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Exploring technology–culture synergy in living heritage education: A grounded theory approach using virtual reality

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ABSTRACT

This paper explores how virtual reality (VR) can be used to improve Intangible Cultural Heritage (ICH) education as a part of Visual Communication Design (VCD). It relies on qualitative research to form the grounded theory of VR-Driven ICH Living Heritage and Learning by using semi-structured interviews with 14 people, such as VR developers, ICH practitioners, VCD educators, and students. Results indicate the transformational effects of VR on VCD education through three mechanisms: (1) technology-enhanced features of embodied learning (high-precision modeling, real-time feedback) facilitate access to ICH skills by overcoming constraints inherent to classrooms, yet technical issues such as motion sickness pose a problem; (2) authentic contextual experiences provided by immersive VR scenes and storytelling enhance cultural identity and internalization of ICH knowledge; and (3) interdisciplinary innovation VR provides a pathway between design practice and cultural transmission, changing ICH. The paper presents the Technology-Culture Synergy Framework, which highlights that the integration of technology in VCD should not be done at the expense of cultural authenticity but should exploit design competencies to fill gaps in expressiveness in traditional ICH education. The research provides a new theoretical basis for reconsidering the VCD curricula of the digital era and promotes a tradeoff between cultural conservation and design innovation.

Contribution/Originality: This study contributes to the existing literature by advancing the understanding of virtual reality in intangible cultural heritage education within visual communication design. It employs grounded theory to develop the "VR-Driven ICH Living Heritage and Learning" model. This research is among the few investigations exploring the synergy between technology and culture in design education.

1. INTRODUCTION

1.1. Research Background

In the wave of the digital era, the development level of "digital cultural heritage" has become a critical indicator for assessing a nation's information infrastructure (Huang, 2015). According to UNESCO's 2003 Convention for the Safeguarding of Intangible Cultural Heritage, the transmission crisis of ICH has been repeatedly emphasized. The formation and evolution of ICH are profoundly influenced by a complex interplay of cultural backgrounds, geography, history, physical conditions, and socioeconomic factors (Fukuda, Uekita, Subroto, & Zhao, 2021). As a vibrant carrier of regional culture and emotional experience, ICH embodies the uniqueness of national cultural identity (Li, Ouyang,

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Wang, & Zhang, 2022). Globally, the transmission of ICH predominantly relies on community-based inheritance models, with the core value lying in the continuity of intergenerational knowledge and skills. Transmission is an intrinsic attribute of ICH, while "living heritage" and "authenticity" distinguish it as a dynamic cultural form, setting it apart from other heritage types (Li & Xie, 2025; Qi, 2022). The concept of "living heritage" not only demands the preservation of material forms but also prioritizes the cognitive experience, promotion, and dissemination of heritage carriers to achieve revitalization and continuity (Liang & Ma, 2008; Zhang & Liu, 2022). In safeguarding ICH, respecting its "authenticity" and maintaining its original state are paramount.

From the perspective of education, curriculum design must dynamically adapt to the evolving demands of science, technology, art, and dissemination, while closely aligning with societal expectations for graduate employability, fostering targeted vocational skill development (Ulita & Hananto, 2022). The widespread adoption of VR technology has opened new avenues for educational reform, shifting research focus from mere technical applications to deeper explorations of educational structures (Zhang, 2022). Integrating VR into education enables immersive ICH experiences, significantly advancing its preservation and transmission. This approach allows learners to deeply engage with the "living heritage" and "authenticity" of ICH, fostering a synergy between cultural transmission and educational innovation.

This study centers on VCD education, employing a qualitative interview approach to investigate how VR enhances Chinese VCD students' understanding of ICH. This research direction aligns closely with the developmental trajectory of VCD, which evolved from mid-19th-century print technology, through phases of decorative arts and graphic design, to a contemporary interdisciplinary field shaped by diverse media and computational technologies, consistently adapting to digital trends (Zhang & Zhao, 2023). Sun and Zhu (2022) highlight the transformative potential of technology in VCD education, effectively bridging traditional and emerging visual cultures.

Building on this foundation, this study leverages qualitative interviews to deeply explore VR's value in enhancing students' ICH knowledge and cultural creativity, responding to the demand for innovative and inclusive education. It also provides practical insights for curriculum reform, addressing gaps in empirical research. By integrating technology with cultural transmission, this research significantly advances the future development of VCD education, enriching its disciplinary significance.

1.2. Research Questions

At the critical juncture where VCD teaching intersects with ICH transmission, significant research gaps persist. To address these deficiencies and explore VR's application in ICH education from multiple perspectives, this study poses the following key research questions: How does VR, through dynamic modeling, enhance the "accessibility" of ICH skills? Besides, how can virtual scenarios preserve the "authenticity" and "living heritage" of ICH? Lastly, how does VR education facilitate the development of cultural identity and skill internalization in ICH learning?

1.3. Literature Review

In 1950, Japan's enactment of the "Law for the Protection of Cultural Properties" marked it as the world's first codified legislation for safeguarding ICH, notably integrating the protection of "tangible" and "intangible" cultural heritage (Hu, 2020). ICH encompasses intergenerational traditional skills, crafts, and contemporary cultural systems formed by urban and rural communities. Unlike tangible cultural heritage with physical inheritances, ICH exists primarily in non-material forms, with human actors at its core and its preservation and transmission shaped by dynamic changes in social living environments. However, in the digital era, the digital preservation of ICH remains notably inadequate, facing challenges such as incomplete digital resource collection, imperfect preservation technologies, and limited dissemination channels (Tromp et al., 2025; Yao, 2023). These issues make maintaining ICH's authenticity increasingly difficult, rendering the protection of its core values urgent.

