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Enhancing Young Generation's Heritage Identity Through Emotional Responses to Virtual Cultural Heritage Experience: A Design Case with Azheke Community and Visitors at Hani Rice Terraces in China

Yaning Li[a,b], Ruoyu Qiu[a,b], Ziyao He[a], Xue Wu[a], Teng Han[c], Xin Tong[d], Yiqing Zhao[a], and Meng Li[a]

[a]Xi'an Jiaotong University, Xi'an, China; [b]Politecnico di Milano, Milano, Italy; [c]Institute of Software, Chinese Academy of Sciences, Beijing, China; [d]Hong Kong University of Science and Technology (Guangzhou), Guangzhou, China

ABSTRACT

While virtual reality (VR) enables emotional engagement in cultural heritage (CH) context, its real-time effects on emotional responses throughout the experience and their potential influence on heritage identity remain unexplored. In this study, we present a case of Azheke Village at Hani Rice Terraces in China, co-designing a CH experience in VR with multi-stakeholders, and evaluate how it evokes emotional responses during the whole experience and enhances heritage identity among young local residents and visitors. Our findings reveal that the VR experience effectively evoked emotional responses and enhanced heritage identity across all groups, with changes of emotional arousal showing the strongest relationship with social-value-based heritage identity enhancement among the local residents. This research contributes to human-computer interaction (HCI) and heritage research field by offering empirical findings, which also provides rich design reflections and implications for future research practices to develop interactive experiences to engage young generations in CH inheritance.

KEYWORDS

Virtual reality; cultural heritage; emotional responses; heritage identity; participatory design

1. Introduction

The cultural heritage (CH) is vital for shaping a region's identity, fostering social cohesion, and promoting tourism (Nitzky, 2013). Rural CH, encompassing tangible and intangible elements from human-environment interactions, reflects local culture and wisdom (Li et al., 2017). However, it faces threats such as urbanization, natural disasters, and social hollowing out, both globally and locally. These challenges underscore the urgency of protection and regeneration efforts (Kong, 2024).

The young generations, recognized as the pivotal forces to protect and transmit CH, however, often find it challenging to appreciate and recognize the intrinsic values of the local CH due to the lack of engagement (Bajec, 2019; Gao and Lee, 2024). This low engagement with CH diminishes their identity and emotional connection with their own CH, hindering its inter-generational transmission. Identity and emotion are, in fact, two key factors in heritage protection (Ashworth, 2013; Smith, 2020), as heritage identity refers to people's rational understanding, attitude, and judgment of heritage (Zhang et al., 2018), while emotion represents humans' sensual responses and expressions towards CH (Watson, 2016). Therefore, this highlights the pressing need for approaches to deepening younger generation's sense of identity and emotional tendency towards indigenous CH (Gao and Lee, 2024).

In the field of heritage studies and human-computer interaction (HCI), VR has demonstrated its potentials in creating virtual presentation of cultural artifacts and providing immersive and interactive experiences to the audiences (Cecotti, 2022; Zhang and Stewart, 2017), hence growing studies have applied VR technology to design CH experiences. Though state-of-the-art studies have revealed that the VR-based CH experience can provide users with emotional involvement (Yang et al., 2023) and evoke profound emotional responses (Mehrabian, 1996), most findings focus more on interpreting their emotional status from recapitulatory perspectives (e.g., evaluation of the overall experience (Yang et al., 2023)), which lacks detailed and in-depth analysis of the emotional variations throughout the whole VR experience (e.g., real-time monitoring and responses at different interaction points). Moreover, current studies have not deeply delved how VR-evoked emotional responses impact other cognitive or behavioral aspects of CH, such as heritage identity, which is crucial for understanding how individuals perceive and judge heritage.

Following the aforementioned challenges and research gaps, we aim to answer the following research questions:

RQ1: What are the effects of VR on users' emotional responses throughout the whole virtual CH experience?

CONTACT Yiqing Zhao zhaoyiqing@xjtu.edu.cn; Meng Li limeng.81@mail.xjtu.edu.cn Xi'an Jiaotong University, Xi'an, China

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RQ2: What are the impacts of users' emotional responses to the virtual CH experience on their heritage identity?

In this study, we select the Azheke Village at Hani Rice Terraces in China as a design case to study, which is culturally representative and important for its unique and long-standing Hani traditional CH with crucial need of preservation, transmission and revitalization (see Section 3 for detailed information). The VR experience is firstly co-designed with multi-stakeholders to capture characteristic CH elements and align with users' emotional tendencies and identity. Then we measure users' emotional responses during the whole process and heritage identity through mixed methods. Our findings reveal that the VR experience effectively elicited emotional responses and strengthened heritage identity, particularly enhancing social-value-based heritage identity among local residents through modulating emotional arousal level (Figure 8).

Through adopting a systematic design approach to co-design the VR CH experience with multi-stakeholders, the major contributions of this study are:

1. **Empirical findings of the nuanced emotional responses during the whole virtual CH experience:** through synthesizing both quantitative and qualitative data, we offer a comprehensive analysis of users' real-time emotional responses throughout the entire experience, highlighting their reactions to specific interactions and the evolution of emotional states throughout the process.
2. **Empirical findings of the impacts of the emotional responses on heritage identity enhancement within virtual CH experience:** we innovatively examines how virtual CH experiences can enhance young generations' heritage identity by evoking emotional responses. Notably, our findings reveal that while these experiences generally support value-based heritage identity, they significantly enhance social-value-based identity among local residents by modulating emotional arousal levels.

Based on the aforementioned empirical findings and additional insights derived from this study, we propose critical reflections and design implications, which can also offer references for future research practices in heritage and HCI field (Figure 1).

2. Related work

2.1. Leveraging VR for emotional engagement in CH experiences

VR technologies facilitate 3D visualization and interactive modalities, providing user-centered experiences that enable the public to engage with and explore immersive, true-to-life cultural environments (Haydar et al., 2011). In the field of HCI, VR has been applied in various CH scenarios (Nofal, 2023), such as reconstructing CH (Picard et al., 2016), designing interactions (Cannavò et al., 2024), creating virtual museums (Carrozzino and Bergamasco, 2010), and game-based knowledge learning (Ch'Ng et al., 2020).

The potentials of VR to serve as an active mechanism for emotion induction have long been recognized, for it can simulate controlled environments with high immersion, presence, and interaction to elicit emotion (Smith and Campbell, 2015). Within CH context, HCI researchers have studied how users emotionally experience in VR environment. For example, Li et al. (Yang et al., 2023) designed a virtual museum to explore users' emotional involvement. Garzón-Paredes and Royo-Vela (Garzón-Paredes and Vela, 2022) immersed tourists in VR environment consisting of Spanish architectural heritage and proved that emotional response caused by CH through VR in individuals is positive. Lee et al. (Lan et al., 2021) investigated the positive emotions in virtual CH tourism experiences.

Although the state-of-the-art studies have demonstrated that users can enjoy a positive emotional engagement in virtual CH experiences, most existing findings were interpreted using recapitulatory approaches such us questionnaires, to obtain a general overview of users' emotional experience. However, it is essential to also understand comprehensively how the emotional status of the user changes and responds in real-time throughout the whole process of the VR experience (e.g., at specific interaction points), which can help better design the representative contents and interactions presented in VR, to serve as a useful trigger of the emotion induction (Smith and Campbell, 2015).

2.2. Participatory approaches to designing virtual CH experiences

Participation in CH has nowadays an extensive literature and a rooted history (Hetland et al., 2020; Zhang, 2017; Reisenzein, 1994). The UN and UNESCO lay the ground for the broader recognition of participatory approach within CH context (Iaione et al., 2022), which is critical as the process helps sustain the significance of tangible and intangible CH (Participatory Approach to Heritage Conservation, n.d).

In the field of HCI, participatory design (PD) has proven effective for developing technological solutions by involving end-users throughout the design process (Azizah, 2019). Its potential for designing interactive cultural heritage (CH) experiences has also been widely explored (McClelland, 2018). For example, Kong (Škola et al., 2020) used PD to co-create and refine a digital diabolo VR game with the diabolo community. Tong et al. (Theodoropoulos and Antoniou, 2022) designed with the indigenous community of a CH site in New Zealand to develop a cinematic VR experience. Innocente et al. (Innocente et al., 2023) presented a framework on extended reality in the CH domain, highlighting the importance of involving experts from different disciplines in the design process. Following the aforementioned suggestions of integrating PD approach in creating interactive CH experiences, Nofal (Nocca, 2017) conducted PD workshops to empower and enable the citizens in the heritage site to share their shared history to support a digital heritage project. Peter and Labadin (Park

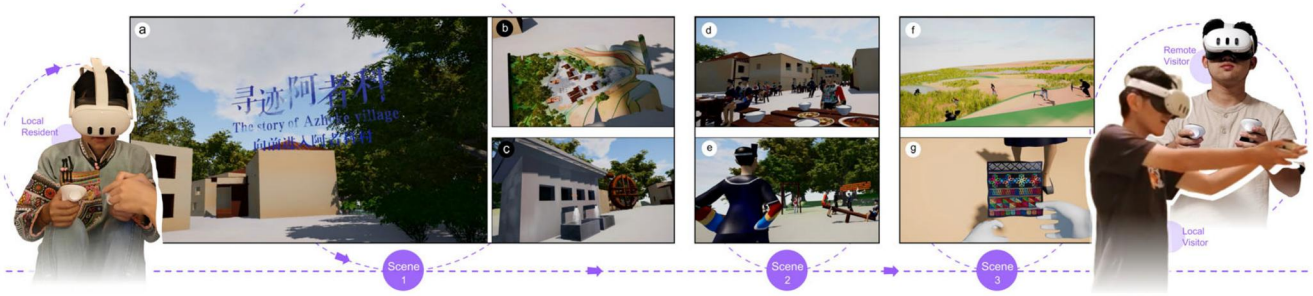


Figure 1. Overview of this study: VR flow of the virtual cultural heritage experience, and three user groups involved in the study.

et al., 2022) highlighted how PD helps bridge the digital divide in projects involving indigenous communities and explored initiatives to co-design digital technologies to preserve indigenous knowledge.

However, the PD approaches adopted in the aforementioned studies mainly focus on involving multi-stakeholders in ensuring the integration of multidisciplinary perspectives, completeness, authenticity, and cultural relevance of the contents in the virtual experience (Theodoropoulos & Antoniou, 2022). As mentioned in the Introduction section, though emotion and identity are also recognized as important factors in discovering CH experience, how to effectively capture and integrate users' emotional expectations and personal identity towards CH elements in PD to design preferable virtual CH experience is still a relatively understudied area.

