

AI-Enhanced Traditional Crafts in Art Education: A Digital Approach to Revitalizing Chinese Tie-Dye in High School

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Abstract: This study examines the empowering role of artificial intelligence (AI) in high school art education, with a focus on teaching tie-dye, a nationally recognized intangible cultural heritage (ICH). Traditional art education often faces constraints in materials, time, and instructional resources. AI offers new opportunities to address these limitations and reframe heritage-based craft teaching. Based on an empirical project with 42 students, this study highlights four instructional models: virtual experimentation, AI-handcraft integration, immersive learning, and interdisciplinary innovation. The findings suggest that AI not only compensates for resource limitations but also strengthens cultural recognition, providing observable evidence for revitalizing traditional crafts in adolescent education. At the same time, challenges remain, including overreliance on digital tools, limited teacher expertise, and concerns over originality and equity. The study concludes that integrating AI into tie-dye education should follow the principle of “technology serving education and innovation grounded in culture.” Practical recommendations are proposed regarding teacher training, curriculum design, resource development, and policy support, aiming for a balanced integration of tradition and technology. By doing so, AI-enhanced art education can foster creativity, interdisciplinary literacy, and cultural transmission, contributing both to pedagogical innovation and the sustainable development of intangible cultural heritage.

Keywords: Artificial Intelligence; Art Education; Intangible Cultural Heritage; Tie-Dye; Virtual Reality; Generative AI; Interdisciplinary Learning

Published: Oct 19, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.663>

1.Introduction

High school art education plays a critical role in developing students' aesthetic literacy, creativity, and cultural awareness. Tie-dye, an ancient Chinese textile craft recognized as national-level intangible cultural heritage, embodies cultural values and ethnic traditions. However, limited classroom resources, time, and technical guidance restrict opportunities for students to experience and master such complex crafts.

1.1 Theoretical Foundations of AI in Art Education

The integration of AI into art education is underpinned by established learning theories that explain how technology can enhance student engagement and cultural understanding. From the perspective of experiential learning theory^[1], AI provides opportunities for “learning by doing” through virtual dyeing experiments, interactive simulations, and iterative testing, enabling students to experience craft processes without the constraints of materials or time. In line with situated learning

theory^[2], AI-powered immersive environments and VR workshops allow learners to participate in culturally rich contexts, positioning them as active participants in authentic heritage practices rather than passive recipients of information. Consistent with constructivist theory^[3], AI facilitates learner-centered exploration, enabling students to generate, manipulate, and reinterpret visual patterns, thereby constructing new knowledge based on personal experience and collaboration^[4].

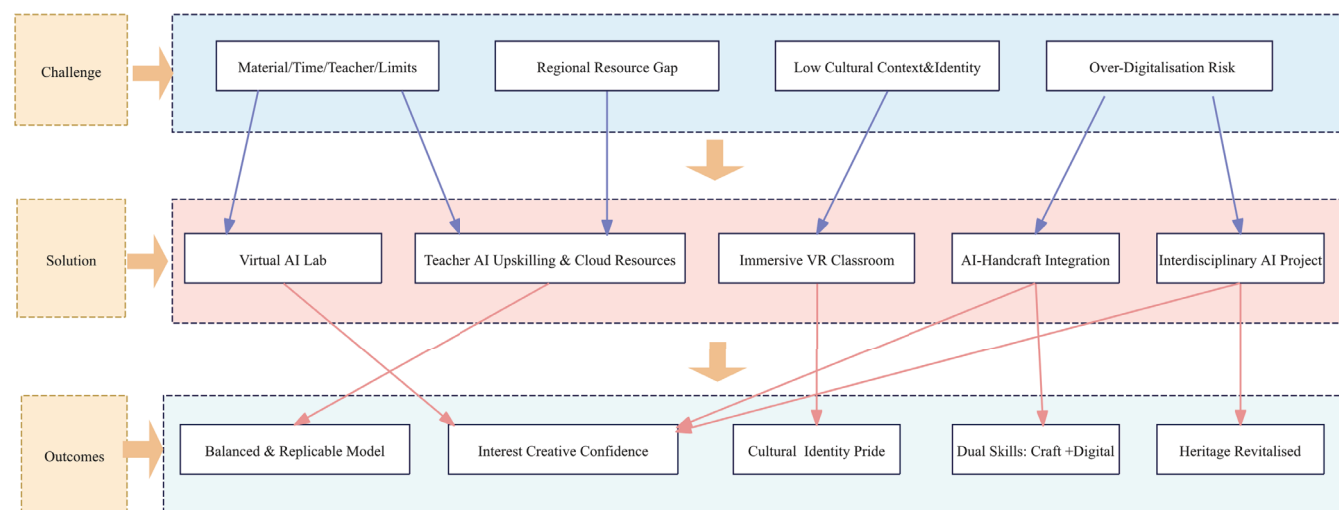
These theoretical perspectives highlight that the role of AI in art education goes beyond technical efficiency. It provides a pedagogical foundation for integrating traditional crafts with digital innovation, cultivating creativity, cultural identity, and deeper learning outcomes.

