

Exploring the Impact of Cultural Heritage Game Mechanics on User Cognition

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Abstract—Amid the accelerating forces of globalization and technological advancement, intangible cultural heritage (ICH) faces increasing challenges in both transmission and dissemination. Due to their immersive and interactive nature, digital games have emerged as a promising medium for the digital preservation of ICH. This study focuses on the core issue of how game interaction mechanisms influence users' cultural cognition. It first reviews the background and challenges of ICH digitalization, highlighting the value of digital technologies in facilitating living cultural transmission. Drawing upon Schell's elemental tetrad and Hall's encoding-decoding model, the research proposes a game design framework that integrates mechanics, narrative, aesthetics, and technology to construct a mechanism-driven path for cultural dissemination. Using the original game *Legend of the White Snake: Pearl of the Spirit* as a practice platform, the study conducts an empirical experiment to evaluate the effects of different interaction intensities on users' cultural understanding. The results indicate that high-interaction mechanisms significantly enhance users' cultural comprehension, emotional identification, and willingness to share, offering both a structured design strategy and a quantitative validation model for ICH-oriented digital games. This research further contributes to the theoretical and practical development of gamified cultural communication strategies.

Keywords—Intangible Cultural Heritage; Digital Game Design; Game Interaction; Cultural Transmission

I. INTRODUCTION

In the context of rapid globalization and technological advancement, cultural heritage—particularly intangible cultural heritage (ICH)—is facing an accelerating crisis of loss and discontinuity. As a vital carrier of national cultural identity, the preservation and transmission of ICH are essential not only for sustaining cultural diversity but also for maintaining a sense of cultural belonging and national identity[1]. Traditional modes of ICH transmission, constrained by physical space, generational gaps[2], and diminishing audiences, are proving increasingly inadequate in the digital age. Emerging digital technologies are offering new possibilities for revitalizing heritage in contemporary forms.

The core goal of this research is to explore the application of digital game design strategies and methods in cultural heritage protection, particularly how game interaction mechanisms, storytelling, aesthetic expressions, and technological implementations can enhance the transmission

of ICH. By analyzing existing digital game design frameworks and considering the particularities of cultural heritage, this research proposes a game design solution for ICH digital protection. The research will also demonstrate through specific game design practices how to reconstruct ICH in virtual environments, enabling users to learn, experience, and pass on these valuable cultural assets through entertainment.

This study addresses the critical issue of how interaction mechanisms in digital games affect users' cultural cognition. By employing a controlled experimental design and questionnaire-based evaluation, the research quantitatively analyzes how different levels of interactivity influence user performance across five key dimensions: sensory immersion, behavioral engagement, cultural understanding, emotional identification, and willingness to share. The study aims to reveal the deeper potential of digital games in optimizing interaction mechanisms and enriching cultural narrative construction within the ICH context.

II. RESEARCH BACKGROUND OF INTANGIBLE CULTURAL HERITAGE

A. Challenges in the Transmission of Intangible Cultural Heritage

Intangible Cultural Heritage (ICH) refers to non-material cultural expressions associated with the history, traditions, arts, crafts, and everyday life of ethnic or regional communities. It encompasses a wide range of elements, including language, folklore, rituals, festivals, and traditional craftsmanship[3]. Unlike tangible heritage, ICH does not exist in physical form but is instead preserved and transmitted through oral traditions and generational inheritance. As such, ICH holds not only distinctive cultural value and social meaning but also represents a crucial manifestation of global cultural diversity[4].

With the accelerating pace of modernization, many forms of traditional ICH are now at risk of disappearing. While globalization has promoted cultural exchange and diversity, it has also led to the erosion of local traditions. In particular, the rapid development of information technology and the transformation of lifestyles have posed significant threats to traditional handicrafts, vernacular practices, and indigenous languages[5]. Against this backdrop, the effective preservation and dissemination of ICH have become pressing

challenges for contemporary cultural heritage research and policy.