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From the perspective of preservation models, ICH's development and safeguarding exhibit diverse approaches, including the use of "Internet Plus," knowledge graphs, and digital technologies for protection and research Li and Duan (2019); Melis and Chambers (2021) and Xue, Li, and Meng (2019). A macro-level review of global ICH preservation practices reveals that civil law countries, aligning with UNESCO's ICH safeguarding trends, have significantly led worldwide efforts (Aikawa & Shen, 2016; Peng & Zhang, 2022). Globally, ICH preservation shares commonalities but also presents areas requiring further exploration, collectively shaping the current realities of its transmission and protection.

Safeguarding Chinese ICH hinges on sustaining its vibrant vitality. Currently, among the 24 endangered ICH items listed by UNESCO, seven originate from China. Academic discussions on ICH development reveal two prevailing perspectives: one emphasizes the "authenticity" and "original ecology" of ICH, prioritizing inheritance and transmission over innovation and firmly opposing commercialization or industrialization, arguing that preserving its "authentic" and "original" essence is fundamental to maintaining core values, as any commercial or industrial intervention could compromise its purity (Varinlioglu & Halici, 2019; Zhang, Wan Yahaya, & Sanmugam, 2024). The opposing view contends that ICH's industrialization, in line with societal evolution, is an inevitable trend. These debates center on ICH's intrinsic attributes and future development, which are central to the ongoing exploration of ICH education, specifically, "how to meticulously design curriculum content for ICH knowledge dissemination."

The interdisciplinarity of ICH research has grown, integrating substantial resources to promote long-term ICH advocacy (Jia & Feng, 2022). This is particularly critical in vocational education, where balancing professional curriculum demands, equipping students with practical knowledge and skills, while preserving ICH's cultural originality, embedding "authenticity" and "original ecology" throughout teaching, is essential. Simultaneously, fostering student innovation is vital, encouraging new pathways for ICH development without compromising its cultural essence, thereby achieving a harmonious fusion of tradition and modernity.

Currently, research in design disciplines, including VCD, is increasingly lagging compared to other fields. Without the timely adoption of new technologies and improvements in the rigor and practicality of theoretical and practical approaches, VCD risks obsolescence due to diminished influence (Cash, 2018). As a multidisciplinary field integrating societal, service, communication, cultural, and technical attributes, VCD's development must align with digital trends, particularly in ICH education. Although ICH is a cornerstone of Chinese traditional culture, its research on digital dissemination and innovative design remains underdeveloped, with the potential of intelligent technologies yet to be fully realized (Intawong, Worragin, Khanchai, & Puritat, 2025; Qin & Jia, 2020). Existing studies demonstrate that VR's visual immersion significantly enhances learning interest and outcomes; however, its educational application is constrained by high development and equipment costs, primarily targeting commercial products like gaming and government training, with cultural education explorations in vocational contexts being extremely rare. VCD research faces challenges such as slow theoretical updates, limited research methodologies, and insufficient interdisciplinary collaboration, necessitating technology-driven innovation to solidify scientific foundations and enhance practical relevance. Integrating VR and similar technologies not only aligns with VCD's developmental needs but also provides a critical pathway for deepening ICH education, underscoring its importance for the discipline's future.

Jiawei and Mokmin (2023) focused on art school students, using systematic reviews and meta-analyses to explore the potential of immersive learning and VR in art education. Their findings confirm that VR significantly improves educational quality by stimulating artistic creativity, enhancing learning outcomes, and boosting students' operational and creative capacities. Traditional learning materials often have limitations, but VR creates a dynamic, engaging learning environment, expanding educational boundaries and highlighting its immense potential in modern education, positioning it as a key driver for educational transformation and innovation.

From the multifaceted perspective of ICH in Chinese education, national strategies for innovating and developing excellent traditional cultures provide clear directions for integrating cultural transmission into disciplinary

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knowledge. "Innovation and creativity" are essential for enhancing cultural transmission efficiency, fostering students' holistic development, and achieving high-quality education (Hu, Li, & Zhong, 2023; Muñoz, Climent-Ferrer, Martí-Testón, Solanes, & Gracia, 2025). Schools serve as vital spaces for cultural transmission, with ICH education offering students significant spiritual motivation and correct value orientation (Zhang & He, 2012). Innovative ICH knowledge education requires multidisciplinary collaboration, facilitating the intelligent integration of VCD teaching, broadening students' knowledge horizons, enhancing cultural literacy, and promoting interdisciplinary professional cooperation.

However, current VCD research predominantly focuses on technical implementation, such as VR's application in design, with little attention to its specific impact on traditional cultural education, particularly in ICH. While studies confirm VR's visual immersion positively stimulates learning interest (Qin & Jia, 2020), they often remain at the technical level, lacking deep analysis of cultural content integration and transmission. Moreover, qualitative research in VCD education is scarce, with existing literature relying heavily on quantitative data or model validation (Zhang & Zhao, 2023), neglecting systematic exploration of students', teachers', and other stakeholders' experiences and perceptions. Additionally, interdisciplinary perspectives are notably absent, as VCD research typically remains confined to the design discipline, failing to integrate theories and methods from education, cultural heritage, and related fields. This research gap limits VCD's potential in traditional cultural education, highlighting the urgent need for qualitative and interdisciplinary approaches.

