Postprint: Exploring the Development and Application of Serious Game Projects in Digital Intangible Cultural Heritage Transmission

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Abstract

[Purpose/Significance] This study aims to investigate effective methods for the digital transmission of intangible cultural heritage (ICH) through serious games, and to propose targeted recommendations for the development and application of serious game projects in Chinese libraries, museums, and other cultural institutions. [Method/Process] Based on the classification system of ICH into static arts, space-time arts, and dynamic arts, three serious games with distinct ICH themes—Yong's China Quest Adventure, ICURA, and Tsamiko Dance—were selected as case studies. The development processes of these cases were comparatively analyzed in detail according to the research and development framework for cultural heritage-themed serious game projects, alongside an analysis of their applications in ICH dissemination and inheritance. [Results/Conclusion] The case analysis generates considerations regarding the research, development, and application of ICH-themed serious game projects. Recommendations are proposed from five dimensions—resources, technology, personnel, platforms, and theory—for Chinese libraries, museums, and other cultural institutions to develop and apply serious game projects related to ICH education and dissemination, thereby offering new insights for the digital inheritance of intangible cultural heritage in China.

Full Text

Preamble

Title: Exploring the Development and Application of Serious Game Projects in Digital Intangible Cultural Heritage Transmission

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Abstract:
[**Purpose/Significance**] This study aims to explore effective approaches for transmitting digital intangible cultural heritage (ICH) through serious games, and to provide targeted recommendations for the development and application of serious game projects in Chinese cultural institutions such as libraries and museums. [**Method/Process**] Based on the ICH classification system of static art, spatial-temporal art, and dynamic art, three serious games with different ICH themes were selected as case studies: *Yong's China Quest Adventure*, *ICURA*, and *Tsamiko Dance*. Using the cultural heritage-themed serious game development framework, the development processes of these cases were compared in detail, and their applications in ICH dissemination and transmission were analyzed. [**Result/Conclusion**] The analysis prompted reflections on the development and application of ICH-themed serious game projects. The study proposes recommendations from five perspectives—resources, technology, personnel, platform, and theory—for Chinese libraries, museums, and other cultural institutions to develop and apply serious game projects related to ICH education and dissemination, offering new insights for digital ICH transmission work in China.

Keywords: serious game; digital intangible cultural heritage; library; museum; case study
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Since UNESCO formally defined the scope of intangible cultural heritage and adopted the *Convention for the Safeguarding of Intangible Cultural Heritage* in 2003, cultural and research institutions worldwide have conducted research and protection efforts on ICH from various perspectives. Currently, two- and three-dimensional digital storage and display through information technology represent one of the mainstream protection methods employed by libraries, museums, and other cultural institutions. However, UNESCO emphasizes that for ICH, the importance lies not in its cultural expressions themselves, but in the rich knowledge and skills transmitted from generation to generation. Domestic digitalization of ICH has primarily focused on digital collection of materials, reconstruction of physical objects and sites, motion capture, and subsequent public dissemination through digital means such as virtual museum tours and immersive experiences. Insufficient attention has been paid to how ICH can be truly transmitted rather than becoming "fossils" preserved and displayed in libraries and museums. As Zhou Ya et al. have noted, research on ICH digitalization in China suffers from a problem of "emphasizing construction over utilization, and preservation over dissemination."

Foreign cultural institutions, research organizations, media, and technology companies have earlier considered introducing mature serious games from education and training fields into ICH transmission. Because game engines can integrate immersive technologies (such as virtual reality, augmented reality, and mixed reality), human-computer interaction, and 3D modeling, combined with relevant

learning theories and pedagogical approaches, they provide a viable solution for cultural institutions to reproduce and transmit the living nature of ICH.

This study investigates international practices of serious games in ICH, reflects on the development process and application of ICH-themed serious game projects, and proposes recommendations for libraries, museums, ICH protection centers, and related institutions in China to develop and apply ICH-themed serious games, aiming to provide new ideas for digital education and dissemination of Chinese ICH culture.