B. Digital Heritage Preservation

Digital technologies have opened up unprecedented possibilities for the preservation of intangible cultural heritage. Through the application of 3D scanning, virtual reality (VR), augmented reality (AR), and digital museum platforms, ICH elements can be transformed into digital forms for precise documentation, archiving, and exhibition. For instance, 3D scanning enables the high-fidelity recording of artifacts, artworks, architectural structures, and traditional crafts, allowing for the creation of detailed digital models that support long-term preservation and public display[6]. Virtual museums, on the other hand, transfer conventional exhibitions into online immersive spaces, making cultural heritage accessible to global audiences regardless of physical limitations[7].

The integration of VR and AR technologies has further advanced the digitalization of ICH. VR provides users with immersive environments in which they can not only observe heritage content but also interact with it—experiencing traditional craft-making processes or participating in virtual cultural rituals. AR enhances these experiences by overlaying virtual content onto real-world environments, enabling intuitive and interactive forms of engagement and strengthening user participation[8].

Despite these advancements, the digital preservation of ICH still faces notable technical and ethical challenges. Issues such as ensuring accuracy and authenticity in the digitalization process, balancing cultural openness with protection, managing high equipment costs, improving technology accessibility, and enhancing user experience remain critical concerns[9]. Only by addressing these issues can digital technologies be more widely adopted and effectively support the sustainable transmission of intangible cultural heritage.

III. ICH GAME DESIGN

A. Significance of Culture Heritage Game Design

Digital games offer distinct advantages in the preservation and dissemination of intangible cultural heritage (ICH). Their core value lies in their interactivity and immersive experience—qualities that align closely with the preferences of contemporary users, especially younger audiences, who favor multisensory and participatory forms of cultural engagement. Unlike traditional museums or documentaries, which often rely on one-way communication, games provide an interactive space for active exploration and deep engagement, enabling users to experience a “cultural re-enactment” within virtual environments.

Through mechanisms such as virtual tasks, role-playing, and situational simulation, digital games can reconstruct complex heritage processes—such as craft-making techniques, festival rituals, or historical narratives—in ways that are both visual and operational. For example, simulating traditional techniques like tie-dyeing or herbal formulation allows users to engage directly with intangible cultural practices, enhancing their visibility while subtly conveying underlying cultural value systems through interaction.

More importantly, well-designed game mechanics can guide users through a progressive path from task completion to cultural understanding, and ultimately toward voluntary dissemination. This facilitates not only the internalization of cultural meaning but also its diffusion across social networks. Therefore, deep engagement at the level of game mechanics is not merely a strategy for enhancing playability—it serves as a critical driver for fostering cultural identification and sustaining collective cultural memory.

B. Current Status of ICH Digital Games

In recent years, an increasing number of digital games have attempted to incorporate elements of intangible cultural heritage into their content. For example, casual games such as *Folding Fan* and *Mortise and Tenon* present traditional craftsmanship through image-based puzzles or interactive animations. However, these projects often suffer from a lack of interaction depth and limited cognitive transformation. Most remain at the level of decorative cultural symbolism, failing to integrate cultural knowledge, practical skills, and user experience in a meaningful and immersive way[10].

At the same time, certain applications of virtual reality (VR) have made notable progress in heritage visualization. Projects such as the virtual reconstruction of Notre-Dame Cathedral before and after the fire have provided users with visually powerful and emotionally resonant experiences[11]. Nonetheless, due to barriers such as high equipment costs, operational complexity, and limited content updates, such VR applications are still far from enabling “everyday participatory dissemination” of ICH.

These observations suggest that while ICH digitalization projects are advancing in visual fidelity and aesthetic presentation, they still lag in the construction of interactive mechanics, narrative depth, and user-centered cognitive engagement. The critical challenge for future ICH game design lies in developing structured game mechanisms that effectively drive user participation and construct meaningful pathways for cultural understanding—thus achieving deeper experiential engagement and more effective cultural transmission.

C. Intergration of Game Design Principles with ICH Digitalization

At its core, game design is a process of creative cultural translation. In the context of intangible cultural heritage (ICH), this translation must go beyond visual or auditory representation to incorporate deeper cultural values into the game's interactive mechanics and narrative structure[12]. Based on Schell's elemental tetrad—Mechanics, Story, Aesthetics, and Technology—ICH digitalization requires a multi-dimensional approach: mechanisms are used to represent the performative and procedural nature of cultural practices; narrative structures serve to convey cultural meaning and historical context; aesthetic symbols reframe traditional visual and stylistic elements; and technological implementation ensures both operational feasibility and long-term sustainability[13].

