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Virtual Reality–Supported Art Appreciation Instruction: Effects of an Immersive Web-Based Platform on Undergraduate Students' Learning Motivation

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Abstract
This study designed and developed a virtual reality (VR)–based instructional website for art appreciation, VirtuArt, and examined the influence of a VR-supported teaching platform on undergraduate art students' learning motivation. A quasi-experimental design was employed, involving 60 undergraduate art students drawn from two intact classes at a public university in China. One class was assigned to the experimental group, which received instruction through the VirtuArt platform, while the other served as a control group and was taught using conventional instructional methods. Learning motivation was assessed using the Instructional Materials Motivation Survey (IMMS). Data were analysed using analysis of covariance (ANCOVA) and multivariate analysis of covariance (MANCOVA) to evaluate the effects of the instructional intervention. The results indicate that, after controlling for pre-test differences, students in the experimental group achieved significantly higher scores on overall learning motivation and its sub-dimensions than those in the control group. These findings suggest that VR technology can play a supportive role in enhancing instructional practice in higher art education, and that the VirtuArt platform demonstrates promising potential for fostering student learning motivation.
Keywords: Virtual Reality–Based Instruction, Art Appreciation Education, Learning Motivation, Immersive Learning Environments, Higher Art Education

Introduction

In the rapidly evolving landscape of higher education, the quality and effectiveness of teaching and learning have become central concerns, particularly in disciplines that rely heavily on students' cognitive engagement, emotional response, and reflective thinking, such as art appreciation. Art appreciation courses play a critical role in cultivating students' aesthetic sensitivity, cultural literacy, and higher-order thinking skills, all of which are essential competencies for creativity-driven societies and knowledge-based economies. However, the instructional effectiveness of these courses is closely tied to students' learning motivation, which has been widely recognised as a key determinant of meaningful learning engagement and sustained academic development (Daniel et al., 2024).

Recent studies have highlighted that technology-supported learning environments can significantly enhance not only academic performance but also learners' intrinsic motivation by offering interactive, learner-centred, and experiential learning opportunities (Eltahir & Babiker, 2024). Within art education, instructional resources that integrate clear pedagogical objectives with rich experiential qualities are particularly valuable, as they enable students to actively engage with artistic content rather than passively receive information (He, 2020). Consequently, exploring innovative instructional approaches that improve motivation and engagement in art appreciation is both timely and pedagogically necessary.

Within the context of higher art education in China, insufficient learning motivation among students has increasingly emerged as a structural challenge that undermines instructional quality and learning outcomes (Wang et al., 2024). Despite ongoing curricular expansion, many students enrolled in art appreciation courses exhibit unclear learning goals, low classroom participation, and limited capacity for self-directed learning (Pu & Jansaeng, 2025). The continued dominance of lecture-centred instructional approaches further reinforces passive learning behaviours, restricting opportunities for experiential and constructivist learning. Empirical evidence indicates that a substantial proportion of students engage with art theory courses only shortly before examinations, reflecting short-term, extrinsically driven motivation and a limited perception of the relevance and value of these courses (Pu & Jansaeng, 2025).

A growing body of educational research consistently demonstrates that low learning motivation is associated with reduced cognitive engagement, superficial learning strategies, and weaker academic and affective outcomes (Chiu et al., 2023; Triarisanti & Purnawarman, 2019). In art appreciation education, such motivational deficiencies are particularly problematic, as they constrain students' ability to engage in deep aesthetic inquiry, critical interpretation, and reflective thinking. Over time, this not only limits students' creative development but also weakens their long-term appreciation of art and culture.

Against this backdrop, enhancing learning motivation in art appreciation courses is not merely an instructional concern but a strategic priority for improving educational quality and relevance in higher art education (Ren, 2024). Immersive and interactive educational technologies—most notably virtual reality (VR)—offer promising solutions by enabling students to experience artworks in rich, contextualised, and exploratory environments. Through sensory immersion and autonomous interaction, VR has the potential to foster intrinsic motivation, sustained attention, and deeper engagement with learning content (Oubibi & Hryshayeva, 2024). Such approaches are particularly beneficial for undergraduate art students, instructors seeking to innovate pedagogical practice, and institutions aiming to enhance teaching effectiveness and learner satisfaction.

