Enhancing Motivation and Learning in Primary School History Classrooms: The Impact of Virtual Reality

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Abstract

Conventional classroom instruction often struggles to effectively convey cultural heritage due to constraints in spatial and temporal dimensions, limiting students' ability to fully engage with and appreciate historical content. In contrast, virtual reality (VR) technology offers a human-centered, immersive way to present cultural heritage, creating a dynamic digital experience particularly beneficial when physical access to heritage sites is unavailable. This study investigates whether VR-based learning can enhance students' performance in cultural education compared to traditional teaching methods. A sample of 228 primary school students from Grades 5 and 6 was randomly assigned to one of two groups: a high-visual engagement group (VR with 360° video) or a low-visual engagement group (static video and textbook). The findings revealed that students in the high-visual engagement group achieved higher levels of intrinsic motivation and demonstrated greater learning improvements than their counterparts in the low-visual engagement group. Furthermore, the study identified negative user experiences as a significant factor moderating the connection between intrinsic motivation and learning outcomes. These results highlight the value of integrating VR into conventional teaching practices, showcasing its potential to enhance student engagement and improve educational outcomes in history and cultural studies.

CCS Concepts

• **Applied computing** → **Education**.

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Keywords

Virtual reality, Cultural education, K-6 learning, Structural equation modeling, Fornell-Larcker criterion, PLS-SEM model, Motivation, Engagement

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1 Introduction

Virtual reality (VR) technology is increasingly recognized as a powerful tool for enhancing education. Its growing accessibility is expected to significantly impact learning environments and support lifelong learning development [1, 69, 70]. Once confined to niche laboratory use, VR has now become a mainstream tool, enabling its integration into classrooms and offering new ways to deliver instruction [27]. Compared to traditional pedagogical methods such as PowerPoint, handouts, and websites, VR-based instruction facilitates dynamic models, simulations, and visualizations, which enhance student engagement, critical thinking, and cognitive development [15]. Studies show that VR improves student motivation and provides immediate, relevant information—such as videos and 3D images—that aid comprehension and cognitive processing [11]. By harnessing these benefits, VR has the capacity to revolutionize traditional education, fostering more interactive and effective learning experiences.

However, most previous studies have focused on subjects like technology, science, and mathematics, likely because these fields often involve abstract, non-observable concepts far removed from everyday experiences [2]. In contrast, history and culture education has received less attention, partly because conveying meaningful experiences through historical sites is challenging due to the temporal and spatial distances involved and the absence of original cultural contexts [4]. Primary school students, while developing basic logical reasoning, still rely on tangible supports and struggle to maintain attention, making it difficult to engage with historical and cultural content in traditional classrooms [41, 47]. Creating engaging experiences is crucial for enhancing intrinsic motivation, a key factor in effective learning [15]. For younger children forming their self-concept, understanding their own culture and distinguishing it from others is still developing [26]. Promoting motivation positively influences academic performance while nurturing a stronger connection to and sense of responsibility for national history and culture [29, 32].

With the rise of the Internet and digital technologies, there is increasing attention on how these environments affect learning motivation, particularly contextual influences [33]. Most existing literature focuses on extrinsic motivation, while fewer studies have explored intrinsic motivation in knowledge acquisition [36]. Cognitive appraisal theory suggests that external factors influencing students' sense of autonomy or competence can significantly impact intrinsic motivation. Research indicates that novel, integrated media can foster intrinsic motivation, such as Weng's [72] role-playing educational game, which enhances student engagement and motivation in mathematics. Recently, augmented reality (AR), VR, and mixed reality have gained popularity as tools for creating immersive learning activities aimed at boosting motivation [73]. These technologies provide highly interactive, person-centered presentations and are particularly useful in digitizing cultural heritage, especially where physical access is limited [76]. VR, in particular, has shown moderate to high impacts on learning about history and culture by providing rich, realistic, and manipulable sensorimotor stimuli [75].

Despite VR's potential, its integration into classroom settings poses challenges, including the complexity and time required to effectively use VR applications [78]. Although many VR technologies have been developed for educational purposes, few have been successfully implemented in classrooms. Furthermore, while the advantages of VR over traditional methods are documented, the exact mechanisms through which VR influences learning outcomes remain unclear. To address these challenges, this study aims to explore the potential of VR in teaching cultural heritage by offering a more effective pedagogical approach that enhances students' motivation to learn history and deepens their understanding of historical culture through immersive media experiences. This research uses a variety of multimedia sources, including VR, text, static video, and 360° videos, integrating digital cultural heritage content into students' learning environments. Thus, this study seeks to answer the following questions:

1. How do different levels of visual stimuli (e.g., VR video stimuli) influence historical learning experiences and affect intrinsic learning motivation?

2. To what extent do virtual classroom experiences impact students' intrinsic learning motivation?

This paper presents the findings of a study conducted with 228 fifth and sixth-grade students from Xi'an, exploring the impact of virtual travel experiences on students' motivation for learning about cultural heritage.

