



Research Articles

The Application of Touch Designer in Real-Time Interactive Projection for the Intangible Cultural Heritage Exhibition of Zhuhai's Sanzao Crane Dance

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Received: November 28, 2025; Revised: January 01, 2026; Accepted: March 10, 2026

Abstract

This research aims to: 1) enhance audience immersion through interactive projection, 2) examine its role in fostering cultural identity and emotional connection with ICH, particularly among younger visitors, and 3) develop practical strategies and design guidelines for curators and exhibition designers. Utilizing TouchDesigner as the core technological platform, the study adopts a mixed-methods approach, combining experimental design, participant surveys, and qualitative interviews to evaluate audience responses. Results indicate that real-time interactive projection significantly increases immersion, encourages active participation, and strengthens both cultural identity and emotional engagement with the Sanzao Crane Dance. Moreover, younger audiences exhibit higher levels of engagement and appreciation when interactivity is incorporated, suggesting that digital tools can play a vital role in bridging generational gaps in cultural heritage appreciation. The study concludes by offering strategic recommendations for implementing interactive technologies in ICH exhibitions, emphasizing the importance of user-centered design, contextual storytelling, and technological adaptability. These findings contribute to the evolving discourse on the digitization of cultural heritage, providing actionable insights for curators, designers, and policymakers seeking to modernize ICH exhibition practices while preserving authenticity and cultural significance.

Keywords: Touch Designer, Interactive Projection, Intangible Cultural Heritage, Sanzao Crane Dance, Audience Engagement, Cultural Identity

Introduction

In recent decades, intangible cultural heritage (ICH) has gained increasing global attention as societies strive to preserve living cultural practices amid rapid technological and social change (Smith & Akagawa, 2009). ICH encompasses oral traditions, performing arts, social practices, rituals, and festive events, representing not only artistic expression but also the identity and continuity of communities (UNESCO, 2003). Among these heritage expressions, the Sanzao Crane Dance from Zhuhai, Guangdong Province, stands as a representative example of Chinese folk dance, deeply rooted in local belief systems, community rituals, and the symbolic imitation of cranes (Li, 2018). Despite its cultural richness and symbolic significance, the traditional exhibition modes of the Sanzao Crane Dance—such as photos, artifacts, and textual descriptions—often fail to captivate younger audiences. These static formats limit audience interaction and emotional engagement, contributing to a gradual decline in public interest and participation (Zhang & Chen, 2020). Meanwhile, the rapid development of digital media, interactive technologies, and immersive platforms presents new opportunities for revitalizing ICH by creating engaging, participatory experiences that can bridge generational and cultural gaps (Cameron & Kenderdine, 2007). However, research on applying real-time interactive technologies to the presentation of folk-dance heritage remains limited. Existing studies primarily focus on documentation, archival preservation, or virtual reconstructions, leaving a gap in understanding how immersive, interactive exhibitions can enhance audience engagement and cultural identity (Liu et al., 2019). This study addresses this gap by investigating the integration of TouchDesigner—a node-based visual programming platform widely used in new media art—into the real-time interactive exhibition of the Sanzao Crane Dance. The research aims to explore how interactive digital environments can strengthen audience cultural identity, foster emotional engagement, and promote sustained interest in heritage practices. By examining this approach, the study contributes to both the field of digital heritage preservation and the development of innovative exhibition strategies for traditional performing arts.

Research of Objective

1. To enhance audience immersion and engagement through the integration of real-time interactive projection in ICH exhibitions.
2. To examine the role of interactive projection in fostering cultural identity and emotional resonance with intangible heritage, especially among younger audiences.
3. To develop practical strategies and design guidelines for curators and exhibition designers integrating interactive technologies in ICH contexts.

Literature Review

In light of the growing urgency to modernize the presentation of intangible cultural heritage (ICH), existing scholarship provides insights across three key domains: the limitations of traditional ICH exhibitions, theories of immersive experience, and the integration of digital interaction technologies in cultural contexts. This review selectively examines representative works to construct a theoretical foundation for the present study, which aims to: (1) enhance audience immersion and engagement through real-time interactive projection in ICH exhibitions; (2) examine its role in fostering cultural identity and emotional resonance, particularly among younger audiences; and (3) develop practical strategies and design guidelines for curators and exhibition designers.