Although the use of VR in education has expanded in recent years, systematic investigations into its pedagogical effectiveness—especially in relation to learning motivation and curriculum-aligned instructional design—remain limited within higher art education. Existing studies often treat VR as a supplementary visualisation tool rather than as an integrated instructional strategy aligned with learning outcomes and motivational theory (Arantes Fernandes et al., 2022; Stracke et al., 2025). Addressing this gap, the present study examines the utility and effectiveness of a VR-supported art appreciation instructional platform, with particular emphasis on its impact on undergraduate students' learning motivation. By doing so, this research contributes empirical evidence to support educators, curriculum designers, and policymakers in making informed decisions about the pedagogically meaningful integration of immersive technologies in higher art education.

Research questions

To examine the effectiveness of different teaching methods (i.e., the VirtuArt platform based on virtual reality and traditional teaching (CI)) in university art education, this study focuses on the following questions:

1. How can virtual reality technology and the VirtuArt website be applied to undergraduate art teaching?
2. What are the post-test results regarding the learning motivation of undergraduate art students in the VirtuArt strategy group and the traditional teaching strategy group?

Overview of Key Teaching Methods

To ensure a meaningful evaluation and implementation of both the VirtuArt instructional strategy and conventional teaching approaches, this study focused on a comparative investigation of the two pedagogical models.

Conventional teaching strategies (CI): Traditional teaching methods usually rely on standard tools such as PowerPoint presentations, blackboards and computers. Its teaching method is still mainly lecture-based, emphasising that students absorb the knowledge imparted by teachers through vision and hearing(Chen, 2025).

VirtuArt teaching strategies (VirtuArt): The VirtuArt instructional strategy involves the use of a custom-developed course website designed in alignment with the official syllabus. Within this framework, students engage in experiential learning through VR head-mounted displays, immersing themselves in the content independently. The instructor assumes a facilitative role, guiding the process while allowing students to take ownership of their learning journey.

VirtuArt educational website design and development

This study employed the ADDIE instructional design model—comprising Analysis, Design, Development, Implementation, and Evaluation—to guide the systematic development of VirtuArt, a virtual reality (VR)–integrated art appreciation website. The platform was designed to provide structured and immersive learning experiences aimed at enhancing students' creative engagement. By aligning pedagogical structure with technological affordances, VirtuArt represents a context-sensitive approach to immersive course design in higher education.

Analysis Phase

During the analysis phase, the instructional objectives, target learners, and learning context were clearly defined. The platform targeted undergraduate students enrolled in art appreciation courses. To ensure contextual relevance, semi-structured interviews were conducted with six experienced university art educators. The interview data were analysed using thematic analysis, which identified three key themes: challenges in current art appreciation instruction, students' learning conditions, and the acquisition of art-related skills. These findings informed the refinement of learning objectives and the functional design of the platform (Morrison et al., 2019). In addition, course syllabus analysis and technical feasibility assessments were conducted to ensure alignment between pedagogical goals and implementation conditions.

Design Phase

The design phase focused on structuring course content, selecting instructional strategies, developing an assessment framework, and outlining the system architecture. Core theoretical components of the art appreciation syllabus were integrated into the platform and enhanced through VR elements to increase immersion and interactivity. Instructional strategies were grounded in constructivist and experiential learning theories, emphasising task-based and exploratory learning within simulated art environments (Ghani & Daud, 2018).

Development Phase

VirtuArt was developed using the HBuilderX framework and front-end technologies, including HTML, CSS, and JavaScript to support page structure, visual design, and interactive functionality (Shah, 2024). Key system components included a VR virtual gallery for immersive art exploration, interactive assessment modules supporting assignment submission and peer/self-evaluation, a user guidance system for onboarding, and database functions for managing learning resources and user data (Figure 1).

Implementation Phase

The platform was implemented in an authentic classroom setting involving 60 undergraduate art students assigned to experimental and control groups. Instruction centred on art appreciation activities supported by head-mounted VR displays. Learning activities were organised around five interconnected components—task orientation, self-directed learning, collaborative work, class discussion, and reflective summarisation—to ensure alignment between immersive experiences and instructional objectives (Filatro & Cavalcanti, 2024). Learning continuity was further supported through pre-, in-, and post-class digital resources and interaction channels.

