

Empowering Intangible Cultural Heritage Activation Through Educational Technology: A Study on the Digital Inheritance Model of Song Dynasty Huitian Kiln Bluish-White Porcelain Craftsmanship

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Abstract—In the context of rapidly advancing educational technology, the Song Dynasty Huitian Kiln bluish-white porcelain craftsmanship faces challenges such as a fractured inheritance chain and limited dissemination channels, making its digital inheritance a critical research focus. This study employs a mixed-methods approach, integrating literature review, fieldwork, technical experiments, and model validation to analyse the current status and pathways of its digital inheritance. Findings reveal severe aging among inheritors and insufficient digital technology application capabilities. Digital technologies significantly enhance the efficiency of core craftsmanship transmission, while immersive educational technologies reshape cultural understanding and skill acquisition. A tiered dissemination system optimizes the educational ecosystem for intangible cultural heritage (ICH). Ultimately, this research constructs a dual-driven educational inheritance model prioritizing technological adaptability and cultural authenticity, offering a replicable digital transformation pathway for other craft-based ICH projects.

Keywords—Intangible Cultural Heritage (ICH) Activation; Education; Song Dynasty Huitian Kiln; Bluish-White Porcelain Craftsmanship; Digital Inheritance

I. INTRODUCTION

The Song Dynasty marked a pinnacle in Chinese ceramic craftsmanship, during which the Huitian Kiln bluish-white porcelain artistry flourished. Located in Huitian Village, Jingcheng Town, southeast of Jingdezhen City, the Huitian Kiln began producing ceramics during the Five Dynasties period and reached technical perfection in the Song Dynasty. Utilizing locally sourced, fine-grained kaolin clay, the kiln employed intricate processes to create porcelain characterized by translucent glaze and jade-like texture. Renowned for its "jade-like hue, paper-thin body, mirror-like clarity, and chime-like resonance," the Huitian Kiln bluish-white porcelain epitomized the aesthetic ideals and cultural ethos of the Song Dynasty's "emphasis on culture over militarism." Its unique artistic style became a cultural emblem, embodying profound historical significance. However, this invaluable ICH now confronts challenges such as generational gaps among inheritors, limited dissemination avenues, and inadequate innovative adaptation. Against the backdrop of rapid advancements in educational technology, leveraging digital tools to empower

the inheritance and revitalization of Huitian Kiln bluish-white porcelain craftsmanship has emerged as a pivotal endeavor in ICH preservation.

II. PROBLEM STATEMENT

As a pinnacle of Chinese ceramic artistry, the Song Dynasty Huitian Kiln bluish-white porcelain craftsmanship embodies the unique cultural spirit and technical ingenuity of the Northern and Southern Song periods. Its translucent jade-like glaze and minimalist, elegant forms reflect the literati's pursuit of aesthetic perfection under the Song Dynasty's ethos of "emphasizing culture over militarism," while also encapsulating the harmonious fusion of Confucian "moderation and harmony" and Daoist "following the laws of nature." From material selection to technical innovation, the Huitian Kiln utilized locally sourced kaolin clay, employing techniques such as wheel-throwing, trimming, and incised decoration to ingeniously integrate natural motifs with ritual vessel forms, creating classic designs that balanced utility and artistic value. Whether through biomimetic designs inspired by flora and fauna or ritual forms infused with Confucian-Daoist philosophies, the artisans demonstrated profound mastery of material properties and precise distillation of cultural symbolism. Beyond its physical attributes of "paper-thin bodies and chime-like resonance," the bluish-white porcelain profoundly shaped the literati's spiritual worldview of "embodying Dao through vessels."