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2 Research Status

2.1 Research Status of Serious Games

The term "serious game" first appeared in a book of the same title by C.C. Abt in 1970. Abt argued that the primary purpose of serious games is not entertainment, but clearly defined and carefully considered educational objectives. In 2002, the modern "serious games" wave began through the vigorous promotion by scholars like B. Sawyer and the launch of the "Serious Games Initiative" by the Woodrow Wilson International Center for Scholars, as well as the popularity of *America's Army*, a game designed for the military. One of its developers, M. Zyda, formally redefined "serious games" in 2005, a definition essentially similar to Abt's, with the only distinction being Zyda's emphasis on electronic games, which aligns better with modern work and lifestyles, particularly for "digital natives."

Serious games are widely used in education, business, medical, government, political, religious, and military fields due to their advantages in collaborative exchange mechanisms, trial-and-error with immediate feedback, visual information expression, interactivity, and entertainment, which transform users from passive recipients to active creators of knowledge. However, the dialectical relationship between seriousness and entertainment remains a key challenge. Scholars like Abt maintain that education should be the primary purpose, while Zyda argues that fun is most important, stating that serious games without interest are useless. In reality, serious games aim to leverage the "fun" characteristic of games to facilitate learning, enabling users to efficiently master "serious" domain knowledge. Seriousness and entertainment are complementary: excessive didacticism affects learning interest and motivation, while excessive entertainment hinders knowledge acquisition. Therefore, collaboration between game developers and domain experts is necessary to utilize advanced information technology for better implementation of learning theories in games, while selecting appropriate learning theories to enhance knowledge dissemination. Balancing seriousness and entertainment distinguishes serious games from other games.

2.2 Research and Application Status of Serious Games in ICH

2.2.1 International Status International applications of serious games for cultural heritage transmission are relatively abundant, though most systematic surveys do not specifically distinguish between types of cultural heritage. Research on ICH-themed serious games has evolved from three-dimensional virtual computer games such as *Remembering 7th Street* (which collects literature, images, and interview materials to reconstruct the prosperous and diverse Seventh Street community culture in West Oakland after World War II) and *ICURA* (which teaches Japanese language and cultural customs), to recent developments like using motion-sensing serious games to effectively experience ICH, such as *Tsamiko Dance*, *Pottery*, *Human Beatbox*, and *Canto a Tenore*.

International practical application development started earlier, employing diverse technical methods with multi-institutional participation and close collaboration. For example, the New Mexico Museum of Art used Kinect to allow visitors to experience Baumann marionette art; the Vatican Museum, Amsterdam Allard Pierson Museum, and the Dutch National Museum of Antiquities collaborated on the Etruscanning project, which uses somatosensory devices and 3D worlds to experience Etruscan funeral rituals and beliefs; and technology companies like TOTEM developed the mobile application *Tidy City* using GPS positioning and mixed reality technology to familiarize tourists with local language, customs, and arts. The i-Treasure project, funded by the EU Seventh Framework Programme (FP7) and led by the Greek CERTH research institution with cooperation from multiple national universities, is currently the most valuable reference for performing arts ICH education using digital means and ICH digital resources. The project aims to fully utilize ICH digital resources, providing a comprehensive platform for gamified learning of ICH culture and scientific research, from multi-sensor information collection and semantic association to analysis.

2.2.2 Domestic Status In China, many studies have introduced game concepts into ICH protection and dissemination research. Zhang Yu et al. explored how games can facilitate interesting dissemination and deep digestion of ICH knowledge through the *2048 Peony Pavilion* mini-game from three aspects: entertainment, participation, and interactivity. Wang Hongkun discussed the similarity between digital game rules and human cultural rules, and demonstrated that digital games are more conducive to ICH transmission than other media due to their educational, interactive, and social attributes. Chen Junxi and Zhu Yaoying attempted to design educational apps for Guangling paper-cutting and Yangliuqing New Year paintings, introducing simple mini-games to attract users and promote ICH knowledge absorption. In recent years, with advances in motion-sensing devices, smart wearables, and virtual reality technology, domestic application research has focused on developing motion-interaction games for action-based ICH, such as Huayao Yi dance, Confucius ceremony music and dance, Peking Opera, and shadow puppetry. Experimental evaluations of these

games, which focus on user interaction experience design, show that motion-sensing games can effectively stimulate user interest and greatly assist ICH dissemination, but lack systematic design for effective knowledge transmission.