2 BACKGROUND

2.1 Cognitive Evaluation Theory

Cognitive Evaluation Theory, a component of Self-Determination Theory (SDT), examines the impact of external influences on students' intrinsic motivation by altering their perceptions of competence and autonomy [19]. Intrinsic motivation arises from the satisfaction students experience in engaging with activities, with autonomy and competence as key factors, though relatedness may also contribute [20]. The theory posits that external events have both controlling and informational aspects, with their effect on motivation depending on which aspect is more prominent [14]. For example, classroom elements like supervision, deadlines, and rules may undermine autonomy and reduce motivation, while providing choices and positive feedback enhances it [16]. Similarly, events that build competence, like constructive feedback, can boost motivation, whereas criticism can diminish it [21].

With the increasing accessibility of immersive technologies such as VR, research has shifted focus to understanding how learning environments impact motivation, especially intrinsic motivation [17]. Several studies have investigated VR's role in enhancing student engagement. Studies have demonstrated that using concept maps within educational computer games can enhance learners' achievements and motivation [45]. Additionally, attention has been analyzed through EEG technology to investigate its influence on learning motivation. Other research has focused on the development of role-playing educational games, designed to provide immersive experiences in a microscopic world [30]. These games have been shown to improve interaction, enjoyment, and indirectly, academic achievement in mathematics. Investigations into online learning environments have highlighted that motivational beliefs significantly affect learning engagement, with motivation acting as a mediator between task value and engagement [79]. Moreover, studies in blended learning settings have revealed that self-efficacy and task value indirectly predict learning engagement through the regulation of motivation [71].

Despite the extensive research on VR in science and technology subjects, cultural learning has received less attention. Yet, as multicultural education and global media influences grow, children face new challenges in identifying with their own culture. VR-based demonstrations, with their dynamic models and immersive visualizations, offer promising solutions by creating engaging environments that enhance cognitive development and critical thinking. However, there remains a need for more focus on cultural education, as motivating children to engage with their cultural heritage is increasingly essential.

2.2 Virtual Reality Classroom Experience

Virtual reality (VR) technology is increasingly being integrated into classroom activities, which offers more immersive and engaging learning opportunities [28]. Previous research has utilized various indicators to evaluate students' experiences with immersive technologies, such as visual stimulation, presence [31], engagement [60], and positive emotions [2]. Learning outcomes in VR environments are influenced by simulated stimuli and feedback, mediated by cognitive factors like self-efficacy. While immersion and presence have been focal points in past research, they are key features that differentiate VR from traditional teaching methods, highlighting the need to measure their impact on students' learning motivation. VR has demonstrated promising effects on learners' cognitive skills, behavioral development [35], and positive learning motivation [59]. Previous studies suggest that strong intrinsic motivation fosters future development opportunities, academic success, and behavioral outcomes, particularly in younger students. This paper, therefore, focuses on the impact of virtual classroom experiences on elementary students' intrinsic motivation.

2.2.1 Visual Experience. As direct participants and key beneficiaries of online learning, students' learning experiences are shaped by various factors. Veletsianos et al. [68] identified key influences on online course experiences, including sensory, emotional, value-added experiences, technological functionality, and course content. Among sensory factors, the simultaneous stimulation of multiple senses, such as vision, hearing, and smell, can significantly enhance students' course experiences. For children, particularly those aged 7-12, vision serves as the primary channel for receiving external stimuli and acquiring information [24]. Research indicates that more than 80% of the information adolescents receive from their environment is visual, underscoring the critical role of visual information in children's overall psychological development.

Despite the extensive focus on visual experiences, the academic community has yet to reach a unified definition of the term. Sedig and Parsons [62] defined visual experience as cognitive activity achieved through visual means, enabling individuals to objectively understand phenomena by observing, thinking, analyzing, and experimenting. Domestically, interpretations of visual experience have been primarily drawn from artistic contexts, with scholars expanding the definition based on both theoretical and practical insights. Krishna [40] defines visual experience as the perception derived from processing spatial information through the visual system, while Xingyang Lv [46] considers it to be the information acquired through the act of "seeing" and interacting with the surrounding environment.

In the realm of educational research, scholars have increasingly addressed the sensory dimension of learning experiences. Wu [74] found that the visual characteristics, usability, and support services of online courses are major factors influencing students' learning experiences, which, in turn, correlate with their learning behaviors and motivation. Empirical evidence demonstrates that visual experience within classroom settings affects students' learning experiences and, consequently, their learning outcomes. Given the growing emphasis on historical and cultural education [23], understanding the sensory experiences of younger students, particularly within VR environments, holds significant implications for both the education sector and the VR industry. Based on these insights, the following hypothesis is proposed:

H1: Visual Experience positively influences students' intrinsic motivation.