2.3. Understanding users in virtual CH experiences from emotion and identity perspectives

Conventional factors that have been evaluated in interactive CH studies include the usability (Hulusic et al., 2023), knowledge acquisition (Minucciani et al., 2024; Somarathna et al., 2023), immersion (Zimmerman et al., 2007) and interests (Karran et al., 2015). However, the majority of these factors are generic metrics which cannot directly indicated the impact of the virtual CH experience on users's cognition, affection and behavior towards CH.

To enable a more CH-specific evaluation of virtual experiences, emotion and identity are highlighted in the Introduction section as critical factors in understanding human-heritage interactions. On the one hand, Watson (Watson et al., 1988) attributed the reason why the emotions matter in heritage sites to the fact that all cultures have an "emotional scale," which is the range of appropriate emotional responses to individuals and community events. Smith (Silver & Clark, 2016b) also emphasized the importance of an emotional perspective in understanding heritage. On the other hand, heritage identity refers to people's subjective cognition, understanding, attitude, and evaluation of heritage (Zhang et al., 2018). In 1994, Ashworth and Larkham (Ashworth, 2013) elaborated on this concept, and since then, various studies have explored the heritage identity of different stakeholders in heritage management and practices (Gieling & Ong, 2016; Hunter, 2011; Wang et al., 2025). Following this, HCI studies have already explored the effects of the VR experience on users' emotional experience in CH scenarios (Garzón-Paredes & Vela, 2022; Lan et al., 2021; Smith & Campbell, 2015; Yang et al., 2023), however, few studies focus on its impact on one's heritage identity.

Considering the crucial role of these two factors, the relationship between them is also noteworthy, no matter in heritage or HCI research field. In the context of CH studies, Yang et al. (Witmer & Singer, 1998) examined the role of emotions in CH tourism. Their findings reveal that tourists' emotional experiences are shaped by cognitive evaluations of both the natural and humanistic environments, which, in turn, trigger deeper cognitive processing and prosocial behaviors. These processes foster a stronger cultural identity among tourists and promote awareness and conservation actions towards CH. Nevertheless, current HCI studies have not focused on this influencing mechanism, which arises further questions for HCI community building on this foundation: as VR transforms the presentation of CH, it offers experiences distinct from the on-site visits. Therefore, this highlights the needs for HCI researchers to bridge the gap: understanding (1) if VR can enhance heritage identity, and (2) whether the emotional responses evoked by VR can influence heritage identity among multi-stakeholders. Addressing these gaps could provide rich design implications for developing interactive experiences tailored to support young generations in future heritage inheritance activities.

In response to the identified research gaps, this study follows a research through design (Zhu et al., 2023) approach shown in Figure 2.

3. Background of the study site

Azheke Village, located in Xinjie Town, Yuanyang County, Honghe Hani and Yi Autonomous Prefecture, Yunnan Province, China, is in the center of the Honghe Hani Rice Terraces World Heritage Site, halfway up Ailao Mountain at an elevation of 1,880 m and spanning an area of 1.43 square kilometres (Li et al., 2024). Since the ancestors of the Hani people moved there over 1,300 years ago, it has developed a rich cultural history including specific architecture, crafts, festivals, and folk activities (Liang et al., 2023). Specifically, this site is culturally representative and important for (1) its unique Hani traditional residential settlement space landscape and long-standing Hani traditional CH, which differ from other heritage sites in China; (2) it is known as "the

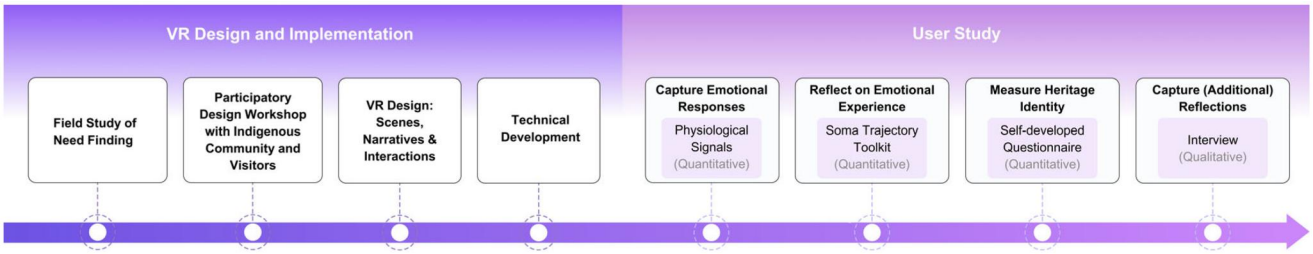


Figure 2. Overview of the research path of this study.

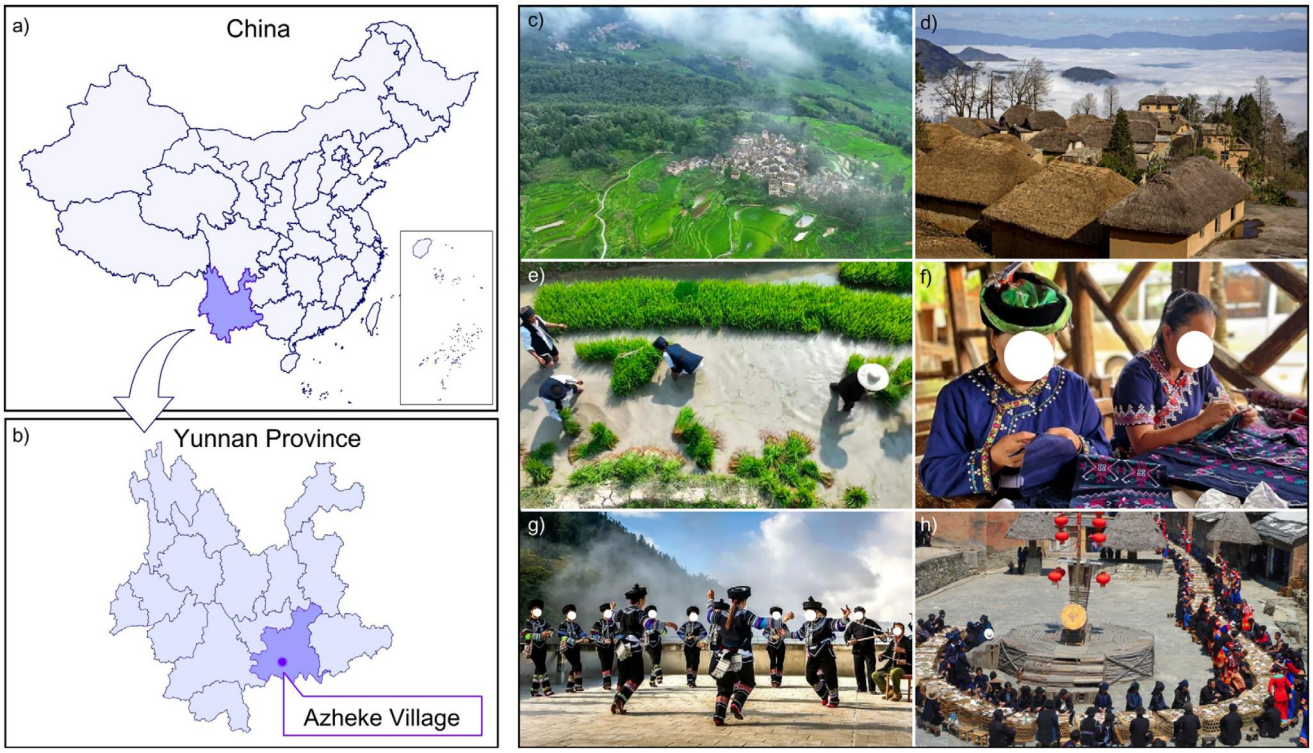


Figure 3. Background information of the study site. This figure provides an overview of (1) its geographical location (a), b)), (2) terrace as a unique geomorphic feature (c)), (3) local architecture (d)), (4) characteristic farming method (e)), (5) craft (f)), and (6) folk activities and festivals (g), h)).

last primitive village of the Hani people," indicating that the preservation, transmission, and revitalization is urgent. Meanwhile, the Hani rely on embroidery and oral traditions in their local language for inter-generational cultural transmission, but these methods hinder wider dissemination outside the local community. Furthermore, urbanization exacerbates this issue, as youth migration leads to declining knowledge of the language and culture, further threatening CH inheritance. Figure 3 provides an overview of the background information of the study site.

4. VR design and implementation

The design and implementation of the VR experience was conducted through a systematic process consisting of (1) a field study and participatory design workshop, (2) VR experience design, and (3) technical implementation (Figure 2, shown above). Specifically, in the following subsections (4.1 & 4.2), we are going to introduce the field study and participatory design workshop that were conducted lasting for three days, at the early stage of the VR experience design. To clarify the overall methodology and procedure, Figure 4 is provided.

4.1. Field study: survey & need finding for virtual CH experience design

The objectives of the field study were to: (1) learn about the local CH, (2) discover the needs related to CH from the community, and (3) understand local residents' and visitors' identity, attitude, and emotional tendency towards local CH.

4.1.1. Participants screening and inclusion

The two-day field study in Azheke Village involved 134 participants (23 local residents, 106 visitors, 2 local government staffs, 2 researchers-in-residence of the village, and 1 local tourism practitioner) in total (for both questionnaire and interview survey), who represent different stakeholder groups. No participant was involved in both surveys simultaneously. Every participant voluntarily joined the survey and signed a consent form at the beginning. The inclusion criteria for the local resident were: (1) familiar with their

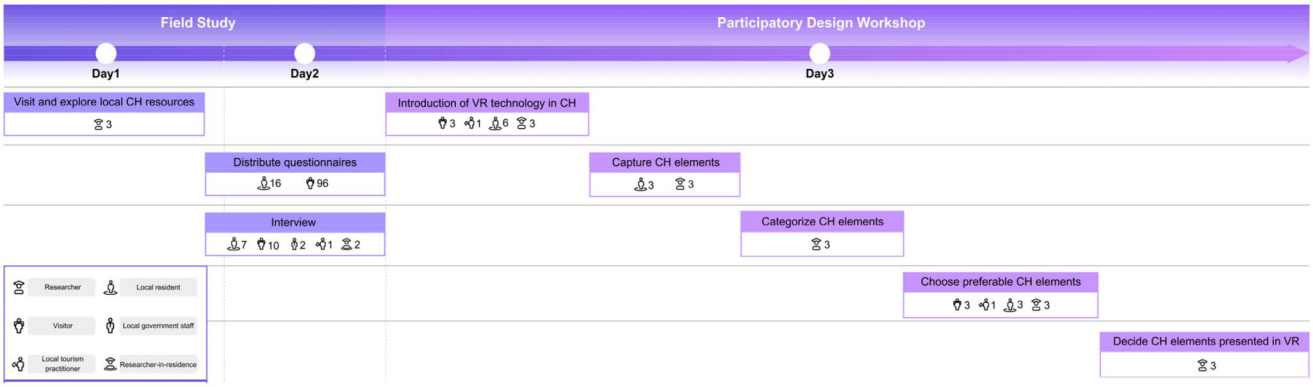


Figure 4. Overview of the methodology and procedure of the field study and participatory design workshop.

own local CH, (2) has the literacy level to read, understand and express oneself. As for the visitor, the criteria are: (1) has already traveled through the village and gained basic knowledge of local CH, and (2) has the literacy level to read, understand and express oneself.