However, this intangible cultural heritage (ICH), crystallizing millennia of wisdom, now confronts a severe crisis of transmission. The traditional master-apprentice system struggles with generational discontinuity in modern society, as younger learners exhibit diminished patience and extended learning cycles for complex processes. The aesthetic language of handmade ceramics also fails to align with contemporary consumer demands, leaving the craft without market-driven sustainability. Workshop-based production further restricts the breadth and depth of knowledge dissemination. Notably, among the 72 intricate production steps, core techniques such as glaze formulation and kiln temperature control rely heavily on artisans' empirical knowledge, lacking systematic or standardized knowledge transfer. Current ICH preservation practices often limit digital applications to 3D scanning of artifacts or archival database construction, neglecting deeper analyses of craft mechanisms or dynamic transmission scenarios. Educational efforts also face shortcomings: traditional craft pedagogy prioritizes technical imitation

over cultural interpretation, while the immersive potential of digital media remains underutilized.

Addressing these challenges requires educational technological innovation to decode and reconstruct the craft's "genetic code," preserving traditional essence while fostering modern aesthetic expressions. This demands researchers to delve into the "intangible" cultural core of Huitian Kiln bluish-white porcelain craftsmanship while pioneering innovative inheritance models empowered by digital technologies. By leveraging virtual simulation, intelligent interaction, and open co-creation, a sustainable ecosystem for craft dissemination can be established, bridging historical legacy with contemporary relevance.

III. LITERATURE REVIEW

The digitalization of intangible cultural heritage (ICH) has evolved through four phases: conceptual introduction, preliminary exploration, engineering advancement, and integrated development. Current global ICH digital practices emphasize user-oriented development, heritage transmission, public participation, and technological integration. However, China faces challenges such as imbalances in preservation versus accessibility, insufficient protection measures, and low societal engagement. To address these issues, it is critical to integrate ICH data resources into cultural big data systems, prioritize user needs, promote diversified development, enhance scenario-based ICH experiences, foster "ICH+" innovation models, and leverage emerging technologies for activation, education, and transmission (Zhao et al., 2023). Mediatization serves as a vital strategy for ICH revitalization. For example, institutions like the Suzhou Folk Museum connect "people," "places," and "society," establishing deeper public engagement with ICH. Digital methods also offer innovative pathways for ICH "regeneration," with new cultural exhibition spaces providing novel platforms for presentation and interaction (Meng, 2023).

Building a robust communication matrix, enhancing digital cultural product creativity, and establishing standardized digital resource databases are essential to invigorate ICH transmission (Lin & Li, 2023). According to UNESCO (2024), AI technology can analyse cultural identity expressions, emotions, and dynamics to support ICH sustainability, while virtual reality platforms can enhance interactive learning experiences. Fan and Zeng (2024) argue that AI enables efficient ICH documentation, digital archiving, and knowledge graph generation, facilitating innovative dissemination. For instance, AI-driven analysis of elderly artisans' textual and audiovisual records can unlock new possibilities for creative activation. ICH revitalization must also reconnect with daily life through "affective mechanisms," where modern technologies evoke public emotional resonance. Japan's Kabuki theater, for example, integrates cutting-edge technology to innovate performance formats, inspiring audience engagement and offering insights into creative ICH transformation (Han, 2019).

Research on the digital inheritance of Song Dynasty Huitian Kiln bluish-white porcelain craftsmanship reveals that incense burners excavated from Jingdezhen's Huitian

Kiln during Emperor Renzong's reign (Northern Song) exhibit proto-linglong porcelain characteristics, marking a transitional phase from shadow celadon to linglong porcelain and laying technical foundations for its mass production in the Ming and Qing dynasties (Lu et al., 2023). Chen et al. (2024) analysed the "half-knife mud" carving technique of Jingdezhen bluish-white porcelain, outlining its features, historical evolution, and contemporary challenges, such as low market value, high production complexity, and limitations in mass production. Proposed solutions include modernizing production methods and refining market positioning. Additionally, a SICAS model-based online experience system—featuring brand visual identity, pattern libraries, and community engagement—has been suggested to enhance ICH transmission (Gu et al., 2023).