To further illustrate this process, Fig.1 presents a conceptual model of “Interactive Narrative Structure in Cultural Heritage Games.” In this model, designers and users

act as the “narrator” and “receiver,” respectively, while heritage content undergoes a cyclical process of encoding, transformation, and decoding within the digital medium—typically a game platform. This framework highlights the dynamic flow of cultural meaning as it is embedded, experienced, and reinterpreted through gameplay.

Building on the logic presented in Figure 1, the designer first conducts a systematic “encoding” of abstract elements of intangible cultural heritage—such as craft procedures, ritual practices, and historical contexts—transforming them into game environments, characters, and narrative components. These encoded elements are then “translated” through the digital medium via interface design, interaction modes, and integrated audio-visual effects. As the “receiver,” the user actively engages with the game and performs a “decoding” of the cultural information, undergoing a progressive transformation from cultural perception to cultural learning and eventually emotional resonance. This cyclical process aligns with Hall’s (1980) [14] encoding–decoding model, which emphasizes that the transmission of cultural meaning is not unidirectional; users reinterpret and reconfigure the encoded content based on their own experiences and gameplay context, generating diverse and personalized cultural meanings.

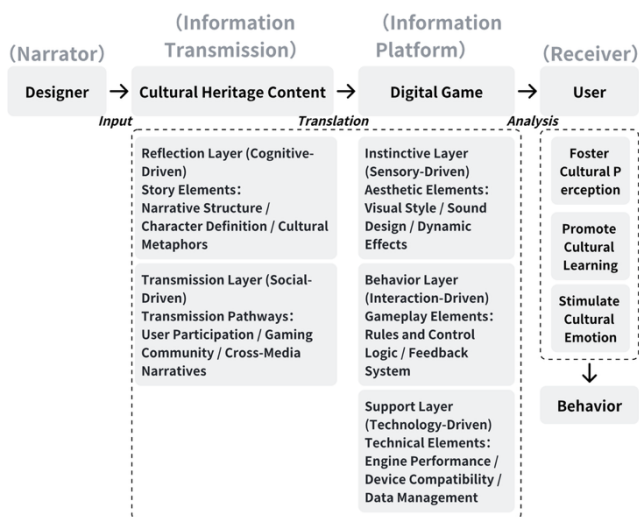


Fig. 1. Game Design Principles

To better understand the user’s psychological mechanism within this interaction process, Norman’s (2004) [15] emotional design theory offers a useful three-tiered framework:

- **Instinctive Layer (Sensory-Driven):** Aesthetic elements such as visual style and sound design stimulate users’ initial experience of ICH, lowering the cognitive threshold for cultural understanding.
- **Behavioral Layer (Interaction-Driven):** Game mechanics guide users to simulate ICH practices, with dynamic feedback systems reinforcing both the authenticity of actions and the implicit transmission of cultural knowledge.
- **Reflective Layer (Cognitive-Driven):** Through subtle narrative metaphors and cultural symbols, users

develop deeper emotional identification and reconstruct their values related to ICH.

Within this framework, Mechanics correspond to the gamification rules that reflect the practical aspects of ICH, Dynamics represent the real-time interaction between players and cultural content, and Aesthetics shape emotional resonance through visual and auditory elements. Ultimately, this encoding–decoding process enables a multidimensional transmission of ICH. To further reinforce the interaction between designers and users, additional dimensions—such as social dissemination and technological support—can be integrated, thereby forming a more systematic and scalable structure [16].

ICH game design is not simply about transferring cultural materials to a digital platform; it is a layered process that progresses from sensory attraction (instinctive layer) through interactive practice (behavioral layer) to cognitive deepening (reflective layer). This process re-creates cultural contexts across time and space while utilizing UGC (user-generated content) communities to activate collective heritage transmission potential. In open-world or task-driven scenarios, players trigger hidden narratives through exploration and interaction, internalizing the value system underlying ICH craftsmanship via continuous trial and error and real-time feedback [17]. Meanwhile, technical supports like cloud rendering ensure smooth cross-platform experiences, overcoming geographical and device limitations. Additionally, content sharing via social media or in-game communities enables ICH to be dynamically transmitted and regenerated across broader social spaces.