4.1.2. Questionnaire survey

After investigating the CH in the village guided by a villager and a local tourism practitioner, we delivered questionnaires (see Appendix A) to 16 local residents (9 people identified as male, 7 as female, including 3 children and 13 adults, aged between 14 and 37, Mean (M)=29.5, Standard Deviation (SD)=8.0) and 96 visitors (52 people identified as male, 44 as female, including 9 children and 87 adults, aged between 15 and 54, M = 30.0, SD = 9.6). Nothing else that might influence the reliability of the survey was involved in distributing the questionnaires. As the amount of local residents and their literacy level is limited, it is difficult to control the number of residents and visitors who completed the questionnaire to be approximately the same in the field study. What needs to be specially explained is that, in this survey, we distributed the questionnaires exclusively to local residents and visitors. This is because, compared to other stakeholder groups (e.g., local government staff, local tourism practitioner, researcher-in-residence) that only contain very few people locally, these populations were more readily accessible for recruitment to obtain a larger number of responses that can be used in questionnaire analysis.

Figure 5 demonstrates the core findings of the questionnaire about local residents' and visitors' attitudes towards the local CH. We found that a large number of visitors and local residents considered characteristic architecture (visitors: 61.8%, local residents: 52.2%, same below), traditional festivals (49.1%, 39.1%), folk music (43.6%, 30.4%), craft (50.9%, 26.1%), costume (56.4%, 34.8%), and natural environment (69.1%, 60.9%) to be very important for the indigenous community. Specifically, as for the traditional festival, a majority of the participants are interested in Kuzhazha Festival (36.4%, 69.6%), while as for the craft, most of them share interests in embroidery (45.5%, 52.2%). These findings provided an initial understanding of local residents' and visitors' attitudes toward local CH for us researchers. Besides, 50.9% of the visitors expected to see the CH of the village to be displayed through VR, AR, or other digital technologies for future tourism experience, while 93.5% of them also wanted to engage in the traditional activities of the indigenous community.

4.1.3. Interview survey

Meanwhile, we also conducted a semi-structured interview with 7 local residents (3 people identified as male, 4 as female, aged between 21 and 55, M = 36.4, SD = 11.1), 2 local government staffs (1 people identified as male, 1 as female, aged 36 and 45, M = 40.5, SD = 6.4), 10 visitors (4 people identified as male, 6 as female, including 1 child and 10 adults, aged between 14 and 38, M = 25.4, SD = 6.6), 1 local tourism practitioner (female, aged 26), and 2 researchers-in-residence (2 people identified as male, aged 24 and 28, M = 26, SD = 2.8). This interview mainly focused on (1) the conflicts, challenges and contradictions faced by local CH protection in Azheke Village after the development of tourism and the listing of the Hani Terraces as a World Cultural Heritage, (2) the impact of changes in population structure, terrace farming patterns and inheritance difficulties, and (3) visitors' traveling experiences and expectations. The detailed questions are reported in Appendix B.

The interview was audio-recorded with participants' consent and later transcribed into text. Two authors conducted a thematic analysis on the transcripts of each stakeholder group, where both authors read the transcripts to gain a sense of the data and then developed a set of initial codes independently. They then discussed their initial codebooks and reached an agreement to identify the common themes, which were consistent across the transcripts and provided insights into the attitudes and opinions towards local CH and community development of different groups.

Here, we summarize the core takeaways of the interview in the field study, according to the emerged themes from the qualitative analysis, which could (1) motivate us to conduct this design study, and (2) provide references for the following design process.

1. **Tensions Between Tourism and Cultural Integrity:** Local residents expressed concerns over the balance between adapting to attract tourists and preserving the cultural integrity of Azheke Village. The village's

Figure 5. Field study in Azheke Village. The first part shows the researchers and participants who were conducting interviews and questionnaires together. The second part demonstrates the results of the questionnaire. The purple circles represent the major categories of CH, while the pink circles refer to the specific components of CH.

demographic shift—marked by youth migration to urban areas—has led to an aging population and a decline in traditional farming due to its low income and labor-intensive nature. While World Heritage status has increased tourism, many visitors lack a deep understanding of the local culture, highlighting a gap between exposure and engagement. This theme underscores the urgency of preserving and revitalizing local CH, while also emphasizing the importance to provide rich resources for visitors to understand the local culture.

2. **Tourist Perceptions and Expectations:** Visitors generally appreciated the village's authenticity, traditional

architecture, and cultural practices, often exceeding their expectations. They valued the immersive atmosphere but suggested improving CH presentation through interactive and participatory activities. Concerns were raised regarding maintaining the village's character amidst increasing tourism, with recommendations for cultural festivals and engagement initiatives to deepen visitor connections. Their feedback demonstrate deep interests in local CH, and desires to be engaged in cultural activities through diverse ways, which can be achieved in the design of this study.

3. **Digital Innovation of Local Culture:** Both local tourism practitioners and researchers-in-residence highlighted the growing role of digital tools in cultural tourism. Tourists increasingly seek immersive cultural experiences, such as guided tours, educational activities, and engagement with local traditions and cuisine. However, challenges such as language barriers and diverse tourist needs necessitate external support. Digital solutions, such as interactive "digital guides" and virtual experiences, were suggested to enhance service quality and cultural engagement. At the same time, researchers-in-residence explored how digital technology could document and present CH responsibly. Using drone surveys, they aimed to develop a 360-degree panoramic metaverse experience, recognizing digital tools as both an engagement medium and a potential risk to authenticity if overused. While they acknowledged VR's potential for deepening tourists' understanding of the local landscape, they advocated for responsible integration that complements rather than distorts CH.

4.1.4. Summary of field study: design requirements analysis

In general, the field study revealed (1) the key challenges in local CH inheritance, dissemination, and revitalization, and (2) demands from multi-stakeholders in revitalizing CH. Through these findings, detailed design requirements can be summarized as follows:

1. **Interactive Media Selection:** in response to local tourism practitioners' need for "digital guides" and the demand for accessible CH experiences by residents and visitors, an interactive VR-based CH experience was developed. VR was chosen over AR and MR for its capacity to create fully immersive virtual environments, enabling digital reconstruction of CH and accommodating both onsite and remote visitors.
2. **VR Experience Contents & Goals:** through the findings, we noticed that the personal connection with the local CH is relatively low, no matter in local residents group or visitors group. Therefore, we aim to design an emotion-triggering VR experience, which can not only demonstrate the representative local CH, but also arouse users' emotional responses and identity towards local CH.
3. **Design Methodology:** as discovered in the field study, different stakeholders have various kinds of attitude and experience towards local CH, therefore, it is important to engage multi-stakeholders in co-designing this virtual experience. Specific design approaches will be introduced in subsection 4.2.

4.2. Co-design with multi-stakeholders: capture & integrate representative CH

Following the field study, we spent the third day organizing a participatory design workshop with 6 local residents (2 people identified as male, 4 as female, including 2 children and 4 adults, aged between 15 and 36, M = 25.5, SD = 8.8), 3 visitors (2 people identified as male, 1 as female, aged between 21 and 32, M = 26.3, SD = 5.5), 1 local tourism practitioner (female, aged 26) in total. The goal of organizing this workshop is to capture the representative CH elements that suit multi-stakeholders' preferences, emotional tendency and identity. The workshop participants, different from those in the field study, were recruited through advertisements distributed in the village, adhering to the same inclusion criteria. All the participants signed the informed consent form. Given the limited familiarity of most local residents with VR technology, the workshop began with a introduction of VR-based CH experience cases. This introduction aimed to equip participants with foundational knowledge to conduct the subsequent participatory design. The collage board shown in the first and second section of Figure 6 was applied in the workshop, to capture and integrate representative cultural elements in the VR experience. We firstly invited 3 local residents to freely list and sketch tangible CH, intangible CH, and the values to their community.

The researchers then categorized, and mapped the mentioned elements, into five categories (see the first section of Figure 6), following the Scene Theory (Bartlett et al., 2003; Siliutina et al., 2024; Silver et al., 2010; Silver & Clark, 2016a), to systematically categorize and integrate tangible and intangible CH. Scene Theory states that the cultural contents in a space can effectively described with the following five components: (1) neighborhood, (2) physical structures, (3) people labeled by different demographic characteristics, (4) the specific combinations of these people and activities, and (5) the value bred in the scene (Bartlett et al., 2003; Siliutina et al., 2024; Silver et al., 2010; Silver & Clark, 2016a).