2.2.2 Immersion. Immersion is a key area of focus for scholars studying the implementation of virtual reality (VR) in classroom activities [33], which encompasses two dimensions. At the technical level, immersion refers to "a vivid illusion of reality transmitted to the user's senses by a computer display," representing the extent to which users disengage from their physical environment. At the psychological level, immersion is the degree to which individuals feel encompassed by sensory stimuli in their environment. In a VR classroom, immersion describes the state of deep cognitive and emotional engagement with the virtual environment, supported by technology that enhances sensory involvement and prompts immersive experiences [8]. For example, head-mounted VR devices with 360 ° views disconnect users from their physical surroundings, providing a completely immersive learning environment. VR can recreate historical settings, enabling learners to experience ancient societies more effectively than traditional methods [9].

Immersion differs from presence in that it emphasizes the feeling of being "surrounded" by stimuli, rather than a sense of physically being in a particular space. For example, one might feel immersed in reading or watching something without feeling a spatial presence. In educational settings, when students are deeply focused on learning activities, their emotional engagement is heightened, with increased attention, curiosity, and interest leading to greater motivation to learn [10].

Research suggests that immersion, characterized by its pleasurable, time-dissolving nature, positively influences students' willingness to participate in learning activities [50]. It promotes self-actualization, representing a psychological state in which learners engage deeply with challenges within their capabilities. VR immersion helps learners focus on the immediate task, fostering feelings of satisfaction and pleasure while diminishing awareness of real-world limitations [55]. This enhanced sense of realism can, in turn, stimulate learning behaviors. Based on these insights, the following hypotheses are proposed:

H2: Visual experience positively influences immersion.

H3: Immersion positively influences students' intrinsic motivation.

2.2.3 Presence. Presence is another key factor distinguishing virtual reality (VR) teaching videos from traditional educational tools, significantly enhancing cognitive performance, emotional development, and overall learning outcomes [11]. It is crucial for learner success in virtual environments and is an important quality indicator of these environments [5]. Presence typically means the subjective sensation of being fully immersed in the VR environment, which plays a vital role in human information processing and cognitive performance [52]. Research shows a strong correlation between presence and positive educational experiences; for instance, students using head-mounted displays tend to experience greater levels of presence and enjoyment compared to those using desktop-based VR systems [61]. Studies across various fields, including history, health, and skills training, demonstrate that immersive VR technologies create a stronger sense of presence compared to non-immersive systems [66]. In educational contexts, virtual presence has been linked to greater enjoyment and cognitive engagement, leading to better learning outcomes. Based on these insights, the following hypotheses are proposed:

H4: Visual experience positively influences presence.

H5: Presence positively influences students' intrinsic motivation.

2.3 Intrinsic Motivation and Learning Outcomes

The connection between learning motivation and academic performance is widely recognized and well-documented [66]. High

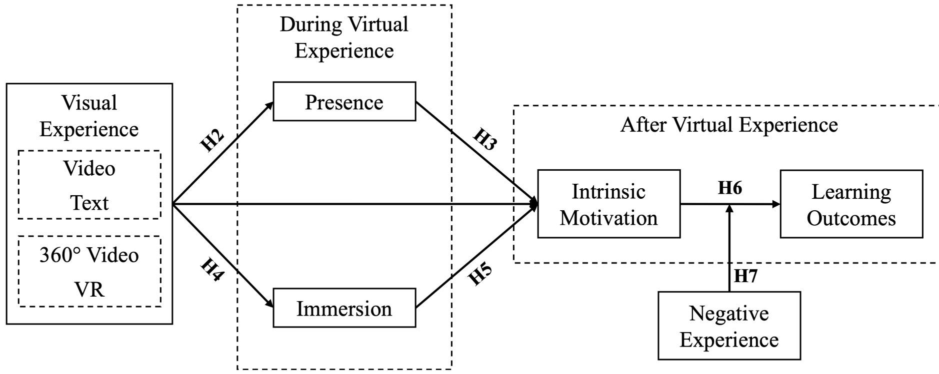

Figure 1: The proposed conceptual framework

levels of autonomous learning motivation are significantly positively correlated with academic achievement [6]. When students exhibit autonomy and enthusiasm in learning, they tend to acquire knowledge more effectively and achieve better academic outcomes. Kim & Ke [38] conducted a systematic analysis of learning motivation research, concluding that stronger motivation is positively correlated with improved academic performance. Similarly, Yeung et al. [77], through a survey, identified strong connections between gender and learning motivation, as well as between motivation and academic success. Existing research primarily examines how motivation affects educational outcomes and explores the underlying mechanisms driving these effects [58]. However, studies specifically addressing intrinsic motivation and its impact on learning outcomes remain limited. Research consistently indicates that intrinsic motivation, as opposed to extrinsic motivation, is more effective in fostering enjoyment and active engagement in learning. When students derive satisfaction and a sense of accomplishment from their studies, they are more likely to participate enthusiastically, ultimately enhancing their academic performance.

Based on these findings, the following hypothesis is proposed:

H6: Intrinsic motivation positively influences students' learning outcomes.