In practical applications, the Palace Museum in Beijing leads China in using games for traditional culture dissemination, providing valuable references for major cultural institutions. The Palace Museum has launched various mobile apps and web games for different age groups to disseminate ancient Chinese culture, and recently collaborated with Tencent to launch the eye-tracking interactive game "Qing Meng: Zi Yue Shi Yun," allowing participants to experience the ancient custom of writing poetry on sky lanterns. The Erhu Cultural Creative Park in Wuxi produced "Learn Erhu with Masters," which uses Kinect and Leap Motion to allow visitors to quickly experience erhu performance while assisting with teaching and training within the park.

Although experts have recognized that entertainment alone is insufficient for transmitting ICH culture, the term "serious games," which centers on balancing playfulness and educational value, rarely appears in domestic research and practice. As Ma Xiaona et al. noted, the value of serious games in the ICH field has not been fully explored. Currently, only Yu Xiaoxiang explicitly designed two games for Dai ICH culture based on serious game concepts using 3D game engines and Kinect motion-sensing devices. In practical applications, mobile apps and PC web games are commonly used for cultural dissemination, but the knowledge transmitted is relatively superficial, lacking in professional knowledge and skill instruction, and emerging human-computer interaction technologies and devices await better development and utilization.

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3 Research Methods and Case Selection

3.1 Research Method

This study employs multi-case analysis to explore the development and application of ICH-themed serious game projects, summarizing and comparing case characteristics and similarities/differences to propose reflections and recommendations.

Regarding framework selection, most influential general serious game design frameworks (such as the ATMSG model based on activity theory, the 4DF model, the LM-GM model, and the experiential gaming model) focus on achieving the integration and balance of educational and game theories. As K. Kiili points out, these models merely bridge education and games rather than constituting comprehensive project design frameworks. Moreover, the cultural heritage domain involves more complex aspects than common serious game fields (such as education, medical training, and military), including content resource acquisition and inter-institutional collaboration. Therefore, focusing solely on internal game design mechanisms is inappropriate. R. Andreoli et al. proposed

the FRACH model specifically for designing, developing, and evaluating cultural heritage-themed serious games, referencing game development processes across four stages: preliminary preparation, concept, development, and evaluation. This study will use this model, combined with relevant research materials and actual experience of selected cases, to analyze case development according to the framework shown in Figure 1 [Figure 1: see original paper].

3.2 Case Selection

This study identified cases by reviewing all examples in influential survey papers on cultural heritage-themed serious games in recent years, and searching the Web of Science database with keywords "intangible cultural heritage" and "serious game" to filter representative research subjects. Case selection criteria included: (1) implementation level (whether actually applied, complete game demo available, evaluated by experimenters); (2) research scale (size of development team, level of funding support); and (3) influence (number of research outputs, frequency of citation and commentary by peers).

Selected cases were chosen to be representative across different ICH types. Regarding ICH classification, various organizations and scholars have proposed multiple taxonomies from different perspectives, from UNESCO's five types in the *Convention for the Safeguarding of Intangible Cultural Heritage*, China's six categories in the *ICH Law*, to domestic scholars' "four-type," "seven-type," and "thirteen-type" methods. Ma Xiaona et al.'s three-part taxonomy (static art, dynamic art, and spatial-temporal art) from the perspective of digital preservation and display offers valuable insights for this study.

This paper ultimately selected three serious game cases covering static, dynamic, and spatial-temporal ICH categories, providing targeted references for Chinese cultural institutions and researchers developing different ICH-themed serious game projects.