Evaluation Phase

The evaluation phase focused on examining the reliability and validity of the VirtuArt platform. Expert evaluation was conducted using a structured questionnaire with a five-point Likert scale, yielding an overall Cronbach's alpha of 0.82, indicating good internal consistency (Bose & Bhattacharjee, 2018). Evaluation dimensions included system stability, VR integration, interactivity, and alignment between instructional content and learning objectives. To further assess reliability, a pilot study involving 60 undergraduate students was conducted, with student questionnaire results yielding a Cronbach's alpha of 0.813, providing additional evidence of the platform's reliability.

The evaluation phase focused on examining the reliability and validity of the VirtuArt platform （Bose & Bhattacharjee， 2018). As the Instructional Materials Motivation Survey (IMMS) was originally developed in English, it was necessary to translate the instrument into Chinese for use in the present study. To ensure linguistic accuracy and conceptual equivalence, a forward–backward translation procedure was employed. Two professional translation experts independently conducted the forward translation and back-translation processes. Following the translation, three subject-matter experts were invited to evaluate the content validity of the Chinese version of the IMMS. The experts assessed the clarity, relevance, and appropriateness of each item, and the validity of the instrument was determined based on their feedback. Using the percentage agreement method, the translated IMMS achieved a content validity level of 90%, corresponding to a content validity index (CVI) of 0.90. In addition, formal authorisation to use an IMMS instrument was obtained from the original author, Keller. To further assess reliability, we conducted a pilot study involving 60 undergraduate students. The Cronbach's α coefficients for the four subscales were: confidence (0.742), attention (0.712), relevance (0.779), and satisfaction (0.745), indicating that the tool has high internal consistency.

Pilot Study

The original version of the Instructional Materials Motivation Survey (IMMS) has demonstrated high reliability, with an overall reliability coefficient of 0.96 (Keller, 1987). Its internal consistency has also been well established in previous studies, with reported Cronbach's alpha values ranging from 0.88 to 0.96 (Jiang & Fryer, 2023). As the IMMS was originally developed in English, it was necessary to translate the instrument into Chinese for use in the present study. To ensure linguistic accuracy and conceptual equivalence, a forward–backward translation procedure was employed. Two professional translation experts independently conducted the forward translation and back-translation processes.

Following the translation, three domain experts were invited to evaluate the content validity of the Chinese version of the IMMS. The experts assessed the clarity, relevance, and appropriateness of each item, and the validity of the questionnaire was determined based on their feedback. Using the percentage agreement method, the translated IMMS achieved a content validity level of 90%, corresponding to a content validity index (CVI) of 0.90. In addition, formal authorisation to use the IMMS instrument was obtained from the original author, Keller.

In the present study, the IMMS was pilot tested prior to formal data collection to examine its internal consistency and to ensure its suitability for repeated measurements. The Cronbach's alpha coefficients for the four subscales were as follows: Confidence (0.742), Attention (0.712), Relevance (0.779), and Satisfaction (0.745). These results indicate acceptable internal consistency across all dimensions and confirm the reliability of the IMMS for assessing the structure of learning motivation among undergraduate art students (see Table 1).

Table 1
Reliability of learning motivation questionnaires

Variables	Number of items	Cronbach's Alpha Reliability
Confidence	9	0.742
Attention	12	0.712
Relevance	6	0.779
Satisfaction	9	0.745

Method

This study employed a quasi-experimental research design and involved 60 undergraduate art students drawn from two intact classes at a public university in China. These two classes were randomly selected from classes of the same major and year. Participants were randomly assigned to either the experimental or control group, with 30 students in each group. The experimental group received instruction using the VirtuArt-based instructional approach, whereas the control group was taught using traditional instructional methods.

Instruction was delivered by two associate professors, each with more than ten years of teaching experience, who were also randomly assigned to the two classes. Both groups followed identical course content and instructional schedules; however, they differed in terms of instructional tools and teaching strategies. To control for potential baseline differences in students' prior knowledge and abilities, a pre-test was administered before the instructional intervention, and pre-test scores were included as covariates in subsequent analyses. The research design incorporated both pre-test and post-test measures to facilitate a comparative analysis of learning outcomes under the two instructional conditions.

The study was conducted over ten weeks, including eight weeks of instructional intervention. The pre-test was administered in the first week, and the post-test was conducted in the tenth week. Prior to the intervention, students completed a motivation questionnaire to establish baseline motivation levels. Following the eight-week instructional intervention—during which the experimental and control groups were exposed to different teaching strategies—a post-test was administered to examine changes in learning motivation. Previous studies have indicated that an eight-week intervention period constitutes a reasonable and empirically supported timeframe for examining instructional effects (Kehinde-Awoyele et al., 2024).