2.4 Negative Experiences

Generally, multi-sensory stimulation enhances the realism and enjoyment of experiences [63]; however, excessive stimulation may cause negative outcomes like dizziness or cognitive overload, which may reduce the sense of presence. This is particularly relevant for elementary school students, as VR devices can cause physiological discomfort. Prolonged use of VR headsets may result in symptoms like headaches and eye fatigue [34]. Some limitations of VR in education are highlighted such as VR environments often depict impossible events that violate physical and biological laws [49]. While many believe that children as young as four can make reliable probability judgments about real-world events [12], others argue that VR may blur children's distinction between reality and fantasy [37]. Additionally, research indicates that student engagement in VR environments can be low, with distractions, language difficulties, insufficient computer skills, and challenges completing reflective tasks contributing to negative user experiences [65].

Some researchers are beginning to explore the potential drawbacks of VR in education, particularly for younger students, studies specifically addressing these negative effects remain scarce [51]. Research into the negative impacts of VR on children is crucial, as their physical and cognitive development is still in progress, and excessive immersion may affect their cognitive processes. In this work, the negative user experiences with VR refer to a range of adverse physiological and psychological responses that children may encounter while immersed in a virtual environment [65]. More research is needed to clarify how learners, especially younger ones, can effectively benefit from VR experiences. Based on this, the following hypothesis is proposed:

H7: Negative experience significantly moderates the effect of intrinsic learning motivation on learning outcomes.

In this study, we examined sensory factors (e.g., visual experience) and cognitive factors (e.g., immersion and presence) that affect VR learning motivation and outcomes. Drawing on cognitive evaluation theory and a motivational perspective [39, 64], we argue that VR enhances intrinsic learning motivation by providing feedback to learners through three key dimensions: immersion, presence, and visual experience. This research introduces a conceptual framework to investigate the pathways through which VR influences learning motivation, as well as the correlation between negative user experiences during VR use and their impact on intrinsic motivation and learning outcomes (see Fig. 1).

3 METHODOLOGY

3.1 Data Samples

The experimental sample comprised 228 fifth and sixth grade students from an elementary school in Xi'an, equally divided between boys and girls, aged 10 to 12 years. All participants had normal vision for their age group, were emotionally stable, and physically healthy prior to the experiment. None had participated in similar experiments before, and informed consent was obtained from their parents. To address potential misunderstandings of the questionnaire due to participants' unfamiliarity with VR, subject teachers provided a brief introduction to VR experimental concepts before the survey. This ensured that students had a basic understanding of VR, enabling them to accurately comprehend the questionnaire items. Participants adapted well to both the 360° video and standard

PC static video, encountering no difficulties in operation. Demographic data indicate that over three-quarters (77.1%) of the participants were fifth graders, and while most lacked prior experience with VR, they expressed enthusiasm about its use in the classroom.

3.2 Equipment and Materials

This study utilized four distinct presentation formats to deliver learning materials, incorporating varying levels of interactivity and immersion. For high-sensory conditions, VR and 360° videos were presented via head-mounted displays (HMDs) and personal computers (PCs), while low-sensory conditions employed static videos and textbooks. The PICO 4 Pro VR headset, a commercial product, was used in the high-sensory conditions. It features two 2.56-inch fast LCD displays with a resolution of 4320×2160, weighs only 304 grams, and includes cushioned support. The headset automatically adjusts for interpupillary distance, allowing individuals with vision correction to view VR content comfortably without removing their glasses. In the PC group, a Dell Latitude 7490 laptop was used. To watch the video, a projector, canvas, and speakers were employed. Participants in the PC, VR, and 360° video groups used headphones to receive audio information.

The study incorporated 360° panoramic aerial photography and video content produced by the top team Airpano, featuring a restoration of the Yuanmingyuan (Old Summer Palace). The panoramic video, compatible with any device, was displayed in high definition across various platforms. To create a fully immersive VR experience, the study used VR headsets, information kiosks, touch screens, and telescopes to present panoramic images and videos. All devices displayed the same content, allowing participants to compare views of palace buildings, garden landscapes, and cultural relics before and after restoration. Featured sites included architectural structures like Fu Cheng Gate, the Great Treasure Hall, and the Three Palaces, as well as garden spots such as Lingquan Tomb and the Nine Tripod Pavilion. Historical and cultural context was also provided to help participants better understand the significance of Yuanmingyuan.

3.3 Experiment Design

This study utilized a laboratory-coordinated experimental design with four workshop groups. The experimental procedures were consistent across all groups. Prior to random assignment, participants were informed about the experiment through a consent form, which outlined general information and their rights as research participants. Randomly, participants were assigned to one of four media groups: VR (57 students), 360° video (57 students), static video (57 students), and text (57 students). These conditions represented different levels of visual experience, with specific experimental manipulations for presence and immersion. A pre-test was designed to assess participant's prior knowledge and gather demographic information.

Individual participants were then assigned to one of four classrooms, with each classroom corresponding to a different media group. This arrangement ensured that participants were unaware of the other groups. Upon arrival at their designated classrooms, students watched a virtual course on the Yuanmingyuan ruins, which served as the core learning material. The course was delivered through the respective media for each group. After viewing the course, participants' knowledge was assessed, and subjective measurements were collected. During the experiment, participants were not permitted to take notes or communicate with one another.