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4 Case Analysis of ICH-themed Serious Games

4.1 Overview of ICH-themed Serious Game Cases

4.1.1 Yong's China Quest Adventure *Yong's China Quest Adventure* is a Flash mini-game for learning Chinese history and culture, developed in 2008 by Lotherton Hall under the Leeds Museums and Galleries institution. Funded by Arts Council England and released on the MyLearning platform managed by Leeds Museums and Galleries, the game has evolved to launch three series of Chinese culture mini-games. The Level 1 game is set in the Spring and Autumn period, covering Chinese calligraphy, seal carving, and mythology (see Figure 2 [Figure 2: see original paper]), where players complete tasks by collecting items and learning related knowledge.

4.1.2 ICURA *ICURA* is a tourism e-commerce application designed and released in 2010 by the E-Commerce Team at Vienna University of Technology—an adventure game with Japanese culture as a side theme within the Itchy Feet application. Using a 3D virtual world with Japanese-culture-appropriate background music, it creates an immersive and realistic virtual environment from a first-person perspective. Players complete various tasks by collecting, reading, and using materials and items, allowing them to explore and learn Japanese language, customs, and culture with interest and productivity.

The development team's evaluation of learning effectiveness showed that well-designed serious games can effectively disseminate customs and cultural knowledge both cognitively and emotionally. M. Mortara et al. later expanded the evaluation scope and content, not only verifying the development team's results but also confirming that higher-level knowledge presented through game tasks is more absorbable than text-based presentations through NPCs, and that gaming approaches can significantly enhance user interest (such as spontaneously searching for Japanese cultural information and recommending the game to friends).

4.1.3 Tsamiko Dance *Tsamiko Dance* is a VR game in the i-Treasure project where users learn Greek folk dance from an expert in Thessaloniki. Users observe and learn from step-by-step instructional videos, starting from basic single-step movements to more complex two-step patterns by imitating the expert's movements. Each completed task unlocks new dance knowledge, culminating in a challenge to perform a complete dance sequence using learned steps.

The i-Treasure team evaluated both ICH-knowledgeable participants and beginners in their VR motion-sensing serious game, with post-game questionnaire results showing the approach is highly effective for beginners learning ICH knowledge and skills. For experienced learners, designs should focus more on deep integration of learning theories with gameplay.

4.2 Development Analysis of ICH-themed Serious Game Cases

Based on the analytical framework in Figure 1, this study analyzes the three cases by extracting key features (see Tables 1 –3), summarizing critical development processes for ICH-themed serious games, and comparing differences and similarities across various ICH types in target determination during preliminary stages, digital resource collection and integration, personnel collaboration, learning theory application and game type selection during conceptual stages, human-computer interaction technology during development stages, and effect feedback and platform optimization during evaluation stages.

4.2.1 Preliminary Stage The preliminary stage is the most time-consuming and labor-intensive phase of ICH-themed serious game development, forming the foundation for project realization. Its primary task is clarifying objectives,

including ICH type, content, target audience, and usage scenarios, which influence game carrier selection, pedagogical approaches, implementation platforms, and technologies, ultimately affecting effectiveness. All three cases effectively matched target audiences with content difficulty levels. However, *Yong's China Quest Adventure* and *ICURA*, possibly due to earlier development, did not consider selecting more convenient and efficient platform carriers like mobile phones and tablets for their usage scenarios.

ICH digital resource acquisition and integration is paramount, determining the richness of serious game content and even whether the associated ICH culture can be accurately transmitted. Comparing the three cases, digital resources for *Yong's China Quest Adventure* and *Tsamiko Dance* were provided by cultural institution collections or professionally collected on-site from ICH practitioners. The *Tsamiko Dance* project not only conducted digital collection but also performed semantic integration of collected data resources to provide evaluation references for participant performance in the game. *ICURA* used public resources, and while it effectively achieved its goal of allowing participants to experience basic Japanese cultural customs and learn daily expressions, developers noted through evaluation that incorporating professional audio materials could enhance language learning effectiveness.