After this step, we showed the collage board to 3 visitors, 1 local tourism practitioner, and another group of 3 local residents (different from the 3 local residents involved in listing CH elements at the beginning), to invite them to annotate the elements demonstrated on the board following the instructions in the second section of Figure 6. In accordance with the design goal, these instructions were structured following one's emotional tendency and identity towards a certain CH element. Finally, the elements to be presented in VR (fourth section of Figure 6) were decided by the researchers, following the inclusion criteria introduced in the third section of Figure 6. Then in Figure 7, we introduce the elements that are captured and integrated in the VR experience from various aspects in Figure 7, it is clear that the

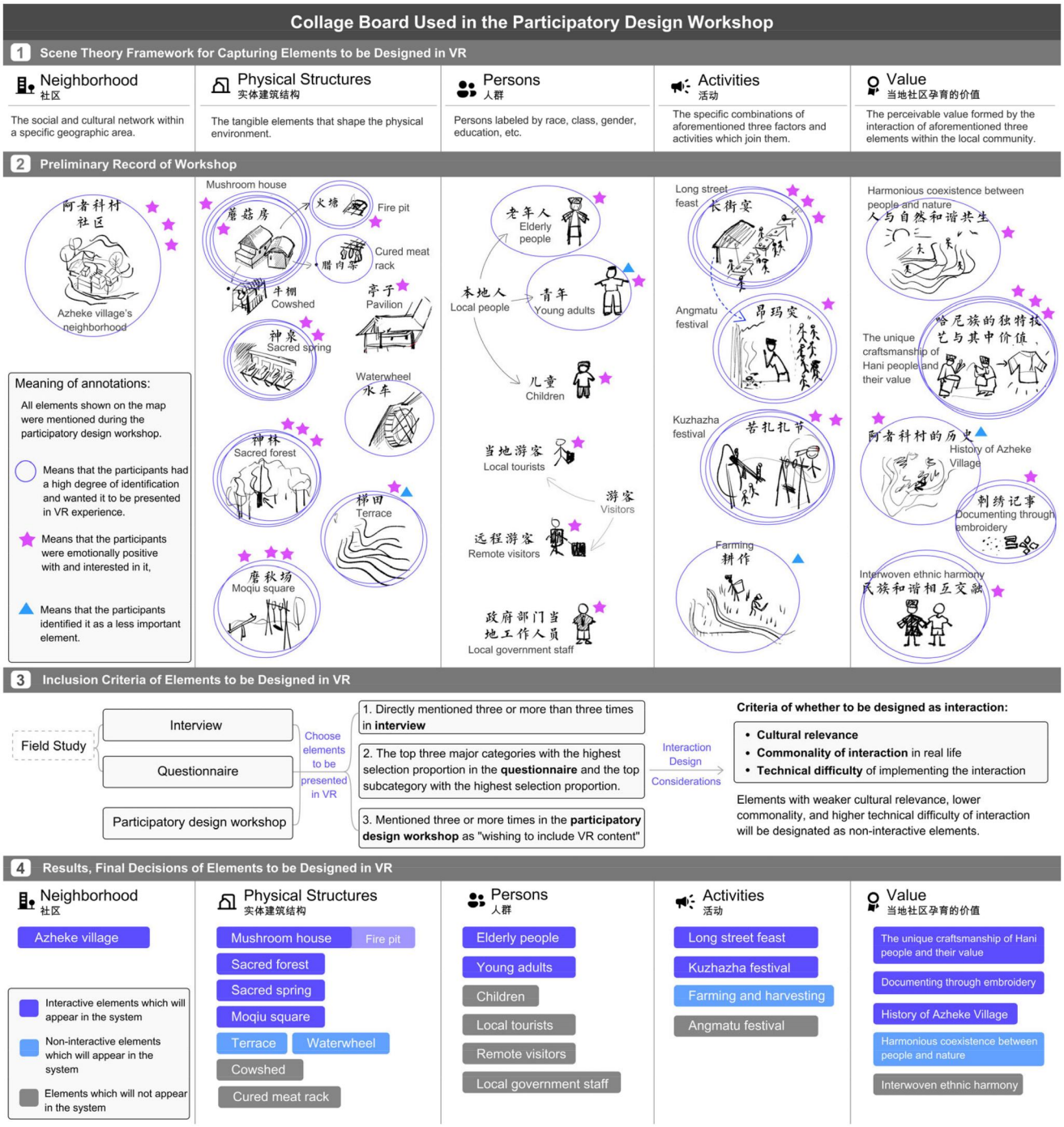


Figure 6. Introduction of the participatory design workshop. (1) Section 1: introduction of the five categories of the Scene Theory Framework used for capturing CH elements; (2) Section 2: preliminary record of the collage board with sketches and annotations; (3) Section 3: inclusion criteria of elements to be designed in VR; (4) Section 4: results and final design decisions. (Note: the original template was in Chinese, we added the translations after the workshop).

selection of CH elements and interaction design can reflect the unique cultural characteristics of the indigenous community.

4.3. VR experience design: scenes, narratives, and interactions

After the participatory design workshop, we developed the scenes, narratives, and interactions. The whole VR experience contains three scenes, each with different interactive tasks and themes. Here, we use Figure 8 to comprehensively introduce the interaction points, tasks, related cultural implications and emotional considerations of interaction design. Users use the joystick on the VR device controller to move in the virtual world. The interactive tasks in the entire VR experience are relatively simple to operate easily, and the instructions on how to interact will be shown in text forms in the VR experience. When interacting in the VR experience, the user can feel the actual haptic feedback (vibration) from the handle controller.

Scene 1 aims to let the user freely explore the village and interact with the typical tangible CH, to build their curiosity

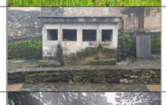
		Element	Photo	3D Modelling & Rendering	Features & Cultural Relevance	Category
Tangible CH	Design for Interaction	Mushroom House			• The most **distinctive** dwellings of the Hani • Named for their **mushroom-like shape** • **Inspired by** insects sheltering under wild mushroom caps, according to legend	**Architecture**
		Fire Pit			• Serves **practical purposes**: cooking, drying food, and providing warmth • Symbolizes the **Fire worship** in Hani beliefs • Every Mushroom House has a central fire pit	**Daily Necessity Belief**
		Sacred Forest			• The **most revered place** for the Hani people • **Entry is forbidden** and plants are protected • **Prayers** are offered for favorable weather and a good harvest during festivals and rituals	**Belief**
		Sacred Spring			• Sacred spring is considered **a gift from the gods** • The Hani obtain their **daliy water** from it • Water is believed to have magical powers of **purification, healing, and blessing**	**Daily Necessitiy Belief**
		Moqiu Square			• A **recreational space** for the Hani people • Moqiu has its **origin legend**, which highlights the resilience and bravery of the Hani people • Also a venue for **festival celebrations**	**Entertainment Festival**
	No Interaction	Terrace			• Terraces are fields resembling steps, transformed from mountain slopes • A unique **local landform**	**Landform**
		Waterwheel			• Harness the power of flowing water to **generate motion** • Azheke Village has many waterwheels along the springs formed by elevation differences • Commonly used for **grinding grains**	**Daily Necessity**
Intangible CH	Design for Interaction	Long Street Feast			• Key part of **Hani festivals** (e.g., **Angmatu Festival**) and agricultural celebrations • Symbolizes **celebrating the harvest**, **praying for happiness, and honoring ancestors**	**Festival Cultural Activitiy**
		Kuzhazha Festival			• Holds **mythical and agricultural** significance • It is celebrated **in gratitude for a celestial being** • The festival's main activities center around **Moqius**, including building and playing Moqiu	**Festival Culture Activity Belief**
		Documenting through embroidery			• **Documenting through embroidery**: The Hani use "**embroidered records**," where patterns represent objects, stories, and meanings. It serves as a way to **preserve and pass down Hani history**	**Craft**
	No Interaction	Farming			• The **Hani terraces** and **farming methods** reflect their adaptation to and transformation of nature. • This agricultural lifestyle has **shaped the cultural and human landscapes** of the Hani people	**Farming System**
Other	No Interaction	Harmonious Coexistence between People and Nature			• Reflects the **Hani's philosophy** of living in harmony with nature • Their **"four elements in harmony"** concept includes forests, water, terraces, and villages coexisting in balance	**Spiritual Value**

Figure 7. Introduction of the CH and other elements captured to be presented in the VR experience: (1) the real photo of the CH element, (2) design outcome of the 3D modelling and rendering of CH in VR, (3) the features and cultural relevance analysis of each CH element in VR, and (4) the general category of each CH element.

and familiarity with the virtual environment. The overall layout of the village in the VR scene is consistent with the real village. The entire process is guided by a map with three interaction points on: Mushroom House, Sacred Spring, and Moqiu Square. The three interaction points are initially highlighted on the map. Each aforementioned interaction point has a different interactive task: (1) open the door of a Mushroom House and visit inside (touch the doorknob with virtual hand), (2) hold the spring water with your hands (touch the water with virtual hand), and (3) touch the Moqiu (similar to a swing) (touch pillar of Moqiu with virtual hand). After completing each interaction task, the previously highlighted point will dim. Finally, the map will appear again with directions highlighted on the ground, guiding the user to Scene 2.

Scene 2 focuses on presenting traditional activities (i.e., the intangible CH), which includes interacting with three non-player characters (NPCs), and completing three interactive tasks: (1) interact with a man in the sacred forest (move to the forest highlighted on the map), (2) sit and join the meal under the guidance of the elderly woman in the Long Street Feast (press the button), and (3) help a girl get on the Moqiu and swing (press the button). After completing a certain interactive task, the scene in VR changes, and then the user will be guided by an NPC to the next task. Scene two intended to convey a lively community atmosphere with many villagers engaged. Through contextual interactions, users participate in local life, aiming to foster a sense of belonging and affinity with the local community. At the end of this scene, a grandmother will guide the user to the rice terraces, where Scene 3 begins.

Scene 3 is designed to guide users to reflect on the current situation faced by the village and evoke their emotional resonance. Through interactions with the elderly woman and the story of Azheke Village told by her (press button), users learn about its history, challenges of the preservation of cultural heritage, and the characteristic way the Hani people record history through embroidery. Finally, the elderly

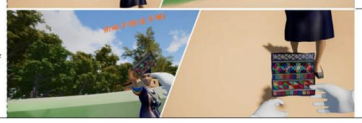
Scene	Interaction Point	Interaction Task		Cultural Implications of Interaction Design	Emotional Design Considerations
Scene 1	1.1 Mushroom House	Open the door (Touch the doorknob with virtual hand)		Mushroom houses and fire pits are the living spaces of the Hani people. **Entering the mushroom house and observing the fire pit** provides a basic understanding of the core elements of the Hani people's daily life and living environment.	Curious, Surprised, Interested
	1.2 Sacred Spring	Pick up water (Touch the water with virtual hand)		Sacred Spring is an important part of the Hani people's belief system. **Picking up the sacred spring with both hands** symbolizes the acceptance of sacred spring's blessings and the wishes for the removal of illness and good health.	
	1.3 Moqiu Square	Touch Moqiu (Touch pillar of Moqiu with virtual hand)		The swing ground is an important public space for the Hani people. **Touching the swing** serves as a record of the user's visit to the swing ground and helps the user understand the uniqueness of these objects.	
Scene 2	2.1 Sacred Forest	Interact with the man (Move to the forest highlighted on the map)		**Users see the village chief complete the ritual and leave the sacred tree.** Although the sacred forest is the most important part of the Hani belief system, outsiders are generally not allowed to enter. Here, users can experience the sacred forest up close and sense its uniqueness.	Welcomed, Happy, Accomplished, Connected
	2.2 Long Street Feast	Sit and join the feast (Press the button)		The long street banquet is the central part of many festivals. **Being invited by locals to join the Feast** showcases the Hani people's hospitality, giving users a sense of closeness and belonging.	
	2.3 Kuzhazha Festival	Help the girl swing (Press the botton)		The main activities of the Kuzhaza Festival revolve around the swing. Users watch the scenes of the Kuzhaza Festival and interact with locals by **helping them swing, thereby participating in the festival.**	
Scene 3	3 Listen to the story	Watch people farming (Press the botton)		**When grammy tells the stories of Azheke Village's past, user can see scenes corresponding to them.** Scenes depict men and women working in the fields, allowing user to immerse themselves in the history and stories of Azheke Village.	Touching, Reflective
		Receive the handkerchief (Touch the handkerchief with virtual hand)		**After watching the story of Azheke village, the grammy hands user an embroidered handkerchief.** By giving the handkerchief to the user, the grammy symbolizes the passing down of history and cultural stories, represents her hope that the user will become someone who continues to share these stories and Hani culture.	