Against this backdrop, this study aims to systematically investigate, through qualitative interviews, how VR effectively enhances Chinese VCD students' ICH knowledge and cultural understanding, driving VCD education toward digital and intelligent transformation. It addresses significant gaps in the literature, including the under-exploration of VR's role in VCD's traditional cultural education, the scarcity of qualitative research, and the lack of interdisciplinary perspectives. By uncovering VR's potential in boosting student engagement, deepening cultural understanding, and fostering curriculum innovation, this research not only provides theoretical support for VCD's development but also contributes critical insights to building a more inclusive and practice-oriented art education framework.

2. METHODOLOGY

This study adopts a qualitative research approach to investigate the practical logic and subjective perceptions of using VR technology in ICH education. The research unfolds in three phases: theoretical integration, data collection, and data analysis, to construct a theoretical framework titled "VR-Driven ICH Living Heritage and Learning." A tri-dimensional analytical framework of "technology-culture-education" is developed, emphasizing how learners, through embodied participation and project-based practice in VR environments, transition from cultural cognition to cultural identification.

Data collection employed purposive sampling to ensure the inclusion of diverse perspectives across disciplines relevant to virtual reality (VR), intangible cultural heritage (ICH), and visual communication design (VCD). A total of fourteen participants were selected, including nine interdisciplinary experts, one national-level ICH practitioner, and five VCD undergraduate students. The selection criteria focused on participants' direct involvement in or experience with VR-based education, cultural preservation, and design pedagogy. All participants were informed of the study's purpose and provided written consent. The expert participants were drawn from several academic and professional institutions to reflect a range of educational, technical, and cultural perspectives. These included the National University of Malaysia (UKM), where several faculty members contributed insights into VCD curriculum design and educational technology integration; Jiangxi Vocational and Technical College of Communications, which served as both a source of VR educators and the student sample; East China Normal University, known for its research in computer science and educational technology; Jiangxi University of Finance and Economics, providing expertise in entrepreneurship education; and Jiangxi Institute of Fashion Technology, contributing insights from the field of

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graphic design and creative industry practices. The inclusion of these institutions allowed for a comprehensive view of how VR intersects with ICH from both pedagogical and technological standpoints. The national-level ICH practitioner was affiliated with the Jiangxi Provincial Department of Culture and Tourism and brought practical experience in traditional craftsmanship and heritage preservation. Meanwhile, the five student participants, all in their second or third year of study, were enrolled in a VR-enhanced elective course on ICH offered at Jiangxi Vocational and Technical College of Communications. Their inclusion provided valuable insights into the learner experience and the perceived effectiveness of VR in fostering cultural identity and skill acquisition. The diverse institutional affiliations of all participants enriched the study by grounding its findings in both academic and applied contexts.

Prior to semi-structured interviews, interviewers introduced themselves to build trust, explained the study's content and purpose, and assured participants of strict confidentiality regarding personal information, with data used solely for educational research purposes.

Table 1 presents the basic information of interviewees, highlighting their research fields, professions, years of experience, and the interview methods applied. Consent forms were signed with each participant and their respective organizations before recording began during formal interviews. Interviews primarily addressed subjective issues challenging to quantify, with individual interviews lasting 15–20 minutes and focus group interviews lasting 20–25 minutes.

Data were analyzed using Nvivo 12, following grounded theory coding strategies (Akkaya, 2023) through a three-level process: initial open coding identified 30 concepts to create a tagging system; axial coding consolidated these into seven core categories; and selective coding integrated them into a theoretical model. Table 2 presents the interview questions structured by domain, objectives, and methods.

Table 1. Basic information of interviewees.

Interviewee code	Research field	Profession	Years of experience	Interview method
VR-1	VR + Digital media teaching	Lecturer, senior engineer	6 years	Individual interview
VR-2	VR + Intelligent transportation	Lecturer, intermediate engineer	6 years	
VCD-1	VCD teaching	Lecturer	7 years	
VCD-2	VCD teaching	Lecturer, arts and crafts master	7 years	
GD-1	Graphic design	Professor	20 years	
ES-1	Entrepreneurship education	Lecturer	8 years	
CS-1	Computer science	Professor	18 years	
VE-1	Vocational education	Associate professor	11 years	
ICH-1	National ICH	Master artisan	15 years	
P1	VCD	Student	3 years	Focus group
P2	VCD	Student	3 years	
P3	VCD	Student	3 years	
P4	VCD	Student	2 years	
P5	VCD	Student	2 years	

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Table 2. Interview outline.