1.2 Research Purpose

This study investigates how AI can empower tie-dye instruction in high school classrooms, enhance cultural recognition, and promote innovative pedagogical practices. The objectives are fivefold: to explore how AI technologies can overcome resource and time constraints in traditional craft education; to examine the effects of AI-enhanced instructional models on students' learning interest, creativity, and cultural identity; to identify the challenges and limitations associated with AI-assisted art education; to provide practical recommendations for teachers, schools, and policymakers in integrating AI into intangible cultural heritage (ICH) instruction; and to develop a conceptual framework for AI-ICH integration that extends beyond tie-dye, offering insights for broader applications of technology in cultural heritage education.

To address these objectives, this study proposes a conceptual framework that illustrates how AI can be systematically integrated into intangible cultural heritage (ICH) education. The framework (Figure 1) connects the major challenges faced in traditional craft instruction with corresponding AI-based solutions and the anticipated educational and cultural outcomes. By positioning challenges such as material and teacher constraints, regional disparities, and risks of over-digitalization alongside targeted AI interventions, the framework highlights both the pedagogical logic and the cultural significance of the study. This visualization also reflects the study's broader goal of developing a transferable model for AI-ICH integration that extends beyond tie-dye education.

Figure 1. Conceptual framework of AI-ICH integration in tie-dye education.



1.3 Data Sources

The data for this study were collected from an empirical teaching project conducted by the author in March–April 2024 at Kunming No.10 Middle School, Kunming, Yunnan Province, China. The project involved a first-year high school elective art class with 42 students (aged 15–16, mixed gender). A total of 39 valid questionnaires were collected (response rate: 92.9%). The questionnaire employed a 5-point Likert scale with Cronbach's $\alpha = 0.85$ for reliability. Data were analyzed using Excel and SPSS 26.0 for descriptive statistics and one-sample t-tests ($p < 0.001$).

2. Artificial Intelligence and Art Education

2.1 Applications of AI in Education

As a significant outcome of contemporary information technology, AI is gradually transforming traditional education.

According to constructivist theory, learners are active constructors of meaning, and knowledge is formed through engagement and dialogue rather than simply transmitted by teachers^[1]. Emerging AI technologies—such as intelligent learning platforms, virtual teaching assistants, and adaptive learning systems—are shifting education from a teacher-centered to a learner-centered paradigm.

Learning platforms powered by big data analytics can track students' progress in real time, identify weak areas, and deliver personalized resources to enhance learning efficiency. AI applications, including speech recognition and natural language processing, are widely used in educational scenarios, such as automated grading systems and online Q&A assistants, significantly reducing repetitive teacher tasks and allowing educators to focus on classroom guidance and in-depth instruction. Consequently, AI integration promotes an intelligent, personalized, and interactive development in education^[2].

2.2 The Intersection of AI, Art Education, and ICH: Addressing the Gap

Prior research has attempted to address the challenges of teaching traditional crafts within formal education by incorporating modern technologies. For example, multimedia tools and digital archives have been used to provide visual resources and preserve intangible cultural heritage (ICH) materials, while online platforms have expanded accessibility to cultural content beyond local communities. Similarly, virtual reality (VR) and augmented reality (AR) applications have created immersive environments that allow students to experience traditional crafts without geographical or material constraints. These efforts have offered valuable resources for heritage education and improved cultural dissemination.