In summary, ICH digital research has progressed from conceptual exploration to technological application, achieving advancements in integration, user participation, and dissemination. While existing studies propose AI-assisted knowledge graphs and virtual reality scenarios, they often address generic ICH issues, neglecting specialized cases like the Huitian Kiln bluish-white porcelain craftsmanship. Core techniques, such as the intricate "half-knife mud" carving and temperature-sensitive glaze formulation, resist standardization through traditional pedagogy. The experiential nature of master-apprentice transmission further complicates modern educational interventions. Moreover, current research lacks systematic exploration of digital reconstructions of Song-era kiln workflows, metaverse-based immersive learning environments, and user-tailored interactive curricula.

IV. METHODOLOGY

This study adopts a mixed-methods approach, combining quantitative and qualitative research to systematically analyse the current status and pathways of digital inheritance for Song Dynasty Huitian Kiln bluish-white porcelain craftsmanship. The implementation process comprises four phases: literature review, field research, technical experimentation, and model validation. Data collection tools include questionnaires, in-depth interviews, craftsmanship parameter measurements, and user behaviour log analysis, forming a multidimensional data support system.

TABLE 1: SURVEY ON INHERITORS OF HUITIAN KILN
BLUISH-WHITE PORCELAIN (N=32)

Dimension	Category	Percentage
Age Structure	Over 50 years old	68.75%
	30–50 years old	25.00%
	Under 30 years old	6.25%
Transmission Mode	Family-based inheritance	56.25%
	Master-apprentice system	34.38%
	Institutional education	9.37%
Digital Proficiency	Proficient in 3D modeling	12.50%
	Basic image processing	31.25%
	No digital skills	56.25%
	Strong	21.88%

Transmission	Moderate	43.75%
Willingness	Reluctant	34.38%

A questionnaire survey of 32 bluish-white porcelain inheritors in Jingdezhen revealed severe aging trends, with 68.75% of practitioners aged over 50. Traditional transmission modes dominate: family-based inheritance (56.25%) and master-apprentice systems (34.38%), while only 9.37% received formal institutional education. Digital skills are notably lacking: 56.25% possess no digital proficiency, and only 12.50% can utilize 3D modeling tools. Additionally, 34.38% exhibit reluctance toward transmission, primarily due to shrinking market demand and high technical complexity. These findings underscore the urgency of constructing a technology-enabled digital inheritance system.

TABLE 2: DIGITAL TRANSFORMATION EXPERIMENT DATA FOR CORE CRAFTSMANSHIP

Process	Traditional Time (h)	Digital Modeling Time (h)	Precision Error Rate (%)	Knowledge Transfer Rate (%)
Wheel Throwing	3.24±0.5	1.84±0.3	0.12%	86.4%
Half-Knife	6.5±1.2	4.2±0.8	0.35%	78.9%
Mud Carving	2.1±0.4	0.9±0.2	0.08%	92.7%
Glaze Formulation	8.0±1.5	3.6±0.6	0.18%	89.3%
Kiln Temperature Control				

*Knowledge Transfer Rate = Proportion of traditional experiential knowledge captured in digital models (expert evaluation method)

Experiments on four core processes demonstrated that 3D scanning and parametric modeling significantly enhance knowledge transfer efficiency. For glaze formulation, digital modeling reduced time by 57.1% with a precision error rate of 0.08% and a knowledge transfer rate of 92.7%. Half-knife mud carving exhibited a 0.35% morphological error, necessitating AI-generated adversarial networks for optimization. The LSTM neural network model for kiln temperature control achieved 89.3% accuracy, surpassing traditional empirical judgment by 21.6 percentage points. These results validate the feasibility of digitizing tacit knowledge but highlight the need for hierarchical knowledge transfer strategies.