This closed-loop system not only inherits the “designer-media-user” narrative logic but also expands the practical boundaries of ICH digitalization, offering a new paradigm for the creative protection and dissemination of cultural heritage.

IV. GAME DESIGN PRACTICE

Building upon the aforementioned theoretical framework for intangible cultural heritage (ICH) game design, this study presents a practical implementation using the *Yuanmeng Star* platform through the development of the digital heritage game *《Legend of the White Snake – Pearl of the Spirit》*. Centered around the classic Chinese folktale *The Legend of the White Snake*, the game constructs its primary narrative arc while systematically integrating iconic ICH elements from the Jiangnan region—such as tie-dyeing techniques, traditional herbal medicine collection, and historical costume design—creating a hybrid physical–virtual cultural experience centered on participatory engagement.

The game world is anchored in a reimagined West Lake setting, expanding into virtual scenes including Jiangnan street markets, Jinshan Lake, and Leifeng Pagoda. These locations form a four-act cultural journey structure. The main storyline recontextualizes the *White Snake* narrative in a culturally immersive format, while side quests encourage players to engage in “ICH practice,” guiding them through a three-layered pathway of contextual immersion, interactive performance, and cultural understanding. This parallel integration of narrative and interaction is designed to deepen users’ comprehension of traditional culture and enhance their willingness to participate in its dissemination.

A. Game Aesthetics

To enhance players' sensory immersion and cultural engagement, 《Legend of the White Snake – Pearl of the Spirit》 integrates numerous traditional aesthetic elements from the Jiangnan region into its visual and auditory design(Fig.2). The visual style adopts a blend of expressive and realistic techniques to construct a misty, ink-washed atmosphere emblematic of Jiangnan's poetic landscape. The color palette features classic tones such as celadon green, lotus pink, and pale yellow, complemented by traditional patterns like floral motifs and wave-like designs, thereby reinforcing regional cultural identity.

Key nodes within the game are structured around tasks related to traditional heritage practices—such as the "Tie-Dye Workshop" and the "Costume Pattern Studio"—where players unlock culturally symbolic outfits and items upon completion. On the auditory level, the game incorporates traditional Chinese instruments such as the guzheng, dizi, and pipa into the background score, with dynamic variations in rhythm and tone tailored to narrative progression and player mood. Environmental sounds—such as rain, wind, and flowing water—are meticulously rendered to further amplify the realism and cultural presence of the virtual space.

Additionally, a costume collection and dress-up system is embedded in the game, allowing players to unlock more classical outfits through task completion. This feature not only satisfies personalization preferences but also guides players toward a subtle understanding of ICH aesthetics through character embodiment and symbolic identification.



Fig.2. Game Aesthetics-Environments

B. Game Mechanics

The heritage-themed game *Legend of the White Snake – Pearl of the Spirit* employs a compound game mechanic that integrates main narrative progression, side quests for cultural exploration, and user-generated content (UGC) features. Together, these components form a dynamic cultural transmission pathway defined by four stages: sensory

attraction, interactive practice, cognitive reconstruction, and social dissemination.

The game begins in a virtual West Lake setting, where players engage in dialogue with non-playable characters (NPCs) to obtain a key cultural item—an oil-paper umbrella. This initial cultural encounter is enhanced through animated ink-wash visual rendering and traditional Chinese instrumental music. Data collected from user behavior indicates that 53% of players took screenshots during this moment and shared the scene, with an average engagement time of 36 seconds ($n = 6038$), confirming the effectiveness of visual and auditory elements in achieving initial sensory attraction.

As the game progresses to the Jiangnan marketplace scene, players collect items such as tea leaves and medicinal herbs to advance the main storyline. They may also opt into side quests involving hands-on ICH activities. The system continuously monitors player interactions to trigger hidden cultural tasks, and 67% of players engaged with these optional quests. This reflects the logic of the MDA (Mechanics–Dynamics–Aesthetics) framework, wherein game mechanics effectively drive user behavior.