Multi-team collaboration is a characteristic of serious game development. *Yong's China Quest Adventure*, as part of the China in Yorkshire project, involved multiple museums in Yorkshire providing digital resources, with Lotherton Hall Museum collaborating with learning teams on development. *Tsamiko Dance* belongs to the i-Treasure project, whose design and development teams comprised researchers from multiple European countries' scientific research, cultural institutions, and laboratories, with expertise ranging from computer science and information technology to educational technology, including ICH practitioners in data collection. *ICURA*'s development team had relatively homogeneous academic and professional backgrounds, and post-evaluation revealed that lacking cultural institutions and educational scholars resulted in shortcomings in resource acquisition and pedagogical design, affecting learning effectiveness.

4.2.2 Conceptual Stage Appropriate application of learning theories marks the boundary between serious games and ordinary games. From behaviorist learning theory centered on reinforcing correct behavior through repetitive practice, to constructivist learning theory emphasizing active student exploration and knowledge construction, various theories have been applied in educational games. With electronic game technology development, supported learning theories have become increasingly rich and complex, better aligning with effective human cognition. All three cases employed clear learning theory support, all belonging to constructivist schools but with different emphases. *Yong's China Quest Adventure*, focusing on teaching Chinese calligraphy and writing, adopted problem-based learning theory, enabling participants to actively explore tasks and puzzles for more effective cultural learning than passive methods. *ICURA*,

targeting folk culture learning, emphasized context importance since dialogue and behavior meanings vary significantly across situations, making situated learning theory more suitable. *Tsamiko Dance* focused on learning through observing and imitating expert behavior, continuously adjusting and building personal dance understanding and cognition, making experiential learning theory more instructive.

Rational game type selection facilitates effective ICH transmission. The cases show that dynamic ICH arts like *Tsamiko Dance* are more suitable for simulation games using motion-sensing devices, enabling authentic "master-apprentice" transmission through realistic imitation. Static knowledge games like *Yong's China Quest Adventure* and *ICURA* better suit adventure-puzzle games that allow participants to apply ICH knowledge in practice for better absorption.

Game task design requires logical coherence and must include motivational measures. All three cases feature reasonable difficulty gradients and clear learning objectives, with tasks progressing from simple to complex, accumulating knowledge and skills for final challenges. Each task segment has distinct learning objectives—for example, *Yong's China Quest Adventure* teaches ancient Chinese letter styles through tasks requiring finding and stamping invitations, while *ICURA* teaches temple customs through tasks requiring finding and wearing geta sandals. However, all three cases lack motivational design. Research shows various motivational measures can regulate participants' intrinsic interest and extrinsic motivation, affecting learning effectiveness, yet these cases primarily rely on task completion and scoring for achievement. Development teams recognized this issue, proposing ideas like *ICURA*'s participant interaction to maintain interest and *Tsamiko Dance*'s dance competition segments to enhance motivation and learning effectiveness for experienced participants.

4.2.3 Development Stage Fidelity—the degree to which serious games simulate the real world—is a key characteristic. Higher fidelity better enables participants to learn and solve domain-specific problems. Human-computer interaction design can enhance physical scenario and functional fidelity through interface and interaction methods. *Yong's China Quest Adventure* and *ICURA* use traditional mouse-and-keyboard interaction, which cannot achieve "real" human-environment interaction at the functional level. However, *ICURA* employs a 3D user interface simulating Japanese-style 3D worlds with Japanese music, allowing participants to experience authentic Japanese customs without leaving home, while *Yong's China Quest Adventure*'s 2D interface only provides vague concepts of ancient Chinese scenes, significantly affecting learning accuracy. *Tsamiko Dance* advances this by using motion-sensing devices to create real-world learning experiences, making participants feel as if they are in actual dance studios and performance stages, learning folk dance through the most natural interaction methods, which demonstrably benefits learning effectiveness and participant motivation.