Domain	Objective	Interview questions
Technology	To understand the feasibility and limitations of VR technology in educational applications	1. In your view, does the current development level of VR technology support the presentation of ICH content in VCD teaching? What are the key technical bottlenecks?
		2. When designing VR applications for educational purposes, what specific demands or challenges differ from commercial products (e.g., gaming)?
		3. How do you perceive the impact of VR equipment and software development costs on educational adoption? Are there potential strategies to lower these barriers?
		4. For the digital representation of ICH, in which areas do you believe VR technology could further optimize visual effects or interactive experiences?
Education	To explore the feasibility and pedagogical impact of integrating VR technology into VCD teaching	1. How would you evaluate the current teaching methods for ICH content in VCD curricula? What are the main shortcomings?
		2. If VR technology were introduced, how could it enhance students' understanding of and interest in ICH?
		3. What practical challenges might VR implementation face in teaching practice (e.g., equipment availability, teacher training)?
		4. Do you believe VR in VCD education should be combined with other teaching methods? If so, how should the curriculum be structured?
Focus group	To gather direct feedback from students and teachers on using VR technology for ICH learning	1. What has your experience been like learning about ICH? What aspects have been engaging or challenging for you?
		2. If you were to experience ICH through VR (e.g., virtual scenes or craft demonstrations), how do you think it would influence your interest and understanding?
		3. Compared to traditional classroom learning, what advantages or inconveniences do you see in VR learning (e.g., immersion, operational difficulty)?
		4. What specific ICH-related content or interactive features would you like to see integrated into VR teaching?

Based on the research objectives, the interview content was established through a literature review and expert consultation, followed by pre-interviews with five individuals to finalize the formal interview outline. This study focuses on the impact of VR technology on ICH knowledge transmission within VCD teaching, targeting three domains: technology development, educational practice, and focus groups to gather multidimensional perspectives. The following outlines the interview guide for each domain, with adjustments to specific questions made during interviews based on the unique backgrounds of the experts, serving as a primary directional framework for preliminary interviews.

3. FINDINGS

3.1. Preliminary Visualization Analysis

Based on association analyses of social network diagrams and word clouds (Figures 1 & 2), this study preliminarily constructs a theoretical framework for VR-enabled ICH education. The social network diagram reveals tight connections among core nodes such as “students,” “cultural,” “project,” and “design,” indicating that ICH learning centers on students, supported by project-based learning and cultural design to form a collaborative network. Technologically, the strong linkage between “interactive technologies” and “experience” suggests that VR reshapes ICH cognition through immersive experiences, aligning with high-frequency terms in the word cloud, such as “immersive evaluation” and “feedback experiences,” which emphasize interactive feedback mechanisms.

The word cloud further highlights a dual practical logic in ICH education: first, clusters like “culture heritage,” “knowledge,” and “skills” reflect the intrinsic demand for cultural transmission, requiring systematic knowledge internalization through “learning process” and “teaching instance”; second, concepts such as “entrepreneurship,”

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"innovation," and "market" point to the innovative extension of ICH education, underscoring the need for technological integration with "vocational interaction" and "applications insights" to drive creative transformation in contemporary contexts. These logics converge dynamically through "experience, understanding, exploration," forming a cyclical linkage of "technology empowerment, cultural cognition, innovative practice."

Overall, grounded theory coding will revolve around three main axes: technology-mediated learning environments, cultural heritage internalization mechanisms, and innovation-driven educational practices. Subsequent coding will focus on analyzing the interplay between technological tools and cultural meaning systems in interview texts, refining a theoretical model for the digital transformation of ICH education.

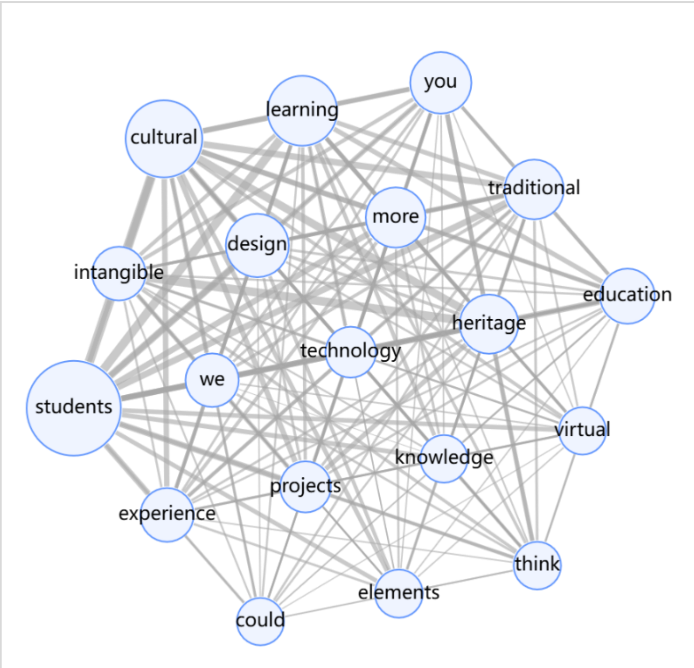

Figure 1. Social network relationship diagram.

Figure 2. Word cloud.

3.2. Open Coding

During the open coding phase, 23 initial concepts were extracted from interview texts, categorized into three dimensions: technical characteristics, learning experiences, and cultural perceptions (see Table 3). The technical characteristics dimension focuses on VR's enabling mechanisms, such as "high-precision modeling" enabling

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contextualized learning by replicating ICH craft details, "real-time feedback" and "gesture control" enhancing interactivity, while "motion sickness" and "operational adaptation difficulties" highlight technical limitations. The learning experiences dimension emphasizes learners' agency, including "immersive learning environments" that boost engagement through visual and auditory multisensory stimulation, "risk-free learning" allowing repeated trials, and "collaborative learning" facilitating knowledge system development. The cultural perceptions dimension reflects VR's role in conveying ICH values, such as "cultural value" being intuitively perceived through virtual experience centers, "narrative design" aiding cultural understanding, and "cultural identity" emerging as a core outcome of the learning process. These coding results comprehensively cover the interactions among technology, education, and culture, laying a foundation for subsequent theoretical development.