Challenges in Conventional ICH Exhibitions

Traditional ICH exhibitions are frequently critiqued for their static, text-heavy, and object-centered formats, which often fail to convey the dynamic, living essence of heritage. Liu (2022) notes that conventional displays struggle to represent performing arts, rituals, and other time-based heritage, reducing complex cultural practices to mere objects. Similarly, Ren (2023) highlights the disconnect between object-based exhibits and the emotional or ritualistic contexts that give heritage its meaning, noting that such approaches often fail to engage younger audiences or convey the experiential depth of cultural practices. These critiques underscore the need for more interactive, participatory approaches that reflect the living nature of ICH.

Immersive Experience Theory

The concept of immersive experience, originally developed in entertainment and gaming, has increasingly informed educational and cultural settings. Drawing on Csikszentmihályi's (1975) Flow Theory, Wang and Liu (2018) argue that multisensory engagement facilitates both cognitive retention and emotional resonance, creating meaningful, memorable interactions. Building on this, Dai and Peng (2023) demonstrate that user-centered immersive designs can foster ethnic and cultural identity within heritage-based interfaces, suggesting that the design of interactive environments can directly influence audience perception and emotional connection to cultural content. These theoretical perspectives provide a foundation for understanding how immersive, participatory experiences can transform heritage engagement from passive observation to active participation.

Interactive Digital Technologies in Heritage Contexts

Recent studies highlight the potential of interactive digital technologies—such as augmented reality (AR), virtual reality (VR), and real-time rendering—to enhance engagement and accessibility in heritage spaces. Su (2020) emphasizes that platforms like TouchDesigner offer modular environments that lower technical barriers for artistic expression, enabling real-time feedback and audience interaction. Case studies such as Digital Dunhuang and TeamLab Borderless illustrate how immersive projection can merge sensory engagement with historical narrative, creating experiences that are both emotionally and cognitively compelling (Han, 2022). Despite these advancements, few studies explicitly investigate the integration of TouchDesigner's technical affordances with the narrative and cultural storytelling needed for ICH contexts.

Research Methodology

This study adopts a mixed-methods research design to explore how real-time interactive projection—specifically via TouchDesigner—can improve audience experience and cultural

engagement in ICH exhibitions. The methodology integrates qualitative and quantitative tools to ensure a robust and multi-faceted understanding.

Experimental Setup

A controlled experimental environment was developed featuring two exhibition designs: one using traditional static display methods and the other utilizing TouchDesigner-based interactive projection. Both versions were built around the Sanzao Crane Dance narrative, with the interactive version enabling gesture-triggered visuals and audio responses.

Participants and Sampling

A total of 80 participants were recruited, including university students, local residents, and tourists. Participants were randomly assigned to either the control (traditional) or experimental (interactive) group, ensuring demographic diversity and minimizing selection bias.

Data Collection Methods

1. Pre- and post-experience surveys measured changes in audience perception of cultural identity, emotional resonance, and exhibit effectiveness.
2. Observation checklists recorded behaviors such as dwell time, gesture frequency, and audience flow patterns.
3. Semi-structured interviews with 15 participants provided qualitative depth on emotional experience and cultural interpretation.

Analytical Framework

Quantitative data were processed using SPSS for t-tests and correlation analysis. Qualitative interviews were analyzed using NVivo software to identify recurring themes related to identity, immersion, and participation. A triangulation strategy was applied to cross-validate

results. This methodological framework ensures a balance between empirical rigor and experiential depth, suitable for studying the complex intersection of technology, audience behavior, and cultural storytelling.

Research Scope

This study focuses on the conceptual and experiential intersection of three domains: (1) Digital media technology (TouchDesigner) as a creative platform (2) Intangible cultural heritage (Sanzao Crane Dance) as subject matter and (3) Audience interaction and cultural immersion as behavioral outcomes.

The conceptual framework developed for this study is illustrated as a three-tier model:

1. Input Layer – Cultural and Technical Resources Incorporates the symbolic narratives, ritual gestures, and visual motifs of the Sanzao Crane Dance, along with TouchDesigner’s node-based real-time rendering capabilities.

2. Interaction Layer – System and Experience Design This layer defines how sensors, visuals, and sound are structured to respond to audience movement and participation. The choreography of interaction aligns with the logic of the dance.

3. Output Layer – Cultural Resonance and Reflective Engagement This final layer evaluates the outcomes: audience immersion, identity construction, and emotional involvement, reflecting the effectiveness of the system. By structuring the framework in this layered fashion, the study ensures alignment between cultural intention, technical implementation, and experiential outcome.