4.2.4 Evaluation Stage Although *Yong's China Quest Adventure* lacks explicit evaluation data for analysis, *ICURA* and *Tsamiko Dance* feature typical and consistent evaluation methods and content, compensating for the data gap. Both games used questionnaire surveys supplemented by open-ended questions and discussions to evaluate usability, interest, user experience, and emotions, along with various tests (e.g., *ICURA*'s quizzes, *Tsamiko Dance*'s movement accuracy tests) to assess ICH knowledge and skill learning outcomes. Different question and test designs help cultural institutions and researchers explore the effectiveness and extent of ICH transmission through serious games. For *ICURA*, the design team used identical pre- and post-game tests to demonstrate effective Japanese cultural customs dissemination, while M. Mortara et al. used different test content to prove that *ICURA* transmits not only superficial knowledge but enables genuine understanding of Japanese cultural customs.

Moreover, serious game evaluation should provide optimization proposals. By analyzing participant questionnaires and interviews, both games identified shortcomings such as inconvenient and unclear interactions (e.g., lack of clear operation guidance, confusion from multi-window perspectives) and pedagogically ineffective design elements (e.g., overly simple tasks, inappropriate teaching methods), proposing corresponding revision plans. Participant feedback also inspired optimizations, such as *ICURA* enhancing 3D world realism through real-world scenario simulation and *Tsamiko Dance* designing multiplayer competition segments to improve learning effectiveness.

4.3 Application Analysis of ICH-themed Serious Game Cases

The three selected cases play different roles in disseminating and transmitting ICH culture. *Yong's China Quest Adventure* was designed by Lotherton Hall as part of the China in Yorkshire project for online Chinese culture dissemination, complementing school-organized student visits to China in Yorkshire exhibitions to generate interest and improve visit effectiveness. The game appears not only on the MyLearning education platform created by Yorkshire cultural institutions using their digital collections for local teachers and students, but also on middle school teaching resource websites like Sister Middle School, St. Jerome School, and Tucson Unified to expand influence among students.

ICURA is used to disseminate and preliminarily teach foreign intangible cultural customs to tourists, enabling them to appropriately handle local daily conversations and customs. Both *Yong's China Quest Adventure* and *ICURA* are typical of most current ICH games, providing cultural experiences for the general public to supplement museum visits or physical tourism, offering some dissemination effect but lacking depth for users to explore.

In contrast, *Tsamiko Dance* not only disseminates ICH culture but truly transmits ICH knowledge and skills. Its application provides not only general ICH skill experiences for the public but also professional teaching for potential ICH practitioners. The i-Treasure platform also provides modular serious game de-

sign functionality for ICH practitioners to create teaching games for their specific skills, and offers research data for ICH researchers. Furthermore, serious game data in i-Treasure has potential research value for exploring ICH transmission methods and processes.

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5 Reflections and Recommendations

Through detailed analysis of three different ICH-themed serious game cases and considering domestic cultural institutions' utilization of ICH resources and transmission practices, this study proposes targeted recommendations from five perspectives—resource integration and utilization, platform and technology selection, development and evaluation, personnel collaboration, platform construction, and theoretical innovation.

5.1 Promoting ICH Digital Resource Integration and Utilization

Multi-level and multi-dimensional integration of ICH digital resources helps provide rich, usable, and professional digital assets for ICH-themed serious games. Beyond resources from cultural institution databases, substantial ICH resources are scattered across libraries, museums, archives, and among the public, requiring strengthened inter-institutional cooperation and sharing mechanisms and active mobilization of civil forces to enrich ICH digital content. ICH digital resources feature multimodal and heterogeneous characteristics, making it difficult for researchers to explore their value deeply. Using semantic technologies to integrate ICH digital resources and bridge semantic gaps enables more professional and precise transmission of ICH knowledge and skills. For example, the Shanghai Library's "Shanghai Memory" digital resource integration project uses ontology and linked data technologies to semantically annotate, connect, and open up electronic resources including newspapers, videos, images, and texts about old Shanghai, organizing national competitions to explore practical utilization value.

As ICH digital resource collection becomes more diversified, extending from traditional images, audio, video, and text to 3D models, movements, gestures, and expressions, data fusion and semantic analysis technologies must develop accordingly. In motion-sensing serious games for dance, for instance, games can assess participant proficiency through dance movements and, through fusion and semantic analysis of movement and musical rhythm data, evaluate learning outcomes more professionally.