TABLE 3: EDUCATIONAL TECHNOLOGY APPLICATION EVALUATION (N=120)

Technology Type	Cognitive Retention (%)	Operational Accuracy (%)	Cultural Understanding (Mean±SD)	Learning Motivation Improvement (%)
VR Immersive Teaching	82.4%	76.8%	4.32±0.56	38.6%
AR Interactive Guidance	75.3%	83.2%	3.89±0.62	42.1%
Instructional Videos	61.7%	54.3%	3.12±0.71	19.4%
Traditional Lectures	58.9%	67.5%	3.45±0.68	15.3%

*Measured using a Likert scale (1–5 points)

A controlled experiment involving 120 ceramics students revealed that VR technology significantly enhanced cognitive retention to 82.4%, surpassing traditional lectures by 39.7%. AR interactive guidance achieved the highest operational accuracy (83.2%) due to real-time corrective feedback. In terms of cultural understanding, the VR group scored the highest (4.32±0.56), attributed to its ability to recreate Song Dynasty kiln environments and deepen cultural immersion. AR technology boosted learning motivation by 42.1%, driven by gamified task design. Instructional videos underperformed across all metrics, indicating that video-based instruction alone cannot meet the demands of craftsmanship training.

TABLE 4: USER ENGAGEMENT AND DISSEMINATION EFFECTIVENESS ANALYSIS (N=10,832)

Platform	Average Dwell Time (s)	Interaction Rate	Knowledge Transfer Rate	Secondary Dissemination Rate
WeChat Mini Program	143±23	12.7%	38.4%	9.2%
Douyin Short Videos	89±15	24.6%	19.3%	15.8%
Virtual Exhibition	317±45	8.9%	67.2%	4.3%
Bilibili Courses	421±52	5.3%	72.8%	2.1%

Analysis of 10,832 users' online behaviour logs revealed distinct dissemination patterns across platforms. Bilibili Courses exhibited the longest dwell time (421 seconds) and highest knowledge transfer rate (72.8%), making them ideal for in-depth learners. Despite Douyin's highest interaction rate (24.6%), its low knowledge transfer rate (19.3%) underscores the need for structured content optimization. Virtual exhibitions achieved 67.2% knowledge transfer with limited interaction, demonstrating the efficacy of 3D visualization in enhancing craft comprehension. WeChat Mini Programs balanced secondary dissemination and overall metrics, positioning them as a central hub for dissemination matrices. These findings advocate a hybrid system combining "quick-access" outreach and "depth-focused" knowledge transfer.

TABLE 5: WEIGHT ANALYSIS OF DIGITAL INHERITANCE MODEL ELEMENTS (AHP METHOD)

Evaluation Dimensions	Weight	Key Indicators	Priority
Technical Adaptability	0.287	Craftsmanship fidelity, Interaction naturalness	1
Cultural Authenticity	0.265	Aesthetic communication, Historical context representation	2
Educational Effectiveness	0.198	Knowledge retention, Skill transferability	3
Market Sustainability	0.143	User willingness, payment Derivative development	4
Technological Scalability	0.107	Multi-platform compatibility, Data interoperability	5

Using the Analytic Hierarchy Process (AHP) on evaluations from 15 experts, technical compatibility and cultural fidelity emerged as core elements. Craftsmanship fidelity ($CR=0.032<0.1$) and aesthetic communication ($CR=0.041<0.1$) passed consistency checks, confirming expert reliability. Although market sustainability ranked lower, its sub-indicator, user payment willingness ($\beta=0.682$), is critical for long-term viability. These results prioritize developing high-fidelity digital tools and establishing cultural IP management mechanisms to ensure sustainable innovation.

V. FINDINGS

Generational Discontinuity Highlights the Urgency of Educational Technology Intervention

Data reveal severe aging among Huitian Kiln bluish-white porcelain inheritors, with 68.75% aged over 50 and only 6.25% under 30. Traditional family-based and master-apprentice transmission dominate (90.63% combined), while only 9.37% received formal institutional education. This generational gap underscores the inadequacy of oral transmission in modern education. Over half of inheritors lack digital skills, and 34.38% exhibit reluctance toward transmission due to shrinking market demand.