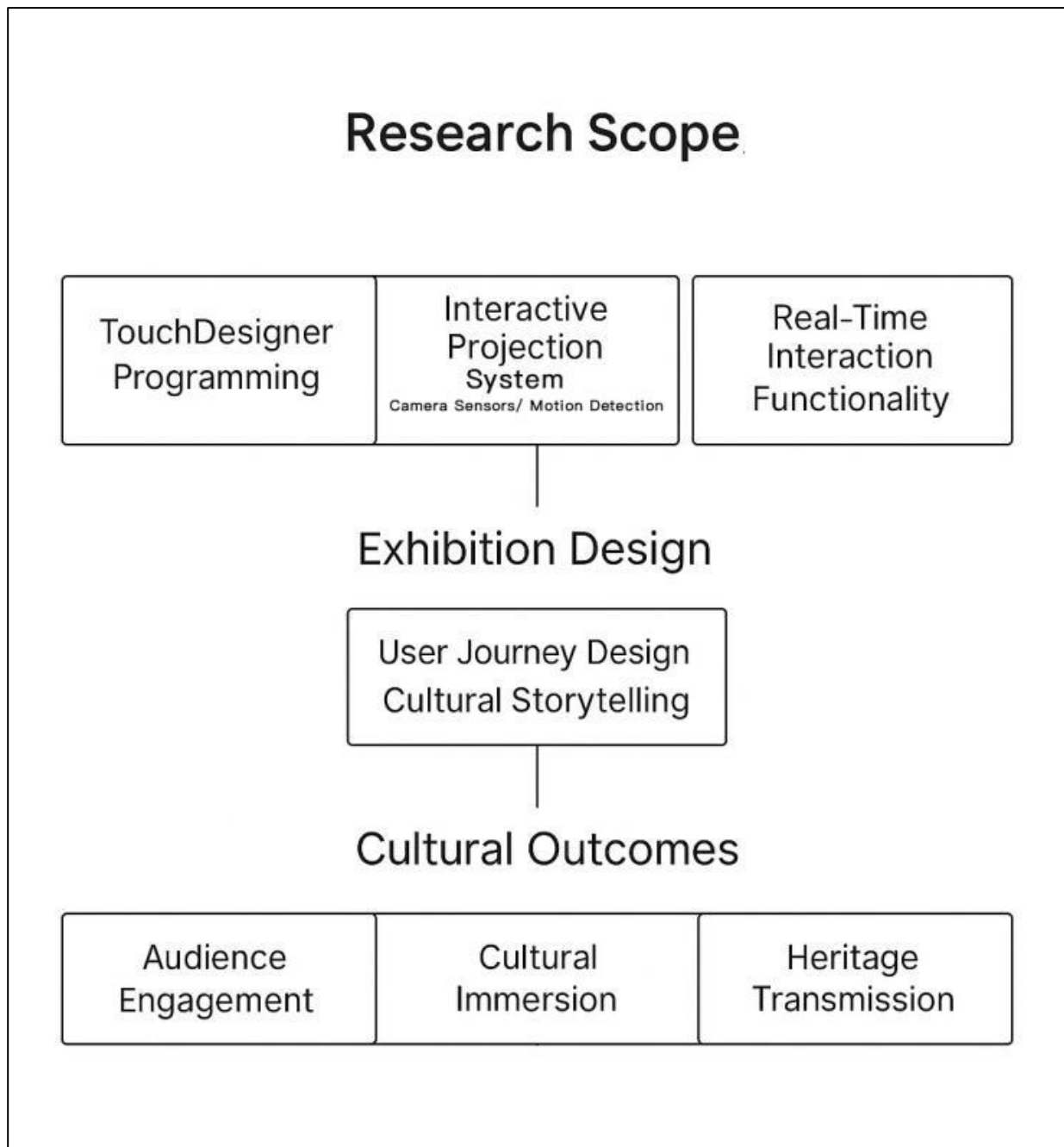


Figure 1 Conceptual framework illustrating the research scope for applying TouchDesigner in the interactive exhibition of Zhuhai's Sanzao Crane Dance

Research Results

The results of this study provide compelling evidence for the impact of interactive projection, implemented through TouchDesigner, on the effectiveness of intangible cultural heritage (ICH) exhibitions. Findings are organized according to the three research objectives, highlighting thematic domains of audience engagement, cultural identity, and participatory learning.