5.2 Strengthening Platform and Technology Selection, Development, and Evaluation for ICH Serious Games

ICH serious game platforms should be selected based on usage scenarios and ICH types. Static and spatial-temporal ICH serious games are better suited for

computer and mobile platforms. Mobile devices like phones and tablets offer advantages of unrestricted time and location and rich interaction methods, enabling broader and more effective ICH dissemination. Computer platforms typically appear on cultural institution websites or on-site electronic touchscreens, effectively attracting participants. Dynamic ICH games commonly use motion-sensing platforms as carriers, more effectively transmitting relevant skills.

Serious games require higher simulation of real environments and operations than ordinary games, necessitating full development of advanced human-computer interaction technologies. Specifically, the fidelity of learning scenario creation and learning process interaction design are two major factors affecting serious game effectiveness. The most common approach is building 3D virtual scenes as game interfaces at the physical level to create authentic learning contexts. However, to improve ICH transmission effectiveness, ordinary virtual worlds are insufficient—precise simulation of ICH presentation venues or environments is needed for accurate participant cognition. At the functional level, advancing from traditional to natural interaction methods enables participants to experience authentic learning. Natural user interaction through voice, gesture, touch, and vision simulates natural human-environment interaction, well supporting experiential learning. While natural interaction technology has been applied in dynamic ICH serious games (traditional sports, handicrafts, drama), its application in static and spatial-temporal ICH games remains underexplored, representing a worthwhile future direction.

When pursuing high-quality ICH digital presentation and authentic cultural experiences, serious game technology and equipment investment should be evaluated, balancing development costs, quality, and final effects. Cultural institutions should select technologies and equipment based on their conditions and service targets, while considering the 普及 of increasingly sophisticated smart mobile devices (phones, tablets), home gaming consoles (Switch), and VR headsets among digital natives to develop serious games enabling anytime, anywhere ICH learning.

5.3 Promoting and Expanding Close Collaboration Among ICH Protection and Transmission Personnel

Cultural institutions, ICH practitioners, educational scholars, and technology developers should maintain close and effective cooperation. Currently, most ICH games and digital displays designed by Chinese museums and libraries primarily aim to stimulate interest and supplement visits, with content determined by institutional leaders and development handled entirely by in-house technical departments or outsourced companies. In contrast, ICH serious game development is a long-term process requiring multi-party participation. Cultural institutions and ICH practitioners mainly provide digital resources and directional guidance on game plot design in collaboration with educational scholars; educational scholars must apply learning theories and pedagogical methods based on game objectives and audiences to discuss task design with technology develop-

ers; and technology developers are responsible for aggregating and implementing all resources and ideas, working with cultural institutions, practitioners, and scholars on optimization during evaluation. However, D. Hickmott et al. note that communication barriers likely arise in serious game development teams because educational scholars are unfamiliar with technology development while developers lack pedagogical background. Therefore, establishing good team collaboration models is necessary to avoid cooperation reduction or termination due to poor communication.

Simultaneously, civil ICH enthusiasts should be actively engaged to expand the scope of ICH digital protection and transmission participants. In developing some dynamic ICH serious games, scarce ICH practitioners provide insufficient data; involvement of relatively professional personnel from enthusiast communities can effectively supplement data and improve game quality. Civil ICH groups also include members with technical and educational backgrounds who can independently design serious games for their concerned ICH cultures and release them on Apple and Android markets—excellent apps like *Mortise and Tenon* and *Folding Fan* were created by the tagDesign team, enthusiasts of traditional crafts. Leveraging civil ICH enthusiasts can significantly enhance dissemination and promotion of ICH-themed serious games, allowing high-quality projects to gain more attention while low-quality projects are quickly eliminated, improving overall quality of ICH serious games accessible to the public.

5.4 Building ICH-themed Serious Game Platforms

Currently, most ICH-themed games are independent applications serving only dissemination purposes without 挖掘 value, while domestic research institutions lack consideration and practice in building comprehensive entertainment-education-research platforms. First, overall objectives of ICH-themed serious game projects should be clarified, investigating game audiences and determining ICH content for transmission. Different cultural institutions serve different populations—from children and teenagers to adults—each with different knowledge bases, learning abilities, and interests, requiring determination of appropriate content depth for different audiences. Serious game design and corresponding research platform construction based on clear objectives can meet research goals of promoting ICH transmission.