However, limitations remain. Many existing approaches emphasize heritage preservation rather than active learning, leaving students in passive roles as viewers or consumers of cultural content. Others lack strong pedagogical alignment with established learning theories, resulting in technological novelty without deep educational impact. Furthermore, such tools often fail to integrate digital experiences with hands-on practice, thereby reducing opportunities for learners to develop both cognitive and manual skills.

This study addresses these gaps by positioning artificial intelligence (AI) not only as a technical aid but also as a pedagogical enabler grounded in experiential, situated, and constructivist learning theories^[3]. By integrating AI tools with the teaching of tie-dye, the research demonstrates how technology can support resource efficiency, enhance creativity, and strengthen cultural identity while maintaining the craft's educational and cultural integrity. In doing so, the study contributes to a conceptual framework for AI-ICH integration that extends beyond tie-dye, providing insights for broader applications in cultural heritage education.

3. Educational Value of Tie-Dye in Intangible Cultural Heritage

Tie-dye, a traditional Chinese textile dyeing technique with over a thousand years of history, achieves localized resist-dyeing through folding, binding, and stitching, followed by repeated immersion in natural dyes to produce unique, inimitable patterns. Recognized as a national-level intangible cultural heritage, tie-dye embodies rich cultural memory and regional characteristics. For instance, the Bai ethnic tie-dye of Dali in Yunnan predominantly uses indigo and natural motifs, symbolizing auspiciousness and harmony. Its techniques not only reflect the Eastern philosophical concept of “harmony between humans and nature” but also encapsulate ethnic aesthetic sensibilities and practical wisdom.

From an educational perspective, cultural heritage instruction should not merely replicate traditional techniques. Instead, project- and context-based learning designs can guide students to understand cultural connotations and generate novel cultural expressions^[4]. Integrating tie-dye into high school art curricula fosters students' hands-on skills, concentration, and patience. The technique's inherent unpredictability stimulates creativity and encourages innovative experimentation. Moreover, the learning process enhances students' cultural identity and ethnic pride, allowing them to engage deeply with the cultural significance behind the craft.

Tie-dye also intersects with multiple disciplines—including textile science, chemistry, mathematics, and aesthetics—offering opportunities for interdisciplinary teaching and contributing to the development of students' comprehensive competencies and creative abilities^[5]. As such, tie-dye is more than an artistic skill; it represents a multifaceted educational resource with both cultural and pedagogical value. Incorporating intangible cultural heritage into school education not only promotes its creative transformation and innovative development but also helps cultivate the cultural foundations necessary for the

intergenerational transmission of Chinese modernity^[6].