Table 3. Initial concepts and corresponding interview excerpts.

Concept	Original sentence
Technical support (Computer science, network technology)	**CS-1** Computer science and network technology can facilitate virtual reality learning, enabling the overcoming of limitations related to time and space.
Immersive learning environment	**VR-1** The greatest advantage of virtual reality technology is its ability to create an immersive learning environment for users.
Virtual reality learning (Immersive, close contact)	**VR-1** Students can truly immerse themselves in different types of cultural heritage through virtual reality, breaking through the limitations of time and space to have closer and more authentic contact with these intangible cultural heritages.
Situated learning (High-precision modeling)	**VR-1** VR technology can use high-precision modeling to reproduce traditional craftsmanship details, providing students with a realistic learning experience.
Scene reconstruction and narrative design	**VR-1** VR technology can help students understand the connotations of intangible cultural heritage through scene reconstruction and narrative design.
Cultural value	**ES-1 VCD-1 VCD-2** VR technology allows students to understand the uniqueness and value of culture more intuitively.
Experiencing the essence of culture	**P1 (Group Study) GD-1 VCD-2** VR technology allows students to experience the essence of intangible cultural heritage in an interesting educational experience.
Breaking spatial and temporal limits	**VR-1** VR technology can break through the limitations of time and space, allowing students to have closer and more authentic contact with intangible cultural heritages.
Risk-free learning	**ZJ-1 ES-1** VR technology allows students to try multiple times in a virtual environment to acquire knowledge without worrying about the actual consequences of failure.
Intuitive learning of intangible cultural heritage	**P2 (Group Study) GD-1** Using VR for learning makes intangible cultural heritage content more intuitive.
Situated learning reduces learning pressure	**P3 (Group Study)** VR learning makes it easier to acquire knowledge. I usually feel a lot of pressure during tests, but the test sections in VR are not boring.
Synchronous interaction (Teachers, peers), knowledge supplementation	**CS-1** After breaking through the limitations of time and space, students can interact synchronously with teachers or peers during the learning process, share their experiences and insights, and supplement any missing or omitted parts.
Collaborative learning, knowledge system construction	**CS-1 ES-1** This collaborative learning process helps students build a more complete knowledge system.
Data collection and analysis, personalized learning	**CS-1** By using network data transmission, relevant data generated during the learning process can be collected in the background in a timely manner. Through statistical analysis, more targeted guidance can be provided for subsequent learning.
Visual expressiveness, interactive experience	**VR-1** The combination of VR and digital media technology can significantly enhance the communication effect of intangible cultural heritage among college students, especially in terms of visual expressiveness, information overlay, and user interaction.
Learning interest	**ZJ-1 VCD-1** VR technology allows students to immerse themselves in the learning process, making it more interesting.
Experiencing the charm of intangible cultural heritage	**P1 (Group Study)** VR experiences are very interesting and allow us to immerse ourselves in the charm of intangible cultural heritage projects.

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Concept	Original sentence
Information overlay (Animated data visualization, real-time interaction)	**VR-1** Digital media technology can provide rich forms of information overlay, such as animated data visualization and real-time interaction.
Real-time feedback (interactivity)	**VR-1** The combination of VR technology and digital media makes the content highly interactive, allowing students to receive real-time feedback during the operation process.
Core interaction elements (Feedback mechanism, gesture feedback)	**VR-2** Core elements of VR interaction design include feedback mechanisms, gesture feedback, and multi-sensory experiences, which allow users to receive real-time responses in the virtual environment.
Gesture control (Natural interaction)	**VR-2** Gesture control helps users naturally participate in key factors of VR, allowing students to interact directly with virtual objects through gestures.
Implementing feedback mechanisms (Operating objects, memory simulation)	**VR-2** In intangible cultural heritage education, feedback mechanisms can be implemented by allowing students to operate specific objects or perform memory simulations.
Multi-person interaction scenarios (Virtual classroom, cultural fair)	**VR-2** VR technology can enhance the enjoyment of learning through multi-person interaction scenarios such as virtual classrooms and virtual cultural fairs.
Interactive design (Virtual explanation)	**VR-2** VR technology can enhance the fun of learning through virtual explanations and interactive design.
Interactive design (Enhancing understanding and memory)	**VR-2** VR technology can enhance students' understanding and memory of intangible cultural heritage through virtual scenes and interactive design.
Multi-sensory stimulation (Visual, auditory)	**VR-1** Vision and hearing are very important elements in VR teaching experiences, helping students to immerse themselves more deeply. Multi-sensory experiences should not be overlooked, especially through the combination of visual and auditory elements, allowing students to deepen their understanding of cultural content while listening to background music and seeing scene changes.
Immersion (Visual and auditory reproduction)	**VR-1** In VR environments, the reproduction of vision and hearing can enhance students' sense of immersion.
Cultural identity (Virtual experience center)	**VR-1** VR technology can enhance students' cultural identity through virtual experience centers showcasing intangible cultural heritage.
Dizziness	**P1 P3 (Group Study)** After wearing the device for more than ten minutes, I feel a bit dizzy.
Operation adaptation difficulty	**P1 (Group Study)** Initially, adapting to the operation, especially directional control, is somewhat challenging.