Figure 8. Introduction of the scenes and interactions in VR: (1) interaction point, (2) interaction task (with corresponding screenshots), (3) cultural implications of interaction design, and (4) initial emotional design considerations.

woman gifts an embroidered handkerchief to the user, establishing an emotional connection and symbolizing the transmission of Hani culture. The user needs to receive the handkerchief (touch the handkerchief with virtual hand), and the whole VR experience ends.

4.4. Technical implementation

We used XR interaction toolkit in Unity 3D to create the whole environment. The project was developed on a computer with Intel Core i7 and NVIDIA GeForce GTX 1660 SUPER. Meta Quest 3 was used as the headset to conduct the user study. Rhino 7 and SketchUp were used for 3D modeling. With these two software programs, we modeled 4 NPCs, 14 intangible CH and other objects, 5 buildings, 4 types of landscape elements such as trees and flowers, and the rice terraces consisting of 13 levels. Textures were created manually in Clip Studio Paint and mapped onto the 3D models in Blender. To create a consistent art style for the VR experience, we took inspiration from the video game Disco Elysium (Domingues et al., 2024), which features a painterly style, based on oil painting (Watson, 2018).

5. User study

In the user study, we evaluated the effects of VR experience on evoking users' emotional responses and enhancing heritage identity using both quantitative and qualitative measurement methods. We also investigated whether emotional changes influenced their heritage identity.

5.1. Participants

38 participants were recruited through advertising. The inclusion criteria were: (1) having no previous experience with VR (for all users), (2) having no experience of traveling to the village before (for all visitors), and having not yet entered the village when they were recruited (for local visitors). They were divided into three groups. Group 1 consisted of 10 participants (3 people identified as male, 7 as female, including 7 children and 3 adults, aged between 10 and 23, $M = 16$, $SD = 4.3$), all local residents of the Azheke Village. Group 2 consists of 13 participants (8 people identified as male, 5 as female, including 6 children and 7 adults, aged between 12 and 29, $M = 19.1$, $SD = 6.9$), all tourists visiting the Azheke Village. Group 3 was composed of 15 participants (11 people identified as male, 4 as female, aged between 19 and 29, $M = 20.5$, $SD = 2.6$), all university

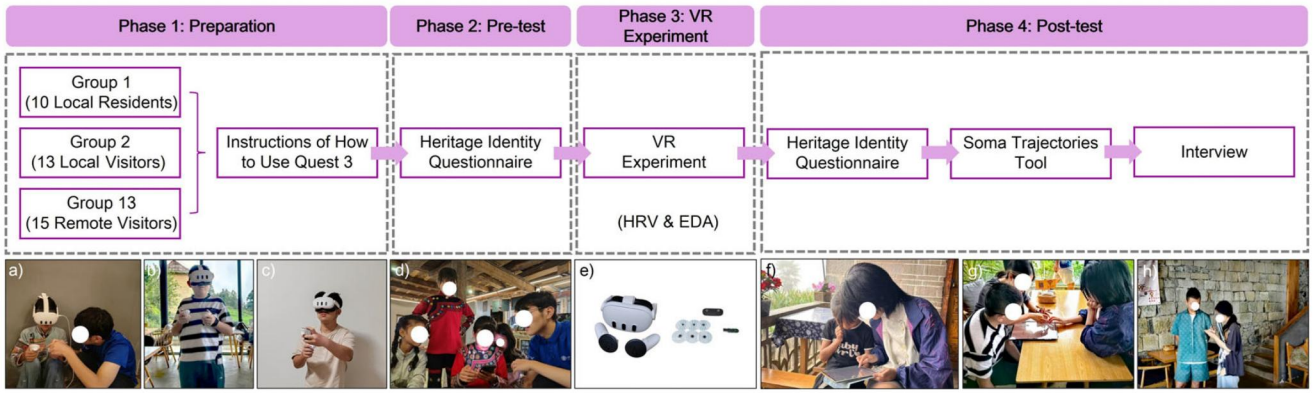


Figure 9. Procedure of the user study. The upper part shows the overall procedure, while the lower part presents the photos collected in user study: (a) local resident, (b) local tourist, (c) remote visitor; (d) a local resident is filling in the questionnaire; (e) Meta quest 3 (left side) and the sensors, electrodes used for collecting physiological signals (right side); (f & g) a local resident and tourist are drawing with the soma trajectories tool; (h) a researcher is interviewing with a local visitor.

students (from undergraduate to doctoral students) serving as remote visitors. The user studies with group 1 and 2 were conducted in the Azheke Village, while the user study with group 3 was conducted remotely, at a Chinese university. All participants signed the consent form at the beginning. At the end of the experiment, the participants were gifted a DIY craft as a reward. The user study was approved by the institutional ethics committee of the first author.

5.2. Procedure

The whole procedure lasted for around 30 min. Firstly, an instruction on how to use Meta Quest 3 was provided. To reduce the novelty effect of the VR equipment, participants underwent a familiarization phase before the experiment. This phase ensured that any physiological or emotional responses triggered during the main VR experience were less likely to result from the use of the equipment itself. Secondly, the self-developed heritage identity questionnaire was filled in by the participants as a pre-test. Then, the participants were equipped with wearable sensors near the chest, subsequently donned the VR headset, and acquired the controllers to interact with the VR system. After the VR experience, the questionnaire was filled in again as a post-test. Finally, the soma trajectories tool and interview were conducted with the participants (see Figure 9). Specifically, the children enrolled in this experiment were all accompanied by their guardians. Detailed instructions on how to complete each task in the user study were provided to all the participants by the researchers.

5.3. Evaluation methods

5.3.1. Capturing emotional responses through physiological signals

Users' emotional response to VR experience was measured through electrodermal activity (EDA) and heart rate variability (HRV). These were collected during the VR experience using a Sichray low-power Bluetooth ECG sensor near the chest, with the chip BMD 101 from Neurosky (Kjeldaas, 2018; Mu et al., 2024). To map the signals to emotions, we relied on the Pleasure-Arousal-Dominance (PAD) framework (McDermott et al., 2013), which is an approach to assess environmental perception, experience, and psychological responses (Bakker et al., 2014). We used two common factors (P and A) of the PAD framework that relate to HRV and EDA respectively (Shoval et al., 2018b). Pleasure (P) refers to the positivity or negativity of the emotional state, while arousal (A) represents the neuro-physiological activation level and excitement (Mehrabian, 1974). The signal processing was conducted in Matlab R2023b and finally calculated two types of data: LF/HF ratio (LF: low frequency, HF: high frequency) and z-SCL value (skin conductance normalized into z-score) to represent HRV and EDA respectively (Selmanović et al., 2020; Shoval et al., 2018a), the technology paths of the physiological signal processing are as follows:

HRV: (1) remove low-frequency (such as baseline drift) and high-frequency (such as noise) interference with second-order Butterworth bandpass filter, retaining only the main frequency band of the ECG signal (0.5 Hz–40 Hz); (2) detect the R-peak in ECG using findpeaks function; (3) calculate the time intervals between successive R-peaks to create a series of inter-beat intervals (IBIs); (4) use interpolation techniques to resample the IBI data at 4 Hz; (5) perform spectral analysis on the resampled IBI series to estimate the power spectral density (PSD); (6) calculate the power in specific frequency bands (LF Band: 0.04–0.15 Hz, HF Band:0.15–0.40 Hz), then sum the power within these frequency ranges to get the LF and HF values, finally calculate the LF/HF ratio by dividing the power in the LF band by the power in the HF band.

EDA: (1) filter the raw EDA signal to remove the noises and artifacts using Butterworth filter with a cutoff frequency of 1 Hz; (2) divide the EDA signal into segments; (3) compute the overall mean and standard deviation of the Skin Conductance Level (SCL) values across all windows; (4) calculate the z-score of the SCL for each window to eliminate the influence of individual differences on SCL values.

As for the LF/HF ratio calculated from HRV, it relates to emotional pleasure (P) (Unger & Wandersman, 1985), the low ratio refers to positivity while the high ratio refers to negativity (Lee et al., 2024; Kang et al., 2023). As for the z-SCL value calculated from EDA, it relates to emotional arousal (A) (Petrelli et al., 2023) and a high value means a high level of emotional arousal (Shi et al., 2017; Shoval et al., 2018a). In this study, we calculated and analyzed the

LF/HF ratio and z-SCL value from the whole-process signals: (1) in the first and last 100 s of the whole VR experience, and (2) at each interaction point. Specially, to avoid potential delays and inaccuracies in collecting physiological data in VR environment: (1) we utilized timestamp markers for key events in user log. These markers captured representative user actions at specific scenes and interactions to align and extract relevant physiological signals, therefore enabling accurate and valid correlation analysis between data fluctuations and specific interactions; (2) prior to the experiment, baseline physiological signals were collected (e.g., variations caused by physical activity), and filter these data during the data processing. In the initial phase of data processing, anomalous data (e.g., those resulting from device connection issues) were excluded. Ultimately, no excessively high or low outliers were identified in the dataset. Regarding the choice of physiological computing, two aspects were considered: (1) our goal was to capture real-time emotional responses during the entire VR experience, which physiological measures are well-suited for; (2) during preliminary testing, we found that traditional questionnaires, such as PANAS (Waterton & Smith, 2010), caused confusion among local residents, increasing cognitive workload and impacting the study's feasibility. Furthermore, related questionnaires are not suitable for understanding real-time emotional responses throughout the whole experience.

5.3.2. Recalling emotional experience using soma trajectory tool

To discover the users' emotional experience qualitatively, the soma trajectories tool was adopted to ask users to recall and interpret their somaesthetic experience after the VR experiment, which is a journey of complex, nuanced, changing sensations and feelings (Sun et al., 2024). The tool used in this study was based on a linear chart with time on the x-axis and the soma experience one wishes to articulate on the y-axis. The x-axis represents the whole process of the VR experience consisting of three scenes, which were divided by different interaction markers of the system. For the y-axis, we selected two sets of emotions from the emotion typology (Desmet, 2012; Fokkinga & Desmet, 2016): sensory pleasure < - > displeasure and admiration < - > dislike. This tool required the participants to recall and draw out individual emotional experiences during the whole VR experiment with annotations or oral explanations (see Figure 14 in Appendix C for the template of the soma trajectories tool).