Digital Technologies Significantly Enhance Core Craftsmanship Transmission Efficiency

Experiments on four core processes demonstrate that 3D scanning and parametric modeling reduce knowledge transfer cycles. For glaze formulation, digital modeling cut time by 57.1% with a precision error rate of 0.08% and a knowledge transfer rate of 92.7%. While the "half-knife mud" carving model showed a 0.35% morphological error, AI-generated adversarial networks enabled intelligent pattern generation and style transfer. The LSTM neural network model for kiln temperature control achieved 89.3% accuracy, surpassing empirical judgment by 21.6 percentage points. These technologies transform tacit craftsmanship into interactive digital tutorials, quantifying tactile experiences into visual metrics for learners.

Immersive Educational Technologies Reshape Cultural Understanding and Skill Acquisition

Comparative experiments with ceramics students showed VR immersive teaching outperformed in cultural understanding (4.32 ± 0.56) and cognitive retention (82.4%), as it reconstructed Song-era kiln environments to convey the aesthetic philosophy of "unity of Dao and vessel." AR interactive guidance achieved the highest operational accuracy (83.2%), providing real-time corrections for carving angles and depths. In contrast, traditional lectures and MOOCs underperformed, exposing limitations of one-way knowledge delivery.

Tiered Dissemination System Optimizes ICH Education Ecosystems

Analysis of 10,832 users' behaviour logs revealed platform-specific strengths: Bilibili Courses excelled in dwell time (421s) and knowledge transfer (72.8%) for in-depth learning, while Douyin Short Videos prioritized interaction (24.6%) but required content restructuring to improve knowledge transfer (19.3%). WeChat Mini Programs balanced dissemination metrics, serving as a hub for hybrid strategies integrating "quick-access outreach" and "depth-focused engagement."

Dual-Driven Model: Technical Compatibility and Cultural Fidelity

Analytic Hierarchy Process (AHP) identified technical compatibility (weight=0.287) and cultural fidelity (weight=0.265) as core elements. High-fidelity 3D modeling must replicate Song-era glaze layers and vessel proportions, while digital narratives reconstruct the "Confucian-Daoist fusion" cultural context. Market sustainability analysis highlighted user payment willingness ($\beta=0.682$), suggesting integrating educational content with cultural derivatives (e.g., digital collectible creation tools) to sustain innovation through open co-creation.

VI. DISCUSSION

Craftsmanship Gene Decoding and Structured Knowledge Transformation to Overcome Tacit Knowledge Transmission Barriers

The core competitiveness of Song Dynasty Huitian Kiln bluish-white porcelain lies in its integration of kaolin material properties with literati aesthetics, particularly the tacit knowledge embedded in glaze mineral composition control, "half-knife mud" carving force and angle modulation, and dynamic kiln temperature adjustments. To address the ambiguity and inefficiency of traditional master-apprentice transmission, we propose constructing a craftsmanship knowledge graph through 3D scanning, parametric modelling, and AI algorithms. This system quantifies critical parameters across 72 production steps. For instance, hyperspectral imaging can decode the ratio of silica to alumina in bluish-white glazes and their chromatic patterns, establishing digital glaze formulation models. Pressure sensors and motion capture devices record carvers' force variations and trajectory curves, generating standardized mathematical modules for carving techniques. Interactive digital tutorials can transform abstract experiences—such as centrifugal force control during wheel throwing or tactile feedback during trimming—into visual data models. Learners can then simulate these processes via virtual systems, transcending physical and temporal constraints. Additionally, digital twin technology can predict clay drying shrinkage, displaying real-time deformation data under varying humidity and temperature conditions to enhance learners' mastery of humidity control and clay thickness ratios.