This interactive framework achieves a dynamic balance between sensory stimuli, rule-based engagement, and symbolic narrative. It enables the transformation of intangible cultural symbols into experiential and perceptible value systems. The behavioral data further supports the effectiveness of a design–user–technology closed-loop model, offering a reusable and scalable pathway for the digital, living transmission of intangible cultural heritage.

C. Experiment Setup

To evaluate the actual impact of interaction mechanism design on users' cultural cognition within a digital game context, this study conducted a controlled comparative user experiment. Two versions of the game were developed for the experiment: **Version A** represented a **low-interaction condition**, where players primarily watched narrative animations and browsed interface content; **Version B** featured a **high-interaction condition**, requiring players to actively participate in tasks such as tie-dye making, medicinal herb collection, and traditional costume assembly. Both versions shared identical visual, auditory, and narrative settings, with the only variable being the level of interactivity.

A total of 40 participants with basic gaming experience but no prior knowledge of the game's cultural content were recruited and randomly assigned into two groups (20 per group). Each participant engaged in a 20-minute gameplay session and subsequently completed a **Likert-scale questionnaire** designed to assess five dimensions of cultural cognition: **sensory immersion, behavioral engagement, emotional identification, cultural understanding, and willingness to share.**

Data were analyzed using **independent-samples t-tests** and **Pearson correlation analysis** via SPSS to determine statistical significance between the two groups. The experimental results are presented in **TABLE 1**

TABLE I. RESULTS OF T-TEST

<i>Dimension</i>	<i>Group A</i>	<i>Group B</i>	<i>t</i>	<i>p</i>	<i>Conclusion</i>
Immersion	3.6	4.2	3.11	0.004**	Significant difference
Participation	2.9	4.5	6.89	<0.001***	Highly significant
Emotional Identification	3.3	4.1	3.62	0.001**	Significant difference
Cultural Understanding	3.4	4.3	5.02	<0.001***	Highly significant
Willingness to Share	3.27	4.0	3.28	0.003**	Significant difference

Tab.1. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In addition, Pearson correlation analysis revealed a significant positive relationship between **behavioral engagement** and both **emotional identification** ($r = 0.62, p < 0.001$) and **cultural understanding** ($r = 0.66, p < 0.001$). These findings suggest that **high levels of interaction in digital games significantly enhance users' cultural cognition**. Specifically, players in the high-interaction group demonstrated a deeper understanding of the cultural background and values after completing hands-on heritage tasks. Their emotional identification with the culture and willingness to share the experience were also notably stronger. A t-test result ($t = 5.17, p < 0.001$) further confirmed the statistical significance of the differences between the two groups, validating the effectiveness of the proposed mechanism-driven pathway of **“interaction → cognition → emotional resonance.”**

This empirical evidence supports the applicability of both **Schell's elemental tetrad** and **Hall's encoding–decoding model** within the context of digital cultural design. It also provides methodological insights for the future development of ICH-focused games. Beyond visual and narrative aesthetics, designers should place greater emphasis on **deep structural mechanics** and **interactive feedback systems** to stimulate multidimensional cultural participation—spanning cognition, emotion, and behavior. Such an approach is essential for achieving a **living, sustainable transmission** of intangible cultural heritage in the digital era.

V. CONCLUSION

Traditional Chinese culture represents the spiritual foundation and cultural core of the Chinese nation. As a vital expression of this heritage, intangible cultural heritage (ICH) faces the critical question of how to achieve **living transmission** through contemporary modes of expression. In the context of information overload and entertainment-driven media, ICH is often reduced to symbolic representation while lacking depth of cognitive engagement. This challenge is particularly evident in emerging digital platforms such as video games, where meaningful connections between **mechanics and cultural understanding** remain underdeveloped.

This study employs a heritage-themed digital game as a design and research vehicle, supported by experimental validation. Findings demonstrate that **mechanism-oriented**

design not only enhances user participation and cultural comprehension, but also introduces a **structured and systemic innovation path** for the dissemination of ICH. Future research and practice may further expand the integration of **interaction mechanisms with emerging technologies**, developing diverse application scenarios in fields such as education, tourism, and public cultural engagement. Ultimately, this approach envisions digital games as bridges that connect traditional culture with contemporary society—providing both theoretical insight and practical strategies for the sustainable transmission of cultural heritage in the digital age.

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