Results and Discussion

ANCOVA and MANCOVA Assumptions

The Levene's test analysis for the equality of variances for the motivation post-test results is displayed in Table 2. The significance values for the dependent variables, learning motivation $F(1, 58) = 960$, $p = .331 > .05$, confidence, $F(1, 58) = 1.536$, $p = .220 > .05$, attention, $F(1, 58) = .141$, $p = .709 > .05$, satisfaction, $F(1, 58) = .982$, $p = .326 > .05$, and related, $F(1, 58) = 1.863$, $p = .235 > .05$, all were higher than the standard cutoff of .05, suggesting that the assumption of equal variances between groups was maintained for these dimensions. This means that the variance between the groups is equal, and means that the MANCOVA and ANCOVA tests can be extended.

Table 2
Levene's test of equality of error variances in the motivation post-test.

Variable	F	df1	df2	Sig.
Learning motivation post-test	.960	1	58	.331
Confidence post-test	1.536	1	58	.220
Attention post-test	.141	1	58	.709
Satisfaction post-test	.982	1	58	.326
Related post-test	1.863	1	58	.235

Note: Significance at p<.05.

Learning Motivation Analysis

The mean score of the post-test of the students who learned art appreciation topics in learning motivation using the VirtuArt teaching was 3.58 (SD = .171) (see Table 3). In comparison, students taught using CI instruction recorded a mean post-test score of 3.29 (SD = .215). These results suggest that learners exposed to VirtuArt demonstrated the highest mean score in the post-test relative to their peers in the CI group.

Table 3
Mean and standard deviation of the post-test scores of each group in the learning motivation test

Module	Mean	Std. Deviation	N
VirtuArt Group	3.58	.171	30
CI Group	3.29	.215	30
Total	3.43	.243	60

The ANCOVA results for between-subject effects (see Table 4) revealed a significant difference in post-test scores between groups, F (1, 57) = 33.595, p = .001< .05, after controlling for the pre-test score as a covariate. Consequently, this indicates that undergraduate students who received VirtuArt instruction achieved significantly higher mean post-test scores compared to those taught using CI instruction. Furthermore, the effect size of the post-test score difference is considered small (d = .371), according to Cohen's (2013) criteria.

Table 4
Test of effects between subjects, post-test learning motivation between groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1.293[a]	2	.646	16.893	<.001*	.372
Intercept	2.707	1	2.707	70.742	<.001*	.554
pre-test	.002	1	.002	.062	.804	.001
Group	1.285	1	1.285	33.595	<.001*	.371
Error	2.181	57	.038			
Total	711.360	60				
Corrected Total	3.473	59				

Learning Motivation Dimension Analysis

The analysis was extended using the MANCOVA test to evaluate the four domains of learning motivation in the dependent variable (post-test). Students in the VirtuArt group demonstrated higher levels of learning motivation across all domains in the delayed post-test compared to their counterparts in the CI group. For Confidence, the VirtuArt group achieved a mean score of 3.39 (SD = .301), whereas the CI group obtained a mean of 3.07 (SD = .366). In the Attention domain, the VirtuArt group reported a higher average of 2.77 (SD = .377), compared to 2.55 (SD = .310) for the CI group. Regarding Satisfaction, the VirtuArt group recorded a mean of 4.33 (SD = .384), while the CI group attained a lower mean of 3.98 (SD= .476). Finally, in the Relevance domain, the VirtuArt group scored 3.83 (SD = .384), outperforming the CI group's mean of 3.55 (SD = .440)(see Table 5).

Table 5
Mean and standard deviation of post-test scores on domains of learning motivation between groups

Domain	Module	Mean	Std. Deviation	N
	VirtuArt group	3.39	.301	30
Confidence	CI group	3.07	.366	30
	Total	3.23	.370	60
	VirtuArt group	2.77	.377	30
Attention	CI group	2.55	.310	30
	Total	2.66	.360	60
	VirtuArt group	4.33	.384	30
Satisfy	CI group	3.98	.476	30
	Total	4.16	.464	60
	VirtuArt group	3.83	.384	30
Related	CI group	3.55	.440	30
	Total	3.69	.433	60

Taken together, these results indicate that students exposed to VirtuArt consistently reported higher levels of motivation across all four domains compared to those in the conventional instruction group.