3.3. Axial Coding

Axial coding integrates the initial concepts from open coding into seven core categories, forming a theoretical interpretive framework (see Table 4). Immersive learning experiences (encompassing immersion and motion sickness) indicate that VR enhances learning motivation through multisensory stimulation, though technical flaws may undermine effectiveness; contextualized knowledge construction reveals that high-precision modeling combined with narrative design promotes cultural understanding; interactive learning mechanisms highlight natural interactions as drivers of knowledge internalization; cultural identity and dissemination reflect the dual objectives of technological applications, strengthening emotional connections while exploring pathways for cultural innovation. Additionally, personalized learning support and learning initiatives with internalization collectively form a learner-centered design logic, while technological optimization and challenges emphasize that technological iteration must balance innovation with traditional preservation. Axial coding establishes a logical chain of "technology empowerment, cultural internalization, educational transformation," systematically explaining the intrinsic mechanisms of VR-enabled ICH education.

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Table 4. Main categories formed by axial coding.

Main category	Initial category	Description and relationship
Immersive learning experience	Immersion, multi-sensory stimulation	• VR enhances students' sense of immersion through visual and auditory stimulation, which is a prerequisite for stimulating learning interest and cultural identity.
	Dizziness, operation adaptation difficulty	• Technical limitations, such as dizziness and operational discomfort, may weaken immersion and pose significant challenges to the learning experience.
Situated knowledge construction	Situated learning (High-precision modeling, scene reconstruction)	• By reconstructing the details and historical context of intangible cultural heritage, VR provides an intuitive learning environment that promotes understanding and memory of knowledge, serving as the core output of the immersive experience.
	Narrative design, cultural value perception	• Through storytelling, VR reveals the cultural connotations, deepening students' understanding of the value of intangible cultural heritage. This approach works in tandem with situated learning to enhance the depth of knowledge construction.
	Intuitive learning, reduced learning pressure	• Intuitive contexts make knowledge acquisition easier and more natural, providing emotional support for situated learning.
Interactive learning mechanism	Real-time feedback, gesture control, natural interaction	• Real-time feedback and natural manipulation enhance participation and learning outcomes, serving as the technical bridge connecting immersive experiences and knowledge construction.
	Multi-person collaboration	• Through virtual classrooms and other multi-person interactions, VR promotes collaboration and knowledge sharing, enhancing the social dimension of learning.
Cultural Identity and Dissemination	Cultural pride, emotional connection	• Immersive experiences stimulate students' emotional identification and pride in intangible cultural heritage, which is a core outcome of the learning process.
	Cultural innovation, market transformation potential	• Technological innovation and market promotion expand the influence of intangible cultural heritage, forming positive feedback with cultural identity and supporting cultural inheritance.
Personalized learning support	Data-driven feedback, risk-free trials	• Data analysis provides personalized guidance, and the virtual environment allows risk-free trial and error, jointly supporting individualized learning needs and enhancing learning initiative.
Learning Initiative and Internalization	Learning interest, learning initiative, and knowledge internalization	• VR stimulates students to shift from passive reception to active learning through fun and exploration, promoting knowledge internalization, which is the driving mechanism of the learning process.
Technological Optimization and Challenges	Technological Improvement Needs, Attention to Details	• Students expect more detailed process displays and complex interactions, reflecting the direction of technological optimization, which is a key condition for improving learning outcomes.
	Cultural authenticity	• Innovation should retain the essence of culture, which is a balancing constraint between technological application and cultural inheritance.

3.4. Selective Coding

Refining the Core Category "Technology-Driven Cultural Reproduction"

Through selective coding, the seven core categories identified in axial coding are synthesized to distill the "VR-Driven ICH Living Heritage and Learning" theoretical framework. Anchored by "living heritage" as its core attribute, this framework systematically elucidates how VR technology, through a balance of technological empowerment and cultural preservation, achieves innovative transmission and education of ICH.

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Table 5 provides detailed information on the categories and their content. Analysis reveals that technological prerequisites and cultural constraints form the foundation of the framework. The applicability of VR depends on immersive learning experiences and personalized learning support, but technical limitations necessitate optimization to ensure experiential integrity. Simultaneously, cultural constraints require that technological innovations preserve ICH's authenticity, avoiding cultural distortion caused by excessive virtualization.

In the dynamic learning process, contextualized knowledge construction and interactive learning mechanisms collaboratively drive students' embodied learning of ICH skills, enhancing the vitality of cultural heritage. Learning motivation, activated through interest-driven exploration and emotional connections to cultural identity, transforms students from passive recipients into active participants in cultural transmission.

Ultimately, the framework (Figure 3), through technology-enabled "living experiences" and culturally innovative "living dissemination," the paradigm shift in ICH education moves from static preservation to dynamic transmission. The theoretical contributions are twofold: first, it introduces the concept of "living heritage," emphasizing that technological applications must balance cultural authenticity with dynamic vitality; second, it reveals the balancing mechanism between technological optimization and cultural constraints, offering a synergistic "innovation-preservation" strategy for VR educational design.

Table 5. Main categories and their descriptions.