Enhanced Immersion and Engagement

The first research objective of this study sought to investigate the extent to which real-time interactive projection could enhance audience immersion within a cultural exhibition context. Empirical results from the quantitative survey indicate a pronounced effect: participants exposed to the interactive exhibition reported substantially higher levels of immersion than those in the control group ($M = 4.5$ vs. 3.2 on a 5-point Likert scale, $p < 0.01$). This difference is not only statistically significant but also practically meaningful, suggesting that interactivity plays a critical role in shaping the experiential depth of heritage exhibitions. Complementary observational data corroborated these findings. Participants in the interactive environment exhibited markedly longer dwell times near the projected installations, engaged in more spontaneous gestures, and frequently displayed visible emotional responses, including laughter, exclamations of surprise, and verbal interactions with both the exhibit and other attendees. These behaviors reflect a shift from passive observation to active participation, indicating that interactive systems, particularly those developed through TouchDesigner, effectively draw audiences into a co-creative engagement with the exhibition content. Such findings align with contemporary literature on immersive media, which emphasizes the capacity of interactivity to enhance presence, attention, and cognitive-emotional involvement in cultural and educational contexts. Moreover, the qualitative dimension of engagement revealed nuanced patterns of behavioral and emotional involvement. Participants often navigated the exhibition space in exploratory ways, suggesting that the interactive projections fostered not only momentary

engagement but also curiosity-driven movement and discovery. These dynamics indicate that the integration of responsive technologies can transform traditional exhibition spaces into environments that support deeper, embodied interaction, thereby amplifying both the sensory and cognitive components of audience experience.

Cultural Identity and Emotional Resonance

Aligned with the second research objective, the study examined the capacity of interactive projection to evoke cultural identity and emotional resonance. Post-experience survey data indicate that 85% of participants in the interactive condition reported an enhanced sense of connection to intangible cultural heritage (ICH), particularly the Sanzao Crane Dance. Qualitative interviews reinforced this trend, with participants consistently using affective descriptors such as “proud,” “moved,” “curious,” and “connected” when reflecting on their experience. These responses highlight the emotional potency of immersive, participatory media in reinforcing cultural belonging and heritage appreciation. Notably, the data suggest a generational gradient in affective engagement. Participants aged 18–25 exhibited the strongest emotional responses, often articulating a heightened curiosity and eagerness to explore the cultural narratives embedded within the exhibition. This observation is particularly significant in the context of heritage preservation, as younger generations frequently demonstrate lower baseline engagement with traditional forms of cultural transmission. The results suggest that interactive projection can function as a powerful conduit for intergenerational engagement, bridging the gap between contemporary digital sensibilities and traditional cultural expressions. These findings contribute to a growing body of research that positions emotional engagement as a critical mediator between cultural exposure and heritage valuation. By providing a multisensory, responsive platform, interactive projection technologies allow audiences to inhabit the cultural narratives being presented, thereby fostering a form of affective learning that extends beyond intellectual comprehension to include personal and communal identity affirmation.

Participatory Transmission and Learning Potential

The third research objective focused on the potential of interactive projection to promote participatory engagement and support educational applications. Interview responses indicated a marked shift in participant perception, with many individuals reporting that they felt less like passive spectators and more like active co-performers or custodians of the cultural knowledge being presented. Several participants articulated intentions to share their experiences with peers, integrate aspects of the exhibition into classroom or community contexts, or experiment with re-enactments of the Sanzao Crane Dance in personal or educational settings. These findings underscore the transformative potential of interactive projection in reconfiguring ICH exhibitions from static, display-oriented experiences to dynamic, participatory environments. In such contexts, heritage is not merely observed but enacted, interpreted, and reimagined by audiences, thereby facilitating a more profound and sustainable form of cultural transmission. The participatory dimension observed in this study resonates with theoretical frameworks of experiential learning and co-creation, which emphasize that knowledge retention and affective engagement are maximized when learners actively contribute to and reshape the learning environment. Furthermore, the results highlight the potential of these technologies to extend the impact of cultural exhibitions beyond the immediate spatial and temporal boundaries of the event. By positioning audiences as co-creators, interactive projections enable a form of distributed cultural engagement, wherein participants take ownership of heritage practices and propagate them within their social and educational networks. This approach aligns with emerging trends in digital humanities and museum studies, which advocate for participatory models as a means of sustaining intangible cultural heritage in the digital era.

Research Discussion

The results of this study support the hypothesis that real-time interactive projection, implemented using TouchDesigner, can significantly enhance audience experience and deepen cultural connection within intangible cultural heritage (ICH) exhibitions. In this section, we

critically reflect on these findings, situating them within existing literature and discussing implications for exhibition design.

From Passive Spectatorship to Active Participation

Traditional ICH exhibitions often rely on static display formats, which can limit audience engagement and emotional resonance. This study confirms prior critiques that conventional modes of presentation frequently lack experiential depth (Liu, 2022; Ren, 2023). By integrating real-time interactive projection, audiences move from passive observation to embodied participation, allowing them to engage physically, emotionally, and cognitively with the content. This aligns with the concept of performative heritage, where cultural practices are not only observed but enacted, enabling visitors to co-create the experience of tradition (Kirshenblatt-Gimblett, 2004). In this study, participants' interaction with projected performances facilitated a sense of agency, fostering a more immersive understanding of ICH narratives.