5.3.3. Measuring heritage identity through a self-developed questionnaire

In this study, we aim to measure users' heritage identity, to explore whether the VR experience can change their heritage identity towards the CH of the village. We developed a questionnaire (see Table 3 in Appendix D), based on the value-based approach (Lupo, 2023; Tong et al., 2024) that has been widely adopted in heritage studies, aiming at capturing value-based heritage identity. There are various classifications of heritage values, including aesthetic (Bhandari et al., 2016; De la Torre, 2002; Tong et al., 2024) historical (Ahmer, 2020; Bhandari et al., 2016; De la Torre, 2002; Tong et al., 2024), cultural (Venice Charter, 1964; English Heritage, 1997), social (Bhandari et al., 2016; De la Torre, 2002; Tong et al., 2024), economic (De la Torre, 2002), and scientific value (Bhandari et al., 2016; Tong et al., 2024). Among them, scientific value refers to whether the place has the potential to add to information that will enhance human knowledge and understanding of the natural, historical aspects and culture of the region (Bhandari et al., 2016). As the aim of this study is not to use VR to enhance knowledge acquisition and understanding, we excluded it and finally selected aesthetic, historical, cultural, social, and economic values that were in line with the Burra Charter (Tong et al., 2024), and used the identification towards them as factors of value-based heritage identity. Finally, the questionnaire was developed to measure the changes in heritage identity after VR experience, which contains 5 sub-scales. The Cronbach's alpha of the questionnaire is 0.98, indicating high internal consistency among the items measuring heirtage identity (Fornell & Larcker, 1981). As this questionnaire was designed to be as simple and easy to understand as possible initially, during the actual experiment, most of the participants can understand the questions easily. If some participants still did not understand the questions, we would provide them with some explanations without interfering with the reliability of the data collected from the questionnaire.

5.3.4. Capturing (additional) reflections on emotional experience and heritage identity in an interview

We interviewed with each participant from different aspects: (1) recalling and describing their emotional experience, (2) their attitude towards the CH of the village, and (3) their attitude towards VR technology for revitalizing CH. The initial transcript was recorded and generated using the transcription tool embedded in iFLY TEK, and subsequently reviewed and corrected by two authors. The transcript of the interview was then translated from Chinese to English by two authors and checked by other authors.

5.4. Data analysis

5.4.1. Quantitative data analysis

The statistical analysis of all the quantitative data (physiological signals, questionnaire) was conducted using IBM SPSS version 26. The differences in all data between the three groups were tested using one-way ANOVA. The differences between pre- and post- tests within each group were compared using paired t-tests. The correlations between emotional changes and changes in heritage identity were analyzed using Pearson correlation analysis. A p-value of < 0.05 was considered statistically significant.

5.4.2. Qualitative data analysis

The qualitative data collected from the interview after the VR experience were analyzed following the thematic analysis

(Clarke & Braun, 2013; Fereday & Muir-Cochrane, 2006). Two authors conducted a thematic analysis on the transcripts of the semi-structured interview after the VR experience, where both authors read the transcripts to gain a sense of the data and then developed a set of initial codes independently. They then discussed their initial codebooks and reached an agreement to identify the common themes. The emerged themes will be reported and analyzed in next section.

6. Results

6.1. Emotional responses during the VR experience (RQ1)

6.1.1. Quantitative results: physiological signals

We here report (1) emotional responses before/after VR experience, and (2) emotional responses at each interaction point, all indicated by physiological signals.

6.1.1.1. Emotional responses before/after VR experience. We collected the physiological signals of the first and last 100 s of the whole VR experience, to conduct a pre- and post-test. The normality of the paired differences was assessed using the Shapiro-Wilk test. The results indicated that the paired differences follow a normal distribution (HRV: Group 1: $W = 0.937$, $p = 0.638$; Group 2: $W = 0.870$, $p = 0.225$; Group 3: $W = 0.927$, $p = 0.243$. EDA: Group 1: $W = 0.881$, $p = 0.341$; Group 2: $W = 0.908$, $p = 0.339$; Group 3: $W = 0.842$, $p = 0.081$). The ANOVA test shows that there are no significant differences in the LF/HF ratio ($F(2)=0.112$, $p = 0.894$) and z-SCL value ($F(2)=1.933$, $p = 0.168$) among the three groups in pre-test. As shown in Figure 10, the paired t-test shows that remote visitors (average ratio: 0.71 vs 0.38, $p = 0.0442 < 0.05$, $t = 2.211$, df = 14, SD = 0.5717) and local visitors (0.71 vs 0.43, $p = 0.0022 < 0.05$, $t = 5.782$, df = 5, SD = 0.1161) underwent significant decreases in LF/HF ratio (HRV), which is indicative of a positive response to the VR experience. However, there is no significant difference in the changes in the LF/HF ratio (HRV, emotional pleasure) of the local residents (0.72 vs 0.40, $p = 0.0822 > 0.05$, $t = 2.574$, df = 3, SD = 0.2192). This might be because the local residents are already very familiar with the content presented in VR so their emotions are relatively flat. Meanwhile, the paired t-test shows that all three groups had significant decreases in the z-SCL value (EDA, emotional arousal) (Group 1: 1.26 vs −0.75, $p = 0.0048 < 0.05$, $t = 5.671$, df = 4, SD = 0.7944; Group 2: 1.90 vs −1.06, $p < 0.05$, $t = 5.593$, df = 7, SD = 1.117; Group 3: 1.01 vs −1.21, $p = 0.0003 < 0.05$, $t = 5.010$, df = 12, SD = 1.345), meaning that all three user groups showed a significant decrease in emotional arousal after the VR experience (see Figure 10).

In general, the results show that the participants underwent a decrease in emotional arousal and an increase in emotional pleasure. Regarding this phenomenon, we refer to the Pleasure-Arousal Theory (Pisoni et al., 2021) to interpret these results: this change of emotional responses corresponds to the "pleasure-deactivation" affective states, characterized by specific emotions such as contentment, appeasement, and comfort. It indicates a psychological state of ease, satisfaction, and tranquility experienced by users after engaging with the virtual CH experience.

6.1.1.2. Emotional responses at the interaction points. We also calculated the LF/HF ratio and z-SCL value at each interaction point, in order to understand how the different interactions evoked users' emotional responses, and how this changed over time. We visualized the data on the VR experience map at each interaction point which can be called "emotional map (Georges et al., 2020) ," using different colors to represent the average values of the LF/HF ratio and z-SCL of each group and the diameter of the circle describe the extent of emotional change (refers to the instantaneous change in emotion from the last interaction point to the next interaction point) (Shaffer & Ginsberg,

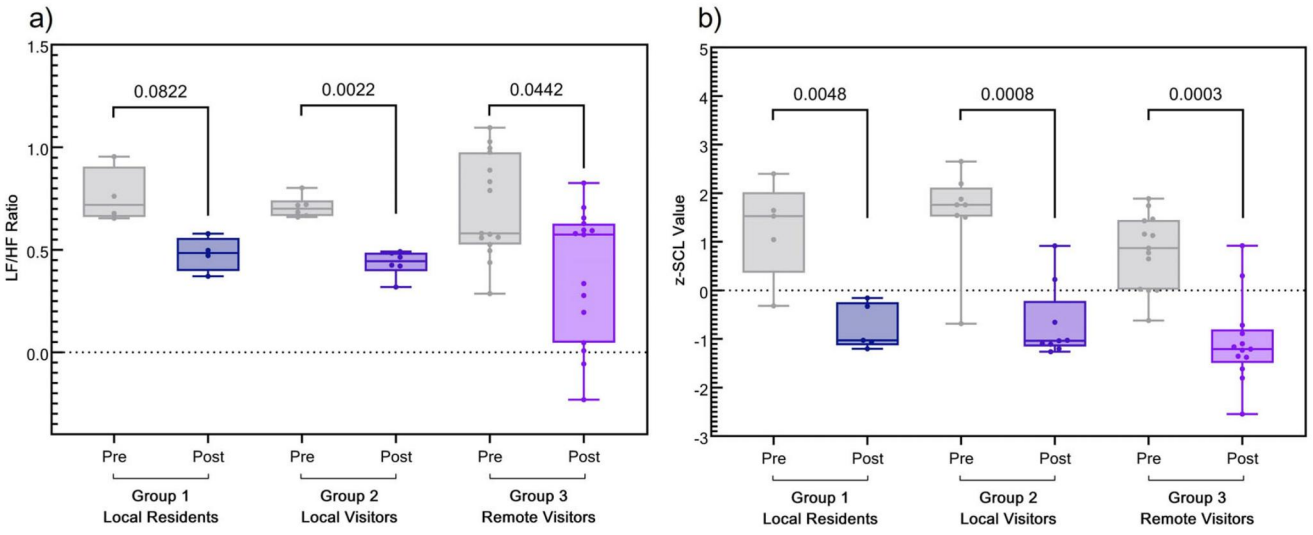


Figure 10. Emotional responses before/after the VR experience indicated by pre- and post-test of physiological signals: the paired t-test shows the emotions of all three user groups were significantly aroused after VR experience [z-SCL calculated from EDA, (b)], while only remote visitors and local tourists became significant more pleasure and positive after experiencing VR [LF/HF ratio calculated from HRV, (a)]. A p-value of < 0.05 was considered statistically significant.