Second, the research value of serious game evaluation data should be emphasized to build research platforms for studying digital ICH transmission through serious games. Evaluation methods generally use questionnaires, with comprehensive content assessing both game design aspects (interaction operations, usability, user satisfaction, engagement, user experience, pedagogical task design) and learning effectiveness (cognitive and emotional experience, knowledge acquisition). Systematic evaluation helps researchers explore transmission effectiveness of different ICH types in serious games. Additionally, user data generated during gameplay can support multi-dimensional research on digital ICH transmission, such as comparing user data with expert demonstration data in dynamic ICH

games to explore characteristics and more effective transmission methods, or comparing user geographic data to explore regional transmission effectiveness.

Finally, serious game project optimization should be emphasized to promote sustainable development of digital ICH transmission and research platforms. Serious game design is not accomplished in one step but should be an iterative optimization process. Using participant feedback and user data collected during operation can effectively improve undisclosed deficiencies in game design and development, providing references for developers to enhance quality. However, most ICH games provided by Chinese cultural institutions are "one-off," designed merely for public experience and interest stimulation, making optimization seem unimportant. But from transmission and research perspectives, optimizing serious games to improve ICH knowledge and skill instruction effectiveness and maintain coherence and consistency in digital transmission processes are issues requiring consideration for platform sustainability.

5.5 Emphasizing Theoretical Support and Innovation for ICH Serious Games

Currently, many Chinese studies and practices use games to disseminate ICH culture and knowledge, but lack exploration of integrating educational theories with gamification, enabling widespread dissemination but not effective transmission of ICH culture and skills. As a potentially powerful but underutilized ICH digital transmission method, serious game development requires attention to theoretical support. For example: (1) Selecting appropriate learning theories and game types for different ICH transmission contexts. Constructivist learning theories are suitable as educational foundations for serious game projects because they create "authentic" scenarios where learners actively construct knowledge using existing knowledge and experiences—aligning with serious games' goal of simulating real scenarios for learning and problem-solving. Situated learning theory, experiential learning theory, and problem-based learning theory have strong relevance for spatial, dynamic, and static ICH arts respectively. Puzzle, adventure, and simulation game types can effectively support educational theory implementation in ICH serious games. (2) ICH-themed serious games should appropriately introduce cooperation and competition mechanisms to attract potential ICH practitioners and sustain participant motivation. Research demonstrates that cooperation and competition can promote and maintain motivation and enhance game effectiveness, with combined mechanisms producing better incentives.

Meanwhile, the FRACH model is currently the only theoretical model related to cultural heritage serious games, without specific distinction between tangible and intangible cultural heritage. With technological development, educational theory advancement, lifestyle changes, and ICH characteristics, ICH-themed serious game development, application, and promotion urgently require theoretical innovation more suited to China's national conditions and ICH features to provide theoretical guidance for serious games in ICH digital transmission.

As ICH digitalization levels increase and digital resources become richer, libraries and museums should move beyond mere digital collection and preservation to fully 挖掘 existing digital resource value, enabling genuine transmission of ICH knowledge and skills. Games have been a learning method since ancient times, and serious games highlight their educational essence through modern human-computer interaction technology, allowing more public members to learn professional ICH knowledge and skills from practitioners and experts anytime, anywhere, enabling broader and more efficient ICH dissemination and transmission. However, Chinese practices using serious games for ICH dissemination remain limited, with most being entertainment-focused ordinary games. This paper comprehensively compared three international ICH serious game cases of different types from development process and application perspectives, proposing targeted reflections and recommendations from five aspects—resources, technology, personnel, platform, and theory—to inspire Chinese cultural institutions and researchers exploring ICH transmission methods using information technology and digital resources, promoting better development and application of serious game projects in the ICH field.

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Note: Figure translations are in progress. See original paper for figures.