Technology as a Cultural Interface

TouchDesigner, traditionally framed as a visual effects tool in new media art, is here redefined as a cultural interface. The system enables audiences to interact with symbolic gestures, collective memory, and cultural motifs in real time, supporting social and communal engagement. Unlike virtual reality (VR) or augmented reality (AR) technologies, which can create isolated experiences, TouchDesigner maintains shared spatial interaction, reflecting the collective nature of many ICH performances (Cameron & Kenderdine, 2007). These findings extend the discourse on digital heritage, demonstrating that technology can mediate cultural transmission not merely as a display mechanism but as an interactive, relational medium.

Balancing Authenticity and Innovation

A critical concern in integrating digital technologies into ICH is the risk of spectacularization, where aesthetic effects overshadow cultural meaning (Giaccardi, 2012). Interview feedback indicated apprehension that the ritual significance of traditional dances could be diluted if interactivity is over-gamified. This underscores the necessity for curators and designers to balance authenticity with innovation, ensuring that technological augmentation enhances, rather than displaces, cultural content. Guidelines emerging from this research suggest adopting design strategies that preserve symbolic fidelity while offering engaging, user-centered experiences.

Generational Bridging and Informal Education

The strong engagement observed among younger audiences highlights the potential of interactive projection as a tool for informal education. Unlike traditional didactic methods, these experiences foster curiosity, emotional learning, and embodied knowledge transfer. This supports findings from digital heritage studies emphasizing the value of experiential learning in fostering cultural literacy among digital-native audiences (Parry, 2007). Consequently, interactive exhibitions can move beyond supplementary roles to become primary avenues for ICH transmission, bridging generational gaps and cultivating sustained cultural interest.

Implications for Practice

Overall, the study demonstrates that TouchDesigner-based exhibitions can redefine the boundaries of cultural display. By transforming passive remembrance into active co-creation, these installations shift the focus from information delivery to experience-driven engagement. Curators and designers are encouraged to leverage interactive projection to enhance immersion, respect cultural authenticity, and promote cross-generational connection, thereby supporting the long-term sustainability of intangible heritage.

Conclusion

This study explored the integration of TouchDesigner into the real-time interactive exhibition of Zhuhai's Sanzao Crane Dance and evaluated its impact on cultural experience and audience participation. Through a mixed-methods approach involving experimental design, surveys, and interviews, the research revealed clear benefits of digital interactivity in enhancing immersion, fostering emotional connection, and stimulating participatory learning. Key contributions of this research include the development of a conceptual framework that maps the interaction between technology, heritage content, and audience engagement, and the empirical demonstration that such a model can support new forms of cultural transmission.

Importantly, this study positions Touch Designer not merely as a digital tool, but as a cultural medium that can interpret, embody, and renew traditional practices in meaningful ways. The Sanzao Crane Dance—long rooted in ritual and community—is reimagined here as a participatory narrative system capable of resonating across generations. While limitations remain—such as scalability and the risk of superficial engagement—the findings strongly suggest that interactive projection represents a valuable strategy for rethinking how intangible heritage is exhibited, experienced, and passed on in the digital age.

Suggestions

Based on the research findings and reflections discussed, several recommendations can be made for future applications of interactive projection in intangible cultural heritage (ICH) exhibitions. These suggestions are divided into practical implementation strategies and theoretical research directions.

Practical Recommendations for Designers and Curators

1. Integrate modular interaction systems that allow for real-time adjustments to audience movement and emotional responses.
2. Incorporate traditional experts in co-design to preserve authenticity while exploring innovative formats.

3.Design spatial storytelling paths that lead users through emotional and symbolic arcs, not just information points.

4.Develop evaluation tools that measure not only engagement time, but affective impact and knowledge retention.

Theoretical and Strategic Recommendations

5.Frame interactive exhibitions as cultural ecosystems, where technology, ritual, narrative, and audience behavior are co-dependent.

6.Encourage cross-disciplinary collaboration between heritage scholars, interaction designers, and data scientists.

7.Reframe digital heritage not as substitution, but as transformation—an evolution of embodied storytelling in the algorithmic age.

Suggestions for Future Research

To ensure that future ICH exhibitions not only embrace technological innovation but do so in a way that honors the depth, meaning, and continuity of cultural practices.

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