4.Exploring AI-Enhanced High School Tie-Dye Education

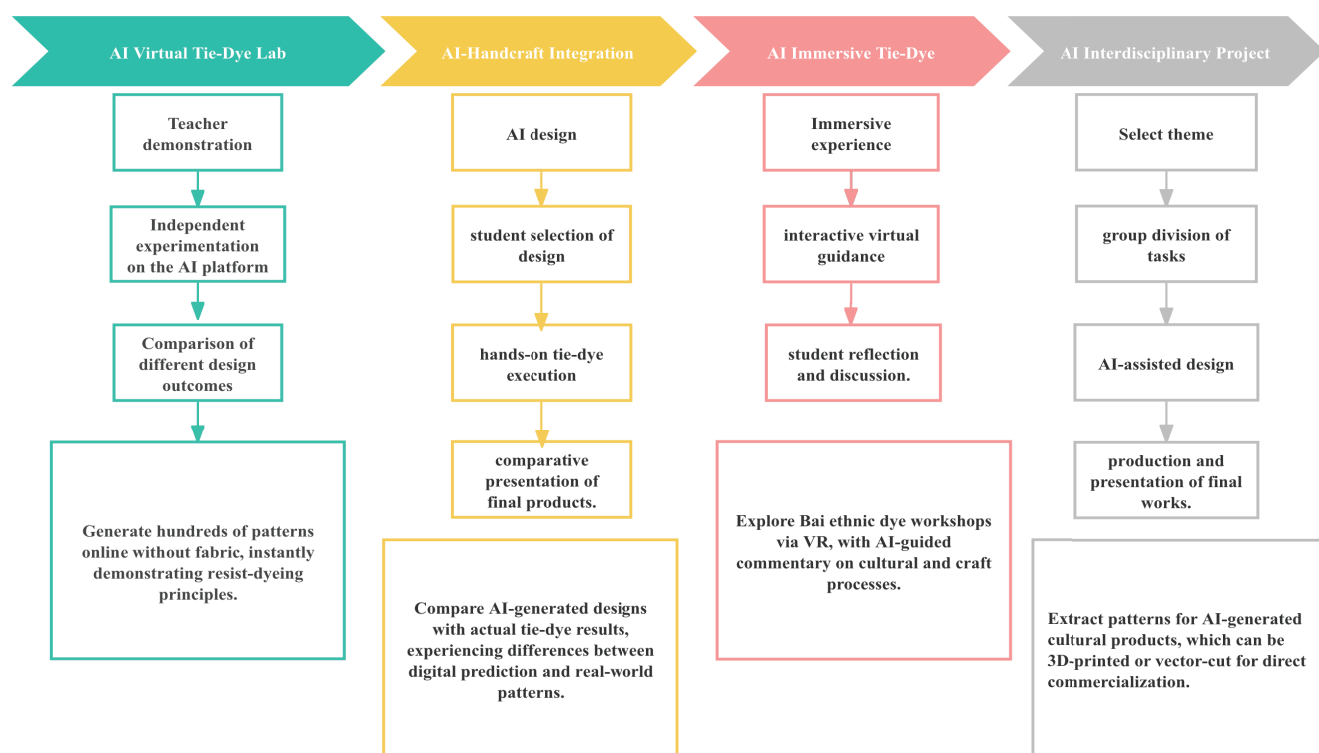
As discussed above, tie-dye holds significant educational value for high school art curricula. However, constraints in resources, time, and teacher expertise often hinder the implementation of systematic and in-depth instruction. The integration of artificial intelligence offers promising solutions to these challenges. Leveraging AI's capabilities in simulation, generation, and interaction, tie-dye instruction can transcend the limitations of traditional classrooms, enabling students to construct complementary learning experiences across virtual and physical environments.

More importantly, AI functions not merely as a tool but as a novel cognitive medium, capable of stimulating students' creative potential and guiding them to engage with intangible cultural heritage through more open and exploratory thinking. To fully realize its educational objectives and ensure instructional quality, high school art classrooms must operate as comprehensive and integrated systems, supporting students' holistic growth and development while fostering both technical skills and cultural understanding.

4.1 Types of AI-Enhanced Tie-Dye Teaching Models

Based on the characteristics of high school art education, AI-enhanced tie-dye instruction can be categorized into four representative models (Figure 2): virtual experimentation, hands-on integration, immersive experience, and interdisciplinary innovation. These models progress from basic to advanced levels, simultaneously addressing skill development and cultural heritage objectives, thereby providing a structured pathway for both technical mastery and creative exploration.

Figure 2. Comparison of AI-Enhanced High School Tie-Dye Teaching Models



4.1.1 AI Virtual Tie-Dye Laboratory

This model primarily leverages AI-based image generation and simulation tools to replicate the tie-dye process. On the virtual platform, students select folding techniques, pattern shapes, and color combinations to instantly generate diverse tie-dye effects. This “low-cost, high-feedback” approach allows repeated experimentation, enabling students to quickly grasp the fundamental principles of tie-dye. Compared with the one-time operations typical of traditional classrooms, AI virtual labs enable students to accumulate more experience in a shorter period, thereby enhancing creative confidence.

Teaching Objectives: Master the basic principles of tie-dye and deepen understanding of pattern formation rules. Instructional Process: Teacher demonstration → Independent experimentation on the AI platform → Comparison of different design

outcomes. AI Tools Applied: Image generation software, simulation platforms. Expected Outcomes: Reduce material consumption, stimulate student interest, and cultivate exploratory awareness.