The corresponding questionnaires can be found from https://github.com/rongjackie/VR-in-history-classrooms

3.4 Evaluation Measurements

After completing the virtual course, participants were requested to submit a post-session questionnaire to collect their perceptions of visual experience, presence, immersion, learning motivation, and learning outcomes. Each concept was drawn from prior research and slightly reworded to align with the context of the study. A pilot test with 16 students was conducted prior to formal data collection, and according to their input, minor revisions were conducted to finalize the survey for the main experiment.

For data analysis, SPSS software was used for data coding and entry, while Smart PLS-SEM software was employed to assess reliability, validity, and overall data analysis. Using the two-step method from [3], the study initially assessed the measurement model to examine the relationships between observed variables and latent constructs, ensuring the model's suitability for the data. Subsequently, the structural equation model (SEM) [25] was adapted to study the interactions of latent constructs, including visual stimuli, presence, immersion, learning motivation, and learning outcomes. For robustness, PLS-SEM analysis was performed using Smart PLS 4.1 [57], incorporating non-parametric evaluation techniques such as bootstrapping and blindfolding.

While SEM aims to establish causal relationships from correlations, it does not definitively prove causality but instead provides credibility to causal hypotheses [25]. This study's structural model is grounded in robust theoretical principles, making SEM a suitable approach for validating the hypotheses.

4 Results

The PLS-SEM model assesses the reliability and validity of measurement constructs [3]. As detailed in Table 1, measurement adequacy is evaluated using various indicators, including construct reliability, composite reliability, convergent validity, and discriminant validity. Cronbach's alpha is applied to measure the internal consistency of items within each construct, with a minimum acceptable value of 0.7 to ensure adequacy. From the results obtained, both Cronbach's alpha and composite reliability values for all constructs surpassed the 0.7 threshold, confirming strong reliability.

Additionally, variance inflation factors (VIF) for all variables were below 5.0 (ranging from 1.000 to 4.385) [22], which suggests a low risk of multicollinearity. Convergent validity requires factor loadings to exceed 0.7 and the average variance extracted (AVE) with a higher value over 0.5 [18, 25]. In the experiments, these conditions were satisfied, confirming the adequacy of the measurement model.

Discriminant validity was evaluated to confirm that each latent variable in the model was distinct from the others. The Fornell-Larcker criterion was used for this assessment [22]. The AVE values for the six factors ranged from 0.62 to 0.71 (Table 2), all exceeding the 0.5 threshold, thus establishing convergent validity. To establish discriminant validity, the square root of the AVE for each construct exceeded its correlations with all other constructs [25], indicating

Table 1: Construct Reliability and Validity

	Composite Reliability	Cronbach's α	AVE
Immersion (IM)	0.909	0.881	0.626
Learning Outcomes (LO)	0.896	0.856	0.718
Intrinsic Motivation (IMO)	0.884	0.804	0.847
Negative Experience (NE)	0.886	0.810	0.722
Presence (PR)	0.922	0.899	0.665
Visual Experience (VE)	0.896	0.855	0.633

that each construct was more strongly associated with its own indicators than with those of other constructs [22]. Furthermore, all cross-loadings were significantly lower than the respective factor loadings, further supporting discriminant validity. The heterotrait-monotrait (HTMT) ratio was also employed as a stringent test of discriminant validity, examining the correlations between traits [3]. HTMT values exceeding 0.85 suggest potential issues with discriminant validity. In this study, all HTMT ratios fell below 0.85, ranging from 0.79 to 0.85, confirming the scale's discriminant validity.

4.1 SEM and Hypothesis Testing

Once the data's validity and reliability were confirmed, the hypotheses were analyzed to evaluate the study's conceptual framework. The relationships between independent and dependent variables were assessed by examining the significance of the hypotheses. The β values for each relationship in the proposed model were identified. The larger β value is, the greater impact the independent variable put on the dependent variable. Both the t-statistics and β values were used to determine the significance levels of the findings. The corresponding results are presented in Table 3.

Positive correlations were observed between visual experience and intrinsic learning motivation (β = 0.230, $p < 0.01$), immersion (β = 0.260, $p < 0.001$), and presence (β = 0.414, $p < 0.001$), providing support for hypotheses **H1**, **H2**, and **H4**. Immersion also demonstrated a noteworthy effect on intrinsic learning motivation (β = 0.198, $p < 0.05$), as did presence (β = 0.143, $p < 0.05$), thereby supporting hypotheses **H3** and **H5**. Furthermore, intrinsic learning motivation was strongly associated with learning outcomes (β = 0.281, $p < 0.001$), validating hypothesis **H6**.

The PLS-SEM analysis also provided strong empirical support for negative user experience as a moderating variable for learning outcomes. As shown in Table 3, adverse user experiences significantly moderated the association between intrinsic learning motivation and learning outcomes (β = -0.60, $p < 0.1$), thereby confirming hypothesis **H7**.