Main category	Description and relationship
Immersive learning experience	Condition: By stimulating multiple senses (e.g., vision, hearing) and providing an immersive experience, VR offers an authentic cultural learning environment. However, technical challenges (e.g., motion sickness) need to be addressed to ensure a seamless experience.
Contextualized knowledge construction	Process: By embedding knowledge in realistic scenarios and narrative design, VR enhances the understanding of ICH by integrating artistic details and cultural values. This approach reduces cognitive load and supports dynamic knowledge construction.
Interactive learning mechanism	Process: Real-time feedback, gesture-based control, and multi-user collaboration reinforce the interactive nature of learning, allowing learners to engage in hands-on cultural activities (e.g., simulated craftsmanship), thereby improving both learning outcomes and cultural vitality.
Personalized learning support	Condition & Process: Data-driven feedback and risk-free trial environments enable personalized learning pathways, overcoming spatial constraints and offering flexible learning trajectories. This ensures the accessibility of VR education while supporting the dynamic transmission of ICH.
Learning motivation and internalization	Outcome: By stimulating curiosity and interactive engagement, VR enhances learners' internalization of knowledge through dynamic participation, strengthening their emotional connection to cultural heritage.
Cultural identity and dissemination	Outcome: Emotional engagement fosters a deeper sense of cultural identity and authenticity, while innovative strategies (e.g., gamification) enrich the dynamic transmission of ICH, achieving both cultural preservation and educational impact.
Technological optimization and cultural balance	Condition & Feedback Loop: Technological advancements (e.g., detailed rendering) enhance the usability of VR, while cultural authenticity constraints guide technological innovation, ensuring a balance between digital representation and cultural integrity to preserve the authenticity and vitality of ICH.

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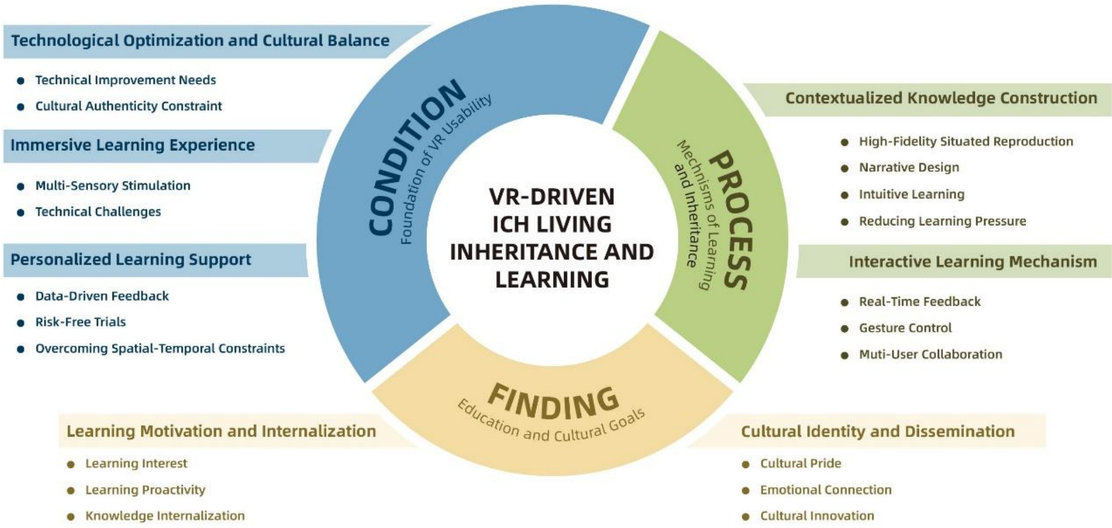

Figure 3. Theoretical framework of VR-driven ICH living heritage and learning.

3.5. Theoretical Saturation Testing

To ensure the rigor of theoretical construction, this study employs systematic steps to verify theoretical saturation. During open coding, the first 12 interview transcripts were analyzed, yielding 23 initial concepts; the subsequent three interviews only provided illustrative examples without generating new concepts, indicating data saturation. In axial coding, seven core categories were derived from 14 interview datasets, with stable content and logical relationships, no new categories or structural contradictions emerging, achieving coding saturation. Using purposive sampling, the study included diverse role-based samples and actively sought counterexamples, all explainable by existing categories without compromising theoretical integrity. Through continuous comparison, scholarly reviews to address logical gaps, and ensuring framework coherence, the study meets the standards for explanatory saturation.

4. DISCUSSION AND MODEL INTERPRETATION

Through grounded theory analysis, combined with social constructivism, this study constructs a theoretical framework centered on "VR-Driven ICH Living Heritage and Learning," addressing the three research questions to analyze and summarize the model's intrinsic implications.

How does VR, through dynamic modeling, enhance the accessibility of ICH skills? Analysis shows that VR, via the interactive learning mechanism of dynamic modeling, significantly enhances the accessibility of ICH skills. Participants noted that VR's real-time feedback and gesture control enable learners to actively engage in virtual ICH practices, such as simulating traditional crafts in VR with immediate system prompts (VR-1). Dynamic modeling, characterized by high-precision simulation (e.g., VR accurately recreates craft details, VR-1), allows learners to manipulate virtual objects, such as students interacting with virtual items via gestures (VR-2). VR enables learners to transcend physical and temporal constraints to experience ICH skills, aligning with expert views like VR breaks spatiotemporal limits (CS-1). However, technical barriers, such as dizziness after prolonged use (P1), indicate that sustained accessibility depends on optimizing user experience. This challenge, evident in multiple cases during technological development, requires future research to focus on balancing virtual and real-world sensory experiences.