4.1.2 AI-Handcraft Integration Course

Building on the virtual laboratory, students transform AI-generated tie-dye designs into tangible works^[7]. This “virtual-to-real” dual experience allows learners to enjoy the convenience of digital creation while engaging firsthand with the complexity and uniqueness of manual dyeing. The model effectively integrates “digital efficiency” with “craft depth,” enabling students to appreciate the aesthetic value of randomness and irreproducibility inherent in tie-dye through comparison between virtual and physical outcomes.

Teaching Objectives: Combine digital design with handcraft techniques to deepen students’ understanding of the essence of tie-dye. Instructional Process: AI design → student selection of design → hands-on tie-dye execution → comparative presentation of final products. AI Tools Applied: Style transfer algorithms, pattern generation platforms. Expected Outcomes: Foster the integration of virtual and real experiences, enhance practical skills, and cultivate aesthetic literacy.

4.1.3 AI Immersive Tie-Dye Classroom

Leveraging VR/AR technologies, teachers can create immersive learning environments that allow students to “enter” traditional dye workshops and experience the full tie-dye process—from weaving and folding to dyeing and drying^[8]. During this immersive experience, students not only learn the craft but also gain insights into the close connections between tie-dye and ethnic life, customs, and cultural practices. AI can further generate virtual mentors to guide students through interactive exploration, reinforcing cultural identification and emotional engagement^[9].

Teaching Objectives: Comprehend the cultural significance underlying tie-dye, and enhance ethnic pride and cultural identity. Instructional Process: Immersive experience → interactive virtual guidance → student reflection and discussion. AI Tools Applied: VR/AR headsets, AI-guided virtual tour systems. Expected Outcomes: Strengthen students’ cultural experiences and emotional resonance, fostering respect and appreciation for intangible cultural heritage.

4.1.4 AI Interdisciplinary Project Course

In interdisciplinary projects, students draw inspiration from tie-dye elements and leverage AI to carry out modern design and innovative applications. Within integrated design instruction, AI and parametric technologies serve as tools for addressing complex design challenges, enabling exploration of AI applications across production, social, knowledge, spatial, and everyday contexts^[10]. For example, students can use AI to create tie-dye-inspired fashion, digital product aesthetics, and cultural creative merchandise, which are subsequently transformed into exhibitable works through collaborative group efforts. This model transcends the traditional boundaries of tie-dye, positioning it as a central resource in contemporary design while fostering teamwork and interdisciplinary competencies^[11].

Teaching Objectives: Guide students to connect intangible cultural heritage with contemporary life, enhancing creativity and comprehensive competencies. Instructional Process: Select theme → group division of tasks → AI-assisted design → production and presentation of final works. AI Tools Applied: AI design software, product modeling tools. Expected Outcomes: Integrate art and design, strengthen students’ creative disposition, and cultivate cultural confidence.

4.2 Comparative Analysis and Educational Value of AI-Enhanced Models

The four AI-enhanced teaching models exhibit distinct instructional emphases: the virtual laboratory focuses on technical simulation and comprehension of fundamental principles; the handcraft integration course emphasizes craft experience and aesthetic awareness; the immersive classroom highlights cultural identity and emotional engagement; and the interdisciplinary project course extends tie-dye into contemporary life and design contexts. Together, these models form a progressive pathway—from skill cognition, craft experience, cultural understanding, to cross-disciplinary innovation—facilitating not only mastery of tie-dye techniques but also the integration of skill development, aesthetic education, and cultural heritage.

Crucially, these models illustrate the multifaceted roles of AI in education: as a “learning tool,” a “cultural communication bridge,” and an “innovation catalyst.” By enriching classroom formats and transforming instructional approaches, AI empowers high school tie-dye education to advance from single-dimensional craft training to broader objectives encompassing cultural identity and creative development. Leveraging virtual simulation, hybrid virtual-real experiences, immersive

learning, and interdisciplinary innovation, this framework offers practical, implementable strategies for art educators while providing new avenues for the preservation and dynamic evolution of intangible cultural heritage in contemporary contexts.