After controlling for pre-test scores, the results presented in Table 6 demonstrate significant group differences across multiple dimensions of learning motivation in the post-test. In the Confidence domain, a statistically significant difference was observed, $F(1, 54) = 12.525$, $p < .001 < .05$, with a small effect size ($d = .188$) (Cohen, 2013). For Attention, the difference between groups was likewise significant, $F(1, 54) = 7.242$, $p = .009 < .05$, with a small effect size ($d = .118$). In the Satisfaction domain, the group effect was highly significant, $F(1, 54) = 21.520$, $p < .001 < .05$, accompanied by a small effect size ($d = .282$). Similarly, Relevance scores revealed a statistically significant difference, $F(1, 54) = 8.572$, $p = .005 < .05$, with a small effect size ($d= .137$). Taken together, Confirming that students in the VirtuArt and CI instructional groups exhibited significantly different delayed post-test learning motivation scores across all four domains.

Table 6
Test of the between-subject effects of post-test scores on domains in learning motivation between groups

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	M-confidence post	1.681[a]	5	.336	2.836	.024	.208
	M-attention post	1.838[b]	5	.368	3.421	.009	.241
	M-satisfy post	5.412[c]	5	1.082	8.031	<.001	.426
	M-related post	1.851[d]	5	.370	2.168	.071	.167
Intercept	M-confidence post	2.523	1	2.523	21.282	<.001	.283
	M-attention post	6.248E-5	1	6.248E-5	.001	.981	.000
	M-satisfy post	.444	1	.444	3.296	.075	.058
	M-related post	2.132	1	2.132	12.488	<.001	.188
Group	M-confidence post	1.485	1	1.485	12.525	<.001	.188
	M-attention post	.778	1	.778	7.242	.009	.118
	M-satisfy post	2.864	1	2.864	21.250	<.001	.282
	M-related post	1.464	1	1.464	8.572	.005	.137
Mconifdencepre	M-confidence post	.021	1	.021	.177	.675	.003
	M-attention post	.440	1	.440	4.092	.048	.070
	M-satisfy post	.085	1	.085	.629	.431	.012
	M-related post	.031	1	.031	.179	.674	.003
Mattentionpre	M-confidence post	.086	1	.086	.727	.398	.013
	M-attention post	.326	1	.326	3.031	.087	.053
	M-satisfy post	.001	1	.001	.007	.933	.000
	M-related post	.356	1	.356	2.085	.155	.037
Msatisfypre	M-confidence post	6.971E-6	1	6.971E-6	.000	.994	.000
	M-attention post	.010	1	.010	.096	.758	.002

	M-satisfy post	2.937	1	2.937	21.791	<.001	.288
	M-related post	.361	1	.361	2.112	.152	.038
Mrelatedpre	M-confidence post	.002	1	.002	.013	.909	.000
	M-attention post	.081	1	.081	.755	.389	.014
	M-satisfy post	.000	1	.000	.003	.959	.000
	M-related post	.013	1	.013	.076	.784	.001
Error	M-confidence post	6.401	54	.119			
	M-attention post	5.802	54	.107			
	M-satisfy post	7.278	54	.135			
	M-related post	9.220	54	.171			
Total	M-confidence post	634.630	60				
	M-attention post	431.201	60				
	M-satisfy post	1050.194	60				
	M-related post	829.185	60				
Corrected Total	M-confidence post	8.081	59				
	M-attention post	7.640	59				
	M-satisfy post	12.690	59				
	M-related post	11.071	59				

Discussion

The Impact of VirtuArt-Based Instruction and Conventional Instruction on Learning Motivation

The findings of this study indicate that, within the scope of the present quasi-experimental design, instruction delivered through the VirtuArt platform was associated with higher levels of student learning motivation compared to conventional teaching methods. After controlling for baseline differences, ANCOVA and MANCOVA results revealed statistically significant differences across all motivational dimensions. These results are consistent with prior research suggesting that immersive and interactive VR-supported environments can enhance learner engagement and motivation (Portuguez-Castro & Santos Garduño, 2024). However, these findings should be interpreted cautiously, given the study's sample size, intervention duration, and contextual constraints.