4.2 Mediated Effects Test

The PLS-SEM analysis also provided significant empirical evidence supporting intrinsic learning motivation as a mediator in learning outcomes. To evaluate the mediation effects, the bootstrap method was applied to all samples, testing both specific and total indirect effects [3].

The mediation effect was assessed by calculating the variance accounted for (VAF) [13], which represents the proportion of the total effect explained by the indirect effect. A VAF exceeding 0.8 signifies full mediation, while values between 0.2 and 0.8 indicate partial mediation.

As shown in Table 4, intrinsic learning motivation fully mediates the relationship between visual experience and learning outcomes (VAF = 61.15%), indicating a strong and significant mediation effect. Additionally, the analysis revealed that visual experience influences intrinsic learning motivation through presence (VAF = 25.40%), suggesting a partial mediation effect [3]. The results also demonstrated a sequential mediation effect involving presence and intrinsic learning motivation, linking visual experience to learning outcomes (VAF = 25.60However, the mediating effect of immersion between visual experience and intrinsic learning motivation was not significant (VAF = 13.49%).

4.3 Multi-group Analysis: from Strong Sensory Experience to Weak Sensory Experience

To explore potential differences in visual experiences, the collected data was split into two groups: one group (n = 114) used high-sensory devices (360° video), while the other group (n = 114) used low-sensory devices (static video and textbook). A guided multi-group analysis (MGA) was utilized to uncover the differences in path coefficients between the two types of visual experiences (Table 5). Such differences suggest that the relationships are influenced by the type of sensory experience. Conversely, a lack of significant differences indicates that the relationships are consistent across groups.

The PLS-MGA results revealed that participants watching low-sensory VR videos showed a significantly different "visual experience → immersion" relationship compared to those watching high-sensory VR videos (β = -0.356, p = 0.002). The high-sensory group also exhibited more pronounced differences in the "visual experience → presence" (β = -0.258, p = 0.015) and "presence → motivation" (β = 0.27, p = 0.037) relationships compared to the low-sensory group.

Further analysis within the high-sensory and low-sensory groups was conducted. The high-sensory group was further separated into two subgroups: participants equipped with VR devices (n = 57) and others watching 360° videos (n = 57). Similarly, the low-sensory group was divided into those watching static videos (n = 57) and those reading textbooks (n = 57). MGA was again applied to assess the differences in path coefficients within each subgroup. In the high-sensory group, the VR subgroup showed a more significant "visual experience → presence" (β = 0.370, p = 0.031) and "presence → motivation" (β = 0.286, p = 0.004) relationship compared to the 360° video group. In the low-sensory group, the static video subgroup exhibited a more significant "visual experience → presence" relationship (β = 0.370, p = 0.031) compared to the textbook group.

5 DISCUSSION

Many studies suggest that VR enhances learning performance compared to traditional methods, though some research indicates it does not significantly affect learning outcomes. The varying results from existing studies create challenges in reaching definitive conclusions regarding the overall effectiveness of VR in education.

Table 2: Discriminant Validity and HTMT Ratios

	Discriminant Validity						HTMT Ratios						
	IM	LO	IMO	NE	PR	VE	IM	LO	IMO	NE	PR	VE	NE × IMO
IM	0.791						-						
LO	0.383	0.796					0.442	-					
IMO	0.342	0.318	0.847				0.405	0.381	-				
NE	-0.378	-0.351	-0.263	0.850			0.447	0.407	0.320	-			
PR	0.364	0.383	0.400	-0.394	0.815		0.407	0.438	0.466	0.452	-		
VE	0.260	0.305	0.378	-0.371	0.414	0.795	0.287	0.351	0.452	0.443	0.469	-	
NE × IMO							0.135	0.093	0.271	0.080	0.055	0.163	-

Notes: VE - Visual Experience; IM - Immersion; IMO - Intrinsic Motivation; PR - Presence; NE - Negative Experience; LO - Learning Outcomes.

Table 3: Hypothesis Testing Results

Structural Path	Immersion	T-Statistic	f2	P-value	Test Result
Visual Experience → Intrinsic Motivation (H1)	0.230	3.196	0.057	0.001**	Supported
Visual Experience → Immersion (H2)	0.260	3.963	0.072	0.000***	Supported
Immersion → Intrinsic Motivation (H3)	0.198	2.766	0.044	0.006*	Supported
Visual Experience → Presence (H4)	0.414	6.865	0.207	0.000***	Supported
Presence → Intrinsic Motivation (H5)	0.233	3.394	0.055	0.001**	Supported
Intrinsic Motivation → Learning Outcomes (H6)	0.281	3.917	0.087	0.000***	Supported
Negative Experience × Intrinsic Motivation → Learning Outcomes (H7)	-0.160	2.673	0.030	0.008*	Supported