5. Advantages and Challenges of AI-Enhanced Tie-Dye Instruction

5.1 Advantages of AI-Enhanced Tie-Dye Instruction

AI-enhanced tie-dye instruction demonstrates clear advantages in high school art classrooms. It overcomes traditional limitations related to materials, procedures, and time. Utilizing virtual laboratory platforms, students can rapidly experience the full tie-dye process without consuming fabric or dye, reducing costs while extending exploration time. AI's generative and interactive capabilities enhance classroom engagement and interactivity, allowing students to experiment with multiple design options and receive immediate feedback, thus transforming the conventional “teacher demonstration, student imitation” model.

AI also enables personalized learning pathways tailored to students' abilities and interests, facilitating differentiated instruction and optimizing overall learning outcomes. Furthermore, it strengthens awareness of cultural heritage and innovation: students engage with the cultural significance of tie-dye through virtual scenarios and interdisciplinary projects, integrating traditional craft with contemporary design to stimulate creative potential. In this way, AI promotes a shift from skill training to creative production and from knowledge transmission to autonomous exploration, fostering core competencies, collaborative skills, and interdisciplinary literacy, and revitalizing intangible cultural heritage within art education.

To evaluate the practical impact of AI-enhanced tie-dye instruction, 39 high school elective art students completed anonymous questionnaires and participated in focus group interviews after course completion. As shown in Table 1, all five items on the Likert scale scored significantly above the midpoint of 3 ($p < 0.001$). “AI tools enhance learning interest” received the highest mean score ($M = 4.72$, $SD = 0.46$), indicating strong student acceptance of technological integration, followed by “AI + handcraft is superior to handcraft alone” ($M = 4.69$, $SD = 0.47$). Standard deviations below 0.6 suggest high consistency in student evaluations. Student A07 commented, “The AI-generated fireworks tie-dye patterns let me try a dozen styles in one go; I finally made a T-shirt to wear to school, and classmates kept asking for the link.” Student C04 noted during the interview, “In VR, the Bai grandmother led me through the dye workshop; I suddenly realized this wasn't just crafting—it was learning a nearly lost way of life.” Both quantitative and qualitative data indicate that AI not only enhances students' creative confidence but also strengthens emotional identification with and willingness to promote intangible cultural heritage, providing observable evidence for the revitalization of traditional crafts among adolescents.

Table 1. Student Feedback on AI-Enhanced Tie-Dye Instruction (Likert Scale)

Survey Item	Mean (M)	Standard Deviation (SD)
AI tools enhanced my interest in learning	4.72	0.46
I am willing to continue practicing tie-dye after class	4.65	0.51
I have developed a deeper appreciation for intangible cultural heritage	4.59	0.49
AI combined with handcraft is better than handcraft alone	4.69	0.47
I am willing to recommend tie-dye to friends or family	4.51	0.55

5.2 Challenges of AI-Enhanced Tie-Dye Instruction

Although AI-enhanced tie-dye instruction offers significant advantages in increasing engagement, enabling personalized learning experiences, and promoting cultural innovation, it also faces several challenges. Excessive reliance on AI may lead students to neglect hands-on practice, limiting the depth of intangible cultural heritage transmission. Teachers are required not only to master tie-dye techniques but also to acquire proficiency in operating AI tools; currently, most educators lack systematic training, which can result in a “technically capable but underutilized” scenario.

Differences in educational resources may exacerbate digital divides, potentially increasing regional disparities in instruction.

Additionally, AI-generated works raise concerns regarding copyright and originality, necessitating guidance for students to use these tools appropriately and maintain academic integrity. The interaction between traditional craftsmanship and innovative applications creates inherent tension; over-digitization risks diminishing both the technical depth and cultural richness of tie-dye. Therefore, AI should be applied judiciously in tie-dye education, following the principle of “technology serving education and innovation grounded in culture^[12].” This approach ensures that the advantages of AI are fully realized while preserving the essence of intangible cultural heritage, ultimately achieving both educational objectives and cultural transmission^[13].