In the confidence dimension, students in the VirtuArt group reported stronger beliefs in their ability to succeed in learning tasks. This finding aligns with previous studies indicating that VR environments may reduce performance anxiety by providing low-risk, exploratory learning spaces (Singh & Masuku, 2014). The ability to revisit tasks and progress at an individualised pace may have supported the gradual development of self-efficacy (Vihos et al., 2024). Nevertheless, it is also possible that increased confidence partly reflected heightened teacher support or students' initial enthusiasm toward a novel instructional format, rather than stable changes in academic self-beliefs.

With respect to attention, the VirtuArt group demonstrated greater sustained focus during learning activities. This outcome is consistent with studies reporting that multimodal VR environments can enhance cognitive presence and reduce external distractions (Gargrish et al., 2020; Makransky & Petersen, 2021). The interactive and exploratory nature of the platform likely contributed to learners' attentional engagement (Yang & Li, 2018). However, the relatively short intervention period raises the possibility that attentional gains were influenced by novelty effects, which may diminish over time as learners become accustomed to the technology.

The relevance dimension showed moderate but significant differences between the two groups. Prior research has emphasised that perceived relevance is a key driver of intrinsic motivation and sustained effort (Hidi & Renninger, 2020; Ghorbani et al., 2020). VirtuArt incorporated interest-based content pathways, allowing students to relate learning materials to their personal artistic goals, which may explain the observed increase in perceived relevance (Tsivitanidou et al., 2021). Notably, the effect size for relevance was smaller than for attention and confidence, suggesting that while VR can support contextualisation, relevance may depend more strongly on curriculum alignment and long-term goal orientation than on technology alone.

Regarding satisfaction, students in the VirtuArt group reported higher levels of enjoyment and perceived accomplishment. This finding echoes previous studies highlighting the role of emotionally engaging learning environments in promoting satisfaction and persistence (Liu et al., 2020). The platform's user-centred design and scaffolded progression may have contributed to these outcomes. At the same time, satisfaction ratings may have been influenced by students' positive affect toward the VR experience itself, underscoring the need for longitudinal research to examine whether such effects persist beyond initial exposure.

In contrast, the traditional lecture-based approach showed limitations in sustaining motivation, particularly in maintaining attention and engagement. Prior studies have reported similar challenges associated with prolonged passive learning, including cognitive fatigue and disengagement (Győri & Czakó, 2020; Samoshkina, 2024). However, it should be noted that instructional effectiveness in the control group may also have been constrained by contextual factors such as limited access to authentic artworks and time-bound instructional conditions, rather than inherent deficiencies of traditional pedagogy.

Conclusions and Educational Implications

This study developed the VirtuArt educational website based on the ADDIE instructional design model. It examined its effectiveness through a quasi-experimental design in the context of art appreciation courses in higher art education. By comparing an experimental group using the VirtuArt-based instructional approach with a control group receiving traditional instruction, the results indicate that VirtuArt was associated with higher levels of student learning motivation. Compared with conventional teaching methods, VirtuArt offered a more immersive and interactive learning experience, enabling students to deepen their understanding through exploration and practice.

The findings have important implications for teaching and learning. In China, art theory courses are still predominantly delivered through lecture-based approaches using traditional tools such as PowerPoint presentations and blackboards, with limited classroom interaction (Saira et al., 2021). However, such methods have been shown to constrain learning experience and student motivation (Samoshkina, 2024). Virtual reality provides new opportunities for innovation in art education by supporting more engaging and experiential learning environments (Wang, 2024). The VirtuArt platform leveraged VR technology to promote active participation and self-directed learning, allowing students to explore artistic content through interactive and immersive experiences, thereby enhancing engagement and experiential learning (Bakhir et al., 2025). From a learning strategy perspective, VR-supported environments such as virtual museums and digital art spaces enable students to interactively analyse artworks rather than relying solely on static instructional materials, which may strengthen cognitive engagement and learning motivation (Makransky & Mayer, 2022).

Several limitations should be acknowledged. The sample size was relatively small and drawn from a single institution, which may limit the generalizability of the findings. Although a quasi-experimental design was adopted, individual-level randomisation was difficult to achieve, and potential influences such as teacher effects or novelty effects cannot be fully excluded. In addition, the eight-week intervention period may be insufficient to determine the long-term sustainability of the observed motivational gains.

Future research should involve larger and more diverse samples to examine the durability and generalizability of VirtuArt-based instruction. Further studies are also needed to address practical implementation challenges, including accessibility, cost, scalability, and learner comfort, and to explore learning outcomes beyond motivation, such as cognitive load and academic performance.

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