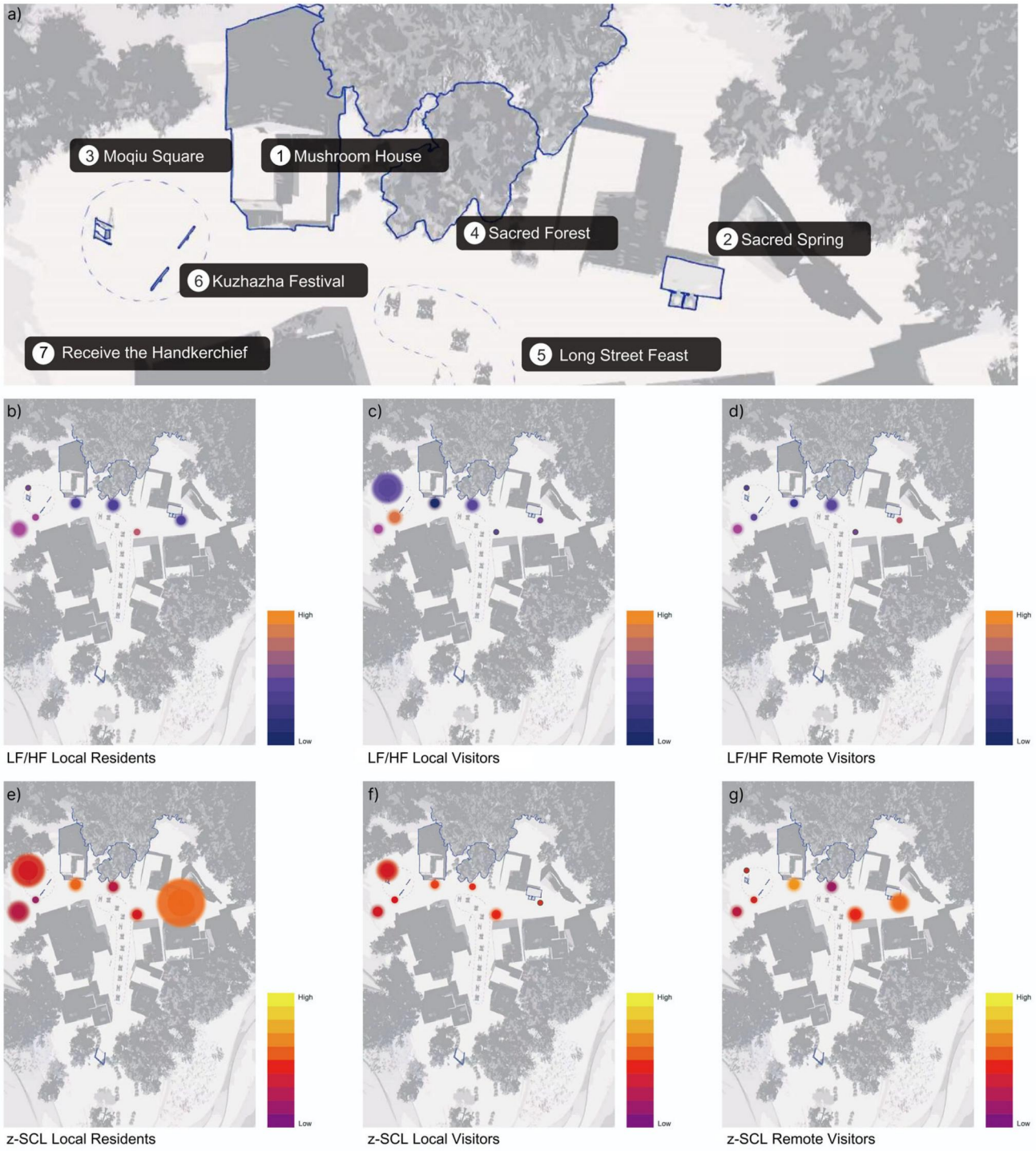


Figure 11. Emotional map: to visualize the emotions of three user groups at each interaction point. The first and second row shows the visualization of the LF/HF ratio (HRV, emotional pleasure) and z-SCL value (EDA, emotional arousal) of each user group respectively. The complete dataset used for the visualization on the map can be found in Table 5.

2017). Figure 11 shows the maps of the emotion of each group visualized by both LF/HF ratio (emotional pleasure) and z-SCL value (emotional arousal) respectively (complete dataset can be found in Table 5 in Appendix).

As for the local residents, Figure 11b shows the LF/HF ratio of the local residents were relatively stable at a low level (high emotional pleasure). In Figure 11e the z-SCL value (emotional arousal) of local residents changed strongly from interaction point 1 to 2 (visualized at point 2, Sacred Spring) and from interaction point 3 to 4 (visualized at point 4, Sacred Forest). In general, their emotions were relatively positive throughout the whole process.

For the local visitors (Figure 11c) shows that their LF/HF ratio stayed mostly at a low level (high emotional pleasure) throughout the entire experience, especially during the initial stages of the VR experience. From interaction point 2 to 3 (visualized at point 3, Moqiu Square), the LF/HF ratio (emotional pleasure) changed significantly. In Figure 11f, their z-

SCL value (emotional arousal) was consistently at a medium level. There was also a significant change in emotional arousal from interaction point 2 to 3 (visualized at point 3, Moqiu Square).

For the remote visitors, Figure 11d shows that their LF/HF ratio remained at a relatively low level (high emotional pleasure) throughout the process, with minimal variation, indicating that the remote visitors had a generally positive experience in the VR system, but the trend of change was relatively flat with minor differences in emotional responses at different interaction points. However, Figure 11g illustrates that the z-SCL values (emotional arousal) fluctuated significantly throughout the VR experience, although the changes were relatively uniform. Significant changes were observed at interaction point 1 (Mushroom House), from point 1 to 2 (visualized at point 2, sacred spring), and from point 4 to 5 (visualized at point 5, Long Street Feast). Overall, the degree of emotional arousal in remote visitors showed a gradually decrease during the VR experience, which means their emotional arousal levels declined throughout the process, leading to a state of high pleasure and low emotional arousal.

Through synthesizing different user group's results, we find that the VR experience can generally can evoke users' emotional responses through interactions using the NPCs and digital representation of local cultural activities, within a VR experience.

6.1.2. Qualitative results: self-recall of emotional experience during whole VR experience

We combine the individual responses collected using the soma trajectories tool, and plot them together per group in one figure, providing a visual means to analyze the subjective feedback. Some responses are marked in grey, which came from participants who mentioned that they suffered from motion sickness.

Figure 12 (left) shows the trajectory responses to the sensory pleasure < - > displeasure dimension. Firstly, most local residents on the whole started and remained positive throughout the whole experience. Secondly, local visitors show a gradual upward trend (i.e., becoming more positive). However, a few responses showed a downward trend (in grey). Thirdly, remote visitors had different subjective feedback: (1) became more and more positive, (2) a peak appeared in Scene 2 but the beginning and end are at a low level (in grey), and (3) a downward trend throughout the whole process (in grey, may due to the motion sickness as reported by the participant P3.12 in the interview after the VR experience).

Figure 12 (right) visualizes the trajectory responses on the admiration < - > dislike scale. Firstly, as for the emotional experience of the local residents, they remained mostly at a high level, though some curves show a downward trend in the third scene. Secondly, most local visitors underwent a gradually increasing trend, although a few of them show a trend of increasing first and then decreasing (in grey). Thirdly, feedback from the remote tourists can be described as: (1) the level of admiration increased over time, (2) a peak appears in Scene 2 but the beginning and end are at a low level (in grey), and (3) a downward trend throughout the whole process (in grey).

6.2. Changes of heritage identity (RQ2)

The normality of the paired differences was assessed using the Shapiro-Wilk test. The results indicated that the paired differences follow a normal distribution (Group 1: $W = 0.850$, $p = 0.074$; Group 2: $W = 0.796$, $p = 0.074$; Group 3: $W = 0.980$, $p = 0.976$). In the pre-test, the ANOVA test shows no significant difference ($F(2)=1.662$, $p = 0.207$) in cultural heritage value identity between the three groups. After the VR experience, as shown in Figure 13a, compared with the pre-test, the heritage identity of Group 2 (13 local visitors) and 3 (15 remote visitors) shows significant improvement respectively (average scores: 81.64 vs 100.09, $p = 0.0014 < 0.05$, $t = 4.362$, df = 10, SD = 14.03; 72.40 vs 91.53, $p = 0.0003 < 0.05$, $t = 4.844$, df = 14, SD = 15.30) in paired t-test. Although Group 1 (10 local residents) shows no significant difference in overall scores (80.71 vs 94.43, $p = 0.9767 > 0.05$, $t = 0.03049$, df = 6, SD = 24.79), the paired t-test shows that it improved significantly in aesthetic (17.67 vs 22.11, $p = 0.0268 < 0.05$, $t = 2.914$, df = 6, SD = 4.928), cultural (17.11 vs 22.89, $p = 0.0097 < 0.05$, $t = 3.729$, df = 6, SD = 4.967) and social (18.44 vs 23.00, $p = 0.0426 < 0.05$, $t = 2.565$, df = 6, SD = 5.305) value-based heritage identity, as shown in Figure 13b.

6.3. Influences between the emotional responses and heritage identity enhancement (RQ2)

The two-tailed Spearman's r correlation shows that there are no significant correlations between emotional changes and improvement of both total scores and each factor of heritage identity in Group 2 (local tourists) and Group 3 (remote visitors). However, in Group 1 (local residents), there is a significant positive correlation ($r = 0.906$, $p = 0.034 < 0.05$) between changes of emotional arousal (z-SCL value, EDA) and enhancement of heritage identity towards the social value of the CH in Azheke Village. This finding indicates that there is a mutual influence between these two factors in local resident group. Complete Spearman's r correlation results are reported in Appendix F.

To interpret the core findings in the local residents group, we refer to the state-of-the-art psychology research related to the approach-motivated positive affect (e.g. (Gable & Harmon-Jones, 2008)). As reported in the subsection 6.1.1, the local residents underwent decrease in emotional arousal level, together with increase in emotional pleasure, this phenomenon indicates that they entered a low-approach-motivated positive affective state. This state relates to the expansion of user's attentional breadth and the broaden of cognition and attention within a comfortable and stable environment (Gable & Harmon-Jones, 2008). This emotional change might cause their social-value-based heritage identity enhancement, which allows them to shift their focus beyond the applications and familiar forms of