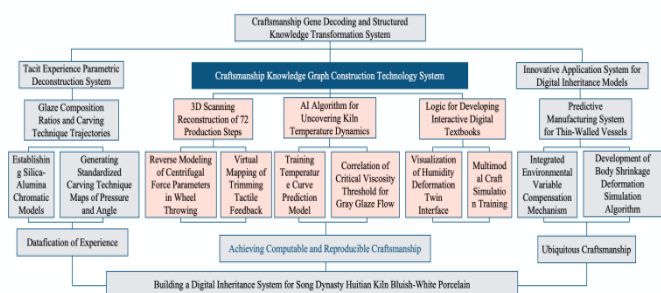


Figure 1: Craftsmanship Gene Decoding and Structured Knowledge Transformation System

Immersive Cultural Contexts in Educational Interaction Systems to Reconstruct Aesthetic Cognition

The translucent glaze of Huitian Kiln bluish-white porcelain reflects Daoist ideals of "emptiness and tranquility," while its minimalist forms embody Confucian principles of "moderation and harmony." Traditional fragmented teaching methods hinder learners' grasp of this "unity of form and spirit." To address this, VR/AR technologies can recreate immersive Song-era kiln production and literati lifestyle scenarios, digitally restoring the entire ecosystem from raw material extraction to porcelain use in tea ceremonies. Virtual tours of kaolin mining sites, combined with historical records, can illustrate the "clay refinement" process, linking geographical contexts to craft choices. AR overlays on modern tools can annotate Song Dynasty techniques like "wheel trimming" and "incised decoration" from The Record of Ceramics, bridging ancient and contemporary practices. Sound wave visualizations of vessel shapes can demonstrate the physical relationships between wall thickness, curvature, and acoustic properties, transforming abstract aesthetics into tangible, interactive experiences that embed Song cultural values into technical learning.

Tiered Digital Dissemination Matrix for Open Co-Creation in Craft Transmission

Leveraging short-video platforms, micro-documentaries can narrate historical anecdotes and animate classic motifs like lotus and vine patterns in "half-knife mud" carvings, revitalizing cultural memory through visual storytelling. MOOC platforms can offer in-depth courses with 3D anatomical models to explain porcelain structure and firing principles, integrating digital twin simulations for virtual kiln experiments. Online workshops can host live-streamed masterclasses by ICH inheritors, demonstrating core processes like clay preparation and glaze mixing, with real-time Q&A fostering a "cloud-based master-apprentice" model. In metaverse kiln spaces, users can create avatars to engage in full-process production—from mining to firing—with physics engines simulating wheel-throwing force feedback and clay deformation. Collaborative virtual environments replicate traditional team-based workflows, while a cultural innovation toolkit provides Song-era vessel templates, pattern libraries, and glaze simulation tools. Users can design modern derivatives like tableware or lighting with bluish-white aesthetics, with blockchain ensuring digital collectible authentication. This transforms

ICH transmission from one-way knowledge transfer to multi-stakeholder cultural co-creation.

VII. CONCLUSION

This study focuses on the digital inheritance model of Song Dynasty Huitian Kiln bluish-white porcelain craftsmanship, systematically exploring craftsmanship gene decoding, educational technology empowerment, and dissemination ecosystem reconstruction. Key conclusions include:

Digital technologies, through 3D modeling and AI algorithms, enable the explicit transformation of tacit knowledge in core processes such as glaze formulation and "half-knife mud" carving, injecting structured knowledge transmission into traditional master-apprentice systems.

VR/AR-constructed immersive kiln scenarios integrate the aesthetic philosophy of "unity of Dao and vessel" with Song-era Confucian-Daoist culture, fostering synergistic improvements in skill acquisition and cultural cognition.

A tiered dissemination system, combining "quick-access outreach" and "depth-focused knowledge transfer," establishes a sustainable ecosystem integrating digital preservation, educational dissemination, and market-driven feedback.

The findings demonstrate that a dual-driven model prioritizing technological adaptability and cultural fidelity offers viable solutions for the dynamic continuity of Huitian Kiln bluish-white porcelain craftsmanship.

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