Conclusion

This study explored the integration of artificial intelligence (AI) into high school art education through the teaching of tie-dye, a nationally recognized intangible cultural heritage. By examining four instructional models—virtual experimentation, AI–handcraft integration, immersive learning, and interdisciplinary innovation—the research demonstrated that AI can effectively overcome resource and time constraints, enhance student engagement, and foster cultural identity. Empirical evidence from student feedback confirmed that AI not only stimulates creative interest and confidence but also deepens appreciation for cultural heritage. At the same time, the findings highlight challenges, including risks of overreliance on digital tools, insufficient teacher training, and concerns regarding equity and originality. Addressing these issues requires coordinated efforts in professional development, curriculum design, resource sharing, and policy support. In conclusion, AI should be applied under the guiding principle of “technology serving education and culture guiding innovation.” When integrated appropriately, AI-enhanced tie-dye instruction can promote creativity, interdisciplinary learning, and cultural transmission, contributing to both pedagogical innovation and the sustainable revitalization of intangible cultural heritage.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.
- [2] Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511815355>
- [3] Piaget, J. (1976). *The grasp of consciousness: Action and concept in the young child*. Harvard University Press.
- [4] Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- [5] Li, S. (2024). Art, design, and new productive qualities: Exploring future education at the School of Design, Central Academy of Fine Arts (Part 3). *Industrial Design*, (05), 5–8.
- [6] di Meana, F. R. (2024). Enhancing artistic education with AI (ERIC Technical Paper No. ED665402). ERIC. <https://eric.ed.gov/?id=ED665402>
- [7] Wu, K., Jin, B., & Zhou, Q. (2024). Exploration of media innovation and teaching model transformation in art education in the era of artificial intelligence [In Chinese]. *Teacher Education Forum*, 37(11), 28–35.
- [8] Wu, X. (2023). A review of constructivist learning theory. *Frontiers in Social Sciences*, (11), 6645–6651. <https://doi.org/10.12677/ASS.2023.1211908>
- [9] Ma, W. (2024). Cultural dilemmas and optimization paths of integrating intangible cultural heritage into school education in ethnic regions: A case study of L County, Ningxia [In Chinese]. *Ethnic Education Research*, 35(2), 129–135. <https://doi.org/10.15946/j.cnki.1001-7178.20240509.001>
- [10] Bai, L., Wang, X., Dong, L., & Jiao, B. (2020). Curriculum design based on the STEAM education concept: A case study of the “Bionic Design” course [In Chinese]. *China Educational Informatization*, (16), 55–58.
- [11] Hutson, J., & Cotroneo, P. (2023). Generative AI tools in art education: Exploring prompt engineering and iterative

- processes for enhanced creativity. *Metaverse*, 4(1), 1–13. <https://doi.org/10.54517/m.v4i1.2164>
- [12] Wang, S. (2024). Enhancing art education through virtual reality: The impact of virtual art museums on junior high school students. *Research and Advances in Education*, 3(9), 52–58.
- [13] Liao, C.-W., Wang, C.-C., Wang, I.-C., Lin, E.-S., Chen, B.-S., Huang, W.-L., & Ho, W.-S. (2025). Integrating Virtual Reality into art education: Enhancing public art and environmental literacy among technical high school students. *Applied Sciences*, 15(6), 3094. <https://doi.org/10.3390/app15063094>
- [14] Jiangsu Normal University Research Group. (2023). Research on constructing STEAM teaching models for cultural heritage transmission (Report) [In Chinese]. Jiangsu Normal University.
- [15] Zheng, W., Wang, Z., Wang, S., Wang, J., & Gao, Y. (2024). Innovative tie-dye pattern design based on sound visualization technology. *Wool Textile Technology*, 52(5), 32–37. <https://doi.org/10.19333/j.mfkj.20230906606>
- [16] Marella, V. C. (2025). The impact of artificial intelligence on traditional art education. *arXiv*. <https://arxiv.org/pdf/2509.07029>
- [17] UNESCO. (2024, October 17–24). Exploring the impact of artificial intelligence and intangible cultural heritage (Policy Lab Materials). United Nations Educational, Scientific and Cultural Organization.