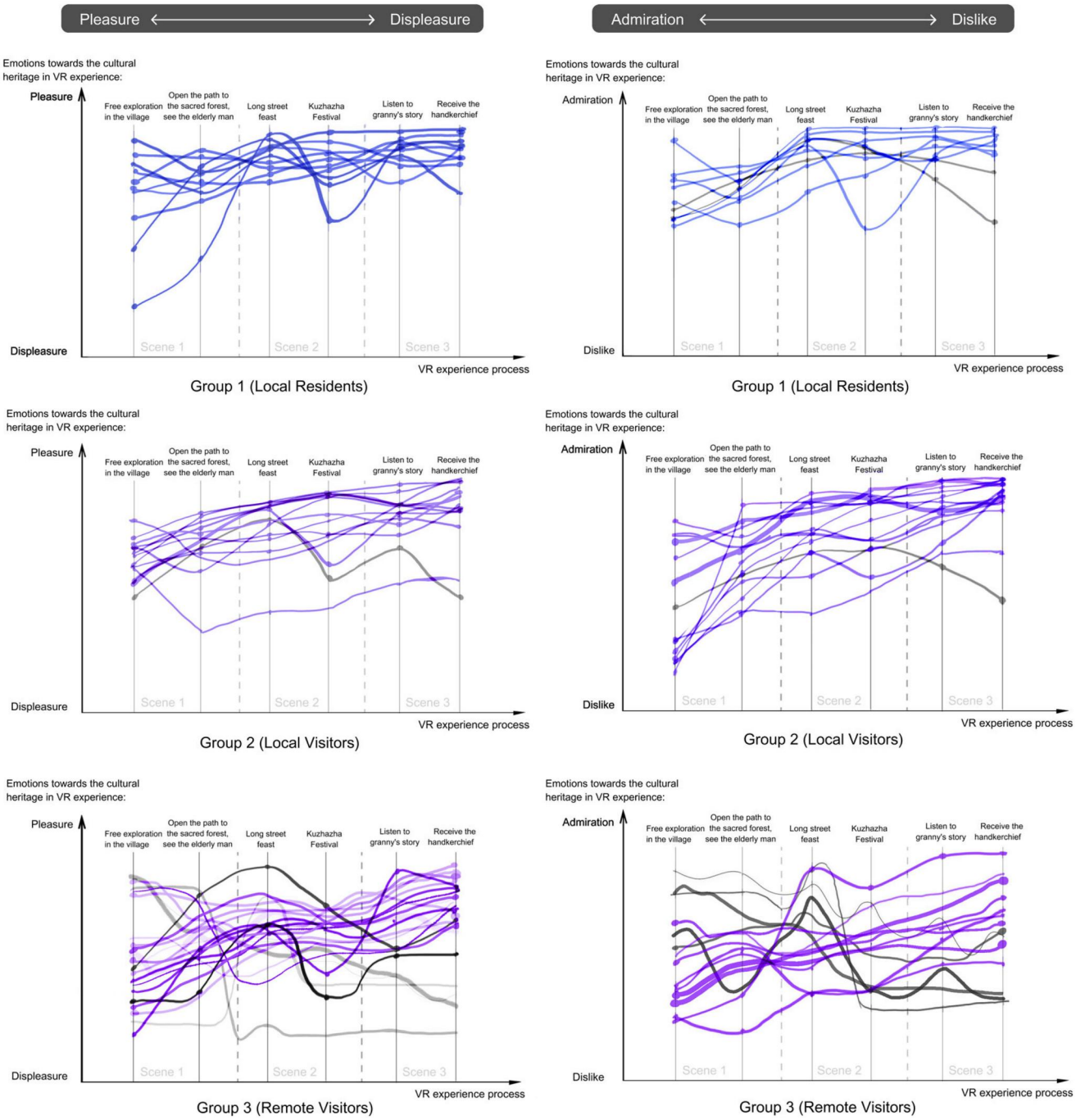


Figure 12. Feedback of pleasure < - > displeasure (left side), admiration < - > dislike (right side) from each group. The x-axis represents the different scenes and interaction points, while the y-axis refers to the soma experience one wishes to articulate. We digitised and integrated each group's feedback into one graph respectively, and used grey to mark the curves that are different from others.

CH in daily life, encouraging reflection on aspects such as community identity, uniqueness, sense of belonging, and cultural practices (Jones, 2017) regarding the social value of heritage which is a collective attachment to place that embodies meanings and values that are important to a community (Byrne et al., 2003; Jones & Leech, 2015).

6.4. Interview results (RQ1, 2)

In this subsection, we analyzed the representative feedback from the interview, and quoted what the participant said in text.

6.4.1. Arousing emotional responses through multiple design features of VR experience

The emotional responses can be aroused by VR experience from two aspects, indicated by the feedback from the interview. Firstly, the design of interactive tasks and scenes caused users' emotional responses to continuously change throughout the VR experience, as reported by participants P3.7 and P3.8. Secondly, we also find that the NPCs can effectively bring positive emotional responses to users, creating a deeper sense of immersion and enjoying emotional experiences (mentioned by P1.5, P2.8, P2.10, P3.10, P3.11). For example:

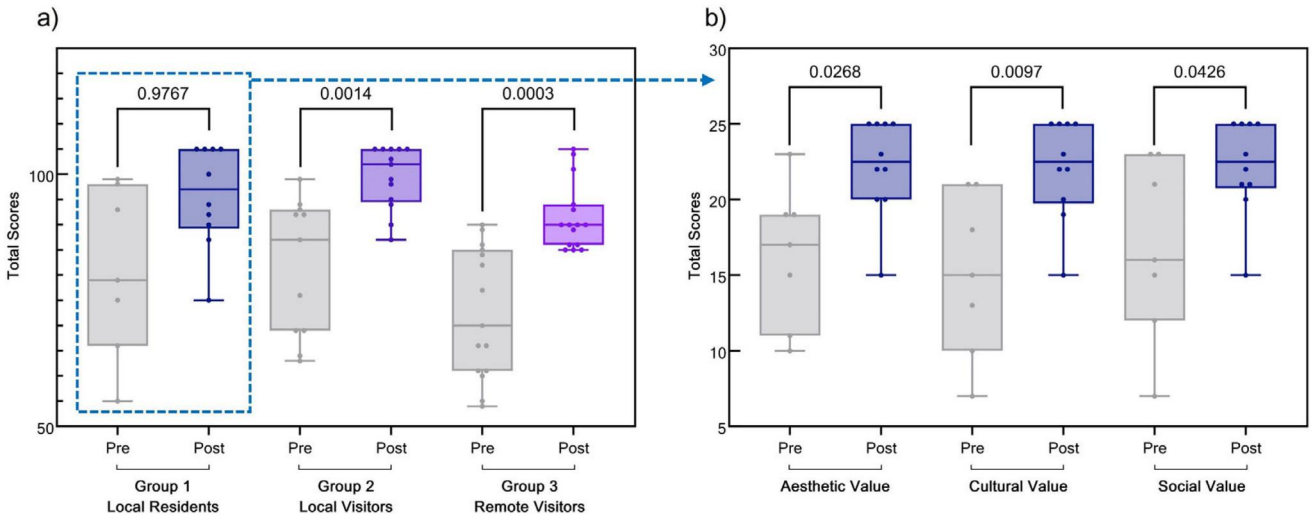


Figure 13. Changes of heritage identity indicated by the scores of pre- and post-test using the questionnaire: the paired t-test shows local tourists and remote visitors improved significantly after experiencing the VR system, while local residents only improved significantly in three aspects (aesthetic, cultural and social value-based heritage identity) but not on the total scores. A p-value of < 0.05 was considered statistically significant.

> When I started to explore freely, my emotions hasn't changed much. I was very curious when I saw the old man, and then I was amazed by the local culture when I went to the long street feast. Then … when I went to the Moqiu, I felt the rich culture. Then when I listened to the grandmother's stories and heard that no one was passing on the local culture, I was depressed. Finally, when I received the handkerchief, I realized that we should inherit and transmit local CH. (P3.7)

> … At the beginning of the VR experience, there was no change in my emotions … However, I felt excited when I saw and interacted with the characters later in VR … (P2.8)

However, users also reported the limitations of the accuracy of the 3D reconstruction of CH that can bring negative effects on their emotional experience. What is more, once the novelty of the VR form itself wears off, the perceived experience becomes quite ordinary (P2.3, P3.2), inspiring us to consider how to optimize the VR design:

> First, regarding the emotional changes during the experiment, in fact, only when wearing VR equipment at the beginning did I have a relatively novel experience. Later, the novelty gradually wore off and I found that there was nothing special … (P3.2)

6.4.2. Developing personal attitude towards CH of Azheke village through VR experience

As for the remote visitors (P3.13, P3.14), this VR experience, which integrates tangible and intangible CH with ethnic stories, can change their attitude from unfamiliarity to understanding, and eventually identifying Azheke Village. It can also inspire their desires to further learn about the local culture, often expressed as a wish to "visit the place":

> To be honest, before the VR experience, I had no idea that there was such a beautiful land in Yunnan Province. The VR experience allowed me to see the vitality of this land. I am more interested in understanding this land and its culture. (P3.14)

For the local visitors (P2.8, P2.9, P2.10), VR experience can provide more additional information for their on-site visits and add more fun, which will indirectly affect their travel experience:

> I originally thought that this was just a tourist attraction and that I came here to have fun, but after playing this VR game, I discovered that there are many … tangible and intangible CH here … It is quite an amazing experience for me. (P2.8)

6.4.3. Reflecting on the VR technology for revitalizing CH

Local residents, especially P1.2, P1.3, P1.4, and P1.9, recognized that VR can attract more tourists, which can help boost the local economy:

> Maybe it can allow more people to first experience it remotely, and then come here to experience. (P1.3)

> It should be helpful. We need more tourists to come here. (P1.4)

The widely acknowledged (P2.8, P3.1) advantages of VR technology are convenience, short time, and being unaffected by spatial distance and other objective factors affecting the quality of experience. Moreover, VR has strong appeal to the youth, especially urban residents. This user group also happens to have little opportunity to learn and experience CH locally:

> It (VR) should have a great driving force and promote the development of this village … It can let many people understand the local culture, and they don't have to pay a long journey to come here … (P2.8)

7. Discussion

7.1. Reflecting on the influences between emotional responses and social-value-based heritage identity enhancement of the local residents

As reported in the subsection 6.3, we innovatively found the significant correlations between changes of emotional arousal and social-value-based heritage identity enhancement. This finding to reflect on this core finding, we interpret it from two perspectives.

Firstly, Dümcke and Gnedovsky (Dümcke & Gnedovsky, 2013) introduced that the social value of CH improves

people's thinking, actively promoting their psychological and social well-being (i.e., emotional well-being), enriching the social environment, providing the community with a collective "memory," and preserving a wealth of creative and intellectual ideas for future generations. At the same time, increasing the cultural identity of regional residents, especially the younger generation, can contribute to motivating them to protect cultural diversity (De la Torre, 2013). Therefore, the significance of and relationship between the social value of CH, psychological well-being, and identity can be found, especially for the young generations.

Secondly, to discuss the significant correlation between emotional arousal changes and social-value-based heritage identity enhancement, we refer to the "cognition-affection–behavior" theoretical framework (Okanovic et al., 2022). This framework recognizes that cognition serves as the basis of emotional response and behavioral tendency, whereas behavior can be affected by cognition and emotion, and has already been adopted in heritage research (Truscott, 2020). For example, Lan et al. (Labadi et al., 2021) used this theory to explain how the two variables of tourism development perception and emotional solidarity affect the value co-creation participation behavior of the local residents in the context of intangible CH tourism while considering the mediating role of emotional solidarity. Meanwhile, Brosch et al. (Brosch et al., 2013) introduced that emotion and cognition are closely intertwined, which extends the theory mentioned above to highlight that emotion and cognition can influence each other. In this study, our finding demonstrates the aforementioned impact mechanism between emotion (changes of emotional arousal) and cognition (heritage identity enhancement). Regarding the "behavior" aspect of the aforementioned theoretical framework (Okanovic et al., 2022), we think that the