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 4: Mediation Analysis

Relationships	Immersion	Boot SE	Cls (2.5%)	Cls (97.5%)	VAF	Test Result
Total effect of VE → IMO	0.378	0.060	0.262	0.494	-	-
Total effect of VE → LO	0.121	0.033	0.071	0.199	-	-
Total effect of PR → LO	0.075	0.027	0.032	0.138	-	-
Total effect of IM → LO	0.063	0.029	0.019	0.130	-	-
Direct effect of VE → IMO	0.230	0.071	0.091	0.371	-	-
Direct effect of IMO → LO	0.320	0.056	0.215	0.437	-	-
Total indirect effect of VE → LO	0.121	0.033	0.041	0.167	-	Unaccepted
VE → PR → IMO	0.096	0.032	0.041	0.167	25.40%	Accepted
VE → IM → IMO	0.051	0.024	0.015	0.107	13.49%	Unaccepted
VE → IMO → LO	0.074	0.028	0.038	0.137	61.15%	Accepted
PR → IMO → LO	0.075	0.027	0.032	0.138	-	Unaccepted
VE → PR → IMO → LO	0.031	0.012	0.013	0.063	25.60%	Accepted
IM → IMO → LO	0.063	0.029	0.019	0.130	-	Unaccepted
VE → IM → IMO → LO	0.016	0.010	0.004	0.042	13.22%	Unaccepted

Table 5: Multi-group Analysis: Structural Model Differences (Strong-weak Visual Experience)

	Between Groups		Within Group			
	Strong-weak Visual Experience		Strong Visual Experience		Weak Visual Experience	
	β difference	p-value	β difference	p-value	β difference	p-value
VE → IMO (H1)	0.151	0.367	0.367	0.273	-0.072	0.784
VE → IM (H2)	-0.356	0.002**	0.387	0.228	-0.293	0.292
IM → IMO (H3)	-0.015	0.991	0.847	0.220	0.112	0.621
VE → PR (H4)	-0.258	0.015**	0.370	0.031**	-0.728	0.003**
PR → IMO (H5)	0.270	0.037**	0.286	0.004**	0.815	0.347
IMO → LO (H6)	0.272	0.066	0.200	0.371	0.414	0.795
NE × IMO → LO (H7)	-0.098	0.384	-0.158	0.479	0.025	0.985

With the ongoing advancement of virtual technologies like immersive VR (I-VR), there is an increasing demand for empirical investigations, especially in educational contexts such as historical and cultural learning [53]. This research examines the influence of VR on students' intrinsic motivation and learning outcomes in history classes, alongside analyzing variations in their reflective processes, to assess the potential of VR as a teaching tool.

Our first research question disclosed that students in the high-experience groups (VR and 360° video) demonstrated increased motivation and learning gains compared to the low-experience groups (static video and text), which aligns with previous research reviewed above. Interestingly, while VR offered the highest level of immersion, No notable difference in immersion was observed between the VR group and the 360° video group.. This may be due to the comparable realism between VR and 360° instructional experiences, suggesting that the pedagogical impact of 360° video can be similar to that of VR in similar learning environments [67]. Our findings extend prior research, although a challenge in VR studies is the difficulty in isolating the effects of individual technological features on learning outcomes. While technology experience is key to cognitive response, our study focused on the distinct contributions of immersion and presence. Results suggest that presence is closely tied to visual experience. We also found that research on VR immersion and presence has primarily focused on higher education, with limited exploration of K-6 students' experiences in virtual classrooms. Given that different stages of education involve the development of distinct skills, the findings of prior studies may not fully apply to younger students. As children's use of VR is expected to rise [67], understanding its implications for lower-grade students is critical. Our results suggest that presence, more so than immersion, plays a greater role in promoting intrinsic motivation among younger students, likely due to their still-developing cognitive and physical abilities. This is consistent with Jinyu's study [56], which found that the quality of attention in primary school students varies significantly with age, though gender differences were not significant.

For the second research question, intrinsic motivation, as a key internal drive, is strongly associated with higher academic achievement. Intrinsically motivated students tend to actively seek knowledge for personal satisfaction and enjoyment, rather than for external rewards or to avoid punishment [7]. Self-determination theory suggests that learning outcomes are shaped by various factors, with their interplay playing a key role in academic success. Although many studies highlight a positive link between motivation and academic performance, individual traits and contextual influences can modify how students react to motivational stimuli. VR's impact may depend on the content being taught. Studies in fields such as surgery, math, and biology have demonstrated VR's ability to provide a level of realism unattainable through textbooks, while avoiding elements that hinder learning [54]. However, whether VR's effects on performance are consistent across subjects remains debated. Our study found that VR was effective in the history classroom, with high-sensory visual experiences leading to greater intrinsic motivation and academic gains compared to traditional methods, supporting VR's potential efficacy in K-6 education.

We also observed that much of the focus in educational technology research is on novelty and technical capabilities, often at the expense of considering the human learning process. Failure to prioritize the learner's experience in technology-enhanced environments can hinder educational goals [22]. In this study, negative user experiences had a significant moderating impact on the relationship between intrinsic motivation and learning gains, exerting a negative influence. Research by Miehlbradt [48] revealed that for children still developing physical coordination, immersive VR can disrupt their natural coordination strategies by prioritizing visual sensory input over proprioceptive and vestibular signals, thus altering the sensory balance. Additionally, VR may be too complex for young learners, as Lim [42] suggests that distractions in virtual environments can make it difficult for children to complete learning tasks. Although research on VR's negative effects on children remains limited, such studies are crucial. Understanding VR's suitability across different educational stages is important, particularly in assessing whether immersive experiences translate into improved academic outcomes for younger students. More work is required to address the potential drawbacks of VR in education and determine the conditions under which it benefits learners.