How can virtual scenarios preserve the "authenticity" and "living heritage" of ICH? In virtual scenarios, the "authenticity" and "living heritage" of ICH are preserved through "contextualized knowledge construction" and "cultural identity and dissemination." Authenticity is maintained through high-precision contextual reconstruction and narrative design, such as "VR authentically replicates traditional craft details" (VR-1), consistent with social

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constructivism's emphasis on cultural context, ensuring learners encounter ICH's true essence (e.g., "narrative design reveals cultural connotations," VR-1). Living heritage is manifested through interactive participation and dissemination potential, such as "virtual cultural fairs enhance learning engagement" (VR-2) and "presenting products to virtual investors" (ES-1). Participants' emotional connections, like "feeling proud to learn Jiangxi is the hometown of calligraphy brushes" (P5), further sustain living heritage. However, the "technological optimization and cultural balance" category highlights constraints, such as "innovation must not deviate from ICH's essence" (ICH-1), underscoring the need for careful calibration of technological applications to preserve authenticity.

How does VR education facilitate the development of cultural identity and skill internalization in ICH learning? VR education, through "learning motivation and internalization" and "cultural identity and dissemination," fosters cultural identity and skill internalization in ICH learning. Cultural identity stems from immersive experiences eliciting emotional resonance, such as "feeling proud that Jiangxi is the hometown of calligraphy brushes" (P5), and a shift in learning attitude from "I have to learn" to "I want to learn" (VR-1), explained by social constructivism as learners co-constructing identity through interactions with cultural contexts in VR. Skill internalization is achieved through repeated practice and feedback in virtual environments, such as "deepening knowledge internalization through craft processes" (ZJ-1). For instance, learners simulate calligraphy brush-making in VR, enhancing skill mastery through "risk-free trials" (ZJ-1).

However, discussions with expert CS-1 revealed that achieving deeper skill internalization in VR requires extensive interactivity and training, integrated with AI technologies and the collection of extensive motion data stored in databases. Thus, future explorations of VR in education must strengthen interdisciplinary collaboration with AI and big data to maximize its potential.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This study, through the "VR-Driven ICH Living Heritage and Learning" model, elucidates VR's role in ICH education, effectively addressing the three research questions. The findings confirm VR's significant impact on CICH education, manifested in the following aspects:

5.1.1. Enhanced Accessibility

VR's dynamic modeling, coupled with real-time feedback and gesture interactions, enables learners to engage in virtual ICH practices, overcoming physical and temporal constraints and greatly improving skill accessibility. However, technical issues like motion sickness require resolution to ensure sustained accessibility.

5.1.2. Preserving Authenticity and Living Heritage

VR leverages contextualized knowledge construction and cultural dissemination, using high-precision modeling to maintain ICH's authenticity and interactive innovation to sustain its living heritage, creating a dynamic cultural presence. Yet, technological innovation must operate within a framework of cultural authenticity to prevent over-virtualization from compromising its essence.

5.1.3. Fostering Cultural Identity and Skill Internalization

VR education, through immersive and interactive experiences, cultivates cultural identity via emotional resonance, transforming learners' connection to ICH, and facilitates skill internalization through practice and feedback, embedding CICH knowledge into personal capabilities. This underscores VR's transformative role in ICH education.

These findings affirm VR's potential as a transformative educational tool, offering valuable insights for optimizing its application in ICH learning and transmission.

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5.2. Future Research Recommendations

Based on the interpretation and analysis of the "VR-Driven ICH Living Heritage and Learning" model, the following recommendations are proposed for future optimization:

5.2.1. Theoretical and Technological Deepening: Developing an Education Technology-Driven Model.

Future research should integrate social constructivism (Vygotsky & Cole, 1978) and the Technology Acceptance Model (Davis, 1989) to construct a "technology-teaching" interaction model, exploring how VR enhances skill accessibility (RQ1) and skill internalization (RQ3). By analyzing the acceptance of dynamic modeling (e.g., "real-time feedback from VR craft simulations," VR-1) and the motivational effects of immersive experiences (e.g., "pride in learning Jiangxi is the hometown of calligraphy brushes," P5), the study can deepen understanding of educational technology's role in facilitating ICH learning. The current scope for systematic research on technology acceptance offers opportunities for theoretical innovation.

5.2.2. Educational Technology Design and Integration: Developing Immersive Teaching Tools

Educational design should leverage VR's immersiveness and adaptability to develop intelligent teaching tools. For RQ1, integrate real-time feedback and multimodal interactions (e.g., haptic simulation of tea ceremonies) to enhance skill accessibility. For RQ2, create high-precision scenarios, such as virtual workshops, and incorporate AI-driven narratives (e.g., generating ICH stories) to maintain authenticity and living heritage. For RQ3, design personalized exercises, such as unlocking pottery-making steps, to foster cultural identity and skill internalization. The potential for deeper technological integration remains significant, pointing to promising directions for educational breakthroughs.

In summary, prioritizing digital education development, integrating intelligent technologies, and advancing theoretical innovation with practical optimization, future research will propel ICH education toward immersive and intelligent transformation. This will expand VR's role in enhancing skill accessibility, promoting cultural transmission, and improving learning outcomes, injecting new vitality into the sustainable development of ICH education.

5.3. Limitations

This study primarily focuses on Chinese ICH teaching for VCD students, and its findings and analyses are not generalizable to all disciplines. Additionally, the number of ICH practitioners interviewed was limited. Given the vast number of Chinese ICH items, particularly endangered ICH projects urgently requiring transmission through education, future research in this field should collect more comprehensive data and tailor VR applications to different projects to advance teaching initiatives.

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