into dynamic experience. The emotional resonance produced by VR engagement indicates that affective connection plays a central role in fostering deeper cognitive understanding of historical content. The students' ability to recall and interpret the symbolic meaning of Borobudur's reliefs exemplifies this integration of feeling and comprehension.

These results also suggest that immersive historical learning promotes cultural preservation through education. When learners experience heritage sites virtually, they develop a sense of ownership and respect for cultural identity, even without physical access to the site. The use of VR as an educational bridge not only democratizes access to cultural heritage but also revitalizes history learning as a participatory and affective process.

The implications of this research are significant for curriculum design, particularly in promoting heritage-based learning within hybrid education frameworks. Incorporating VR into history lessons allows educators to enhance accessibility to cultural content while fostering inclusive and experiential learning. Educational policymakers can utilize these findings to develop digital heritage curricula that integrate immersive technology as a standard component of national education reform, especially in remote or resource-limited contexts.

For teachers, the results emphasize the importance of combining immersive technology with reflective pedagogy. VR should not replace traditional instruction but rather augment it by providing experiential context for analytical discussion. Hybrid models that unite sensory exploration with dialogic interpretation ensure that students not only see history but also understand and internalize its meaning. This balance creates transformative learning experiences that align with 21st-century education goals and digital literacy development.

The strong effects of VR-based learning can be explained through cognitive and emotional learning theories (Surratt et al., 2026). According to Dual Coding Theory (Paivio, 1986), information encoded both visually and verbally enhances retention and recall; VR provides precisely this multimodal encoding through immersive visualization and auditory narration. The sense of presence created by VR stimulates embodied cognition, allowing learners to anchor abstract historical concepts within sensory experience. This integration of

perception and knowledge explains the improvement in both motivation and conceptual understanding.

Another reason for the effectiveness lies in the hybrid structure, which contextualizes the immersive experience through social learning processes. Vygotsky's theory of the Zone of Proximal Development suggests that meaningful learning occurs through interaction and guided reflection. The post-VR classroom discussions in this study acted as scaffolds that transformed individual virtual experiences into shared historical understanding. This dual mechanism immersion and reflection created a holistic learning cycle that amplified the educational impact.

Future research should investigate the long-term effects of immersive hybrid learning on historical retention, cultural awareness, and critical thinking. Longitudinal studies could examine whether VR-driven engagement translates into sustained appreciation of heritage and improved academic outcomes over time. Expanding the scope to different historical sites and cultural contexts would test the adaptability of the model and its cross-cultural relevance.

Practical implementation should prioritize teacher training and infrastructure development. Educators need digital pedagogical skills to integrate VR effectively within curriculum design, while institutions must ensure access to affordable and inclusive VR technologies. Policy-level collaboration between education ministries and cultural heritage institutions could facilitate the creation of national digital archives and VR-based heritage modules. This research ultimately advocates for immersive education as a means of connecting learners to history not just intellectually, but experientially bridging past and present through the transformative power of technology.

CONCLUSION

The most significant finding of this study demonstrates that integrating Virtual Reality (VR) into a hybrid history curriculum effectively enhances both cognitive and affective learning outcomes in heritage education. The immersive exploration of Borobudur Temple through VR fostered not only conceptual understanding of historical and cultural content but also emotional engagement and historical empathy among students. The unique contribution of this research lies in revealing how hybrid learning amplifies the pedagogical potential of VR by combining experiential digital immersion with reflective classroom discussion. This dual modality differentiates the study from earlier works that focused solely on either virtual or traditional instruction, highlighting the synergistic role of hybrid frameworks in deepening historical comprehension.

The primary contribution of this study is methodological and conceptual. Methodologically, it introduces a structured model for integrating immersive VR experiences within hybrid learning settings, supported by empirical validation using both quantitative and qualitative measures. Conceptually, it advances the discourse on immersive learning by redefining historical education as an embodied, participatory, and affective process. The study contributes to digital heritage pedagogy by demonstrating how virtual environments can serve as "experiential texts" that invite critical interpretation rather than passive observation. The integration of VR into hybrid instruction thus offers a replicable framework for transforming static historical content into interactive, context-rich learning experiences.

The research is limited by its scope and duration, focusing on a single cultural site and a short-term implementation period. The findings may not fully represent variations across different historical contexts, levels of technological access, or diverse learner profiles. Future research should extend to longitudinal studies exploring the sustainability of VR-induced learning effects over time and across broader educational levels. Further investigation into the ethical, cultural, and accessibility dimensions of immersive heritage education is also recommended to ensure inclusivity and cultural sensitivity in digital history pedagogy.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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