5.1 Practical Implications

The immersion and interactivity offered by VR provide learners with a unique educational experience, addressing the limitations of traditional classrooms, such as the constraints of space, time, and uniform teaching contexts. While VR's potential in enhancing classroom performance has been widely studied, there remains a lack of research focused on its application for elementary school students and strategies for effective classroom implementation. VR allows for independent, exploratory learning in virtual environments, offering students more engaging content than traditional methods. Given the increasing use of this technology by children [43], understanding its impact on both academic and attitudinal outcomes is essential.

Our findings suggest that VR, as a visually immersive experience, significantly enhances students' intrinsic motivation through engaging and vivid classroom scenarios. Students in the high visual experience group (VR and 360° video) showed improved learning outcomes compared to those using traditional methods. VR transforms static images and videos into immersive, interactive virtual environments, allowing students to not only observe but actively participate in the learning process. This leads to a deeper understanding of complex or abstract textual content, including the underlying thoughts and emotions intended by the authors.

Thus, using VR as a supplementary tool for subjects like history and culture can greatly enrich students' learning experiences, enabling a more comprehensive understanding of complex historical knowledge—something difficult to achieve with textbooks, artifact displays, or annotations alone [44]. Incorporating VR into classroom instruction presents an effective method for fostering intrinsic motivation and promoting self-directed learning, which in turn enhances student engagement and learning outcomes. By creating personalized, interactive virtual learning environments, students become active participants in content learning, rather than passive observers. This study offers a new teaching approach for K-6 history and culture curricula, providing practical insights and support for enhancing teaching and learning.

5.2 Theoretical Implications

This study investigates the impact of VR experiences in history and culture classrooms on the intrinsic motivation and academic achievement of lower-grade students, providing better contextualization of theoretical content. While previous research has largely focused on factors influencing higher education students, this study shifts the focus to K-6 students, contributing to a broader understanding of SDT in younger learners. By doing so, it enriches research in this field and aims to further expand the application of SDT within educational theory frameworks and practical strategies for classroom instruction.

5.3 Limitations and Future Work

Despite the positive outcomes of this study, several limitations exist due to the exploratory nature of applying VR technology on campus, as well as time and logistical constraints. First, the novelty of VR technology may have influenced learning motivation. Since VR is not yet widespread in schools, fewer than 40% of the students in this study had prior experience with VR devices. The novelty of the technology might have heightened students' motivation, potentially impacting the results. Research on the novelty effect suggests that learners' achievements may decline as they become more familiar with the technology. To mitigate this effect, future studies should be conducted over longer periods to account for the diminishing influence of novelty.

Second, the operational difficulty of the VR technology could have impacted learning outcomes. As most participants were using VR for the first time, they were unfamiliar with the virtual learning system. The brief group training provided may not have been sufficient to ensure that every student was fully comfortable with the system. Some participants reported missing classroom content due to operational errors, which may have negatively affected their learning motivation and experience. Future studies should allow for more comprehensive training on the VR system to ensure students are adequately prepared.

Additionally, the study's results were influenced by the specific themes and content of the learning materials. This research focused on fifth and sixth-grade students from two schools and examined historical knowledge within the language subject. The content and virtual environment were narrowly defined, limiting the generalizability of the findings. Future research should broaden the scope by applying VR in other history and culture courses to increase the diversity of research results. Furthermore, integrating additional technologies, such as artificial intelligence, into VR learning environments could provide students with personalized learning experiences, enhancing their understanding of subject matter while fostering a deeper sense of responsibility and identity with respect to national history and culture.

6 CONCLUSION

Despite the noted limitations, this study offers empirical support for the potential benefits of using VR in history and culture education, particularly for younger students in K-6 classrooms. The results highlight VR's value in enriching history lessons, serving as a bridge between conventional teaching approaches and immersive learning environments. Grounded in established theories, this study elucidates the pathways between visual experience, learning motivation, and learning outcomes for lower-grade students, offering insights that may facilitate the integration of VR into traditional classrooms.

The results indicate that students using VR exhibit significantly higher intrinsic motivation and improved learning outcomes compared to those in traditional classroom settings. Notably, there were significant differences in presence and intrinsic motivation between the high-experience (VR) and low-experience (static video) groups, suggesting that VR provides richer, more immersive learning experiences than static video content. This aligns with previous research, which highlights VR's ability to create engaging and interactive environments that enhance student performance.

Furthermore, we examined the potential drawbacks of VR, particularly negative user experiences, emphasizing the importance of carefully considering teaching methods when implementing VR in practice. Overall, this study offers valuable insights and practical reference points for the effective application of VR technology in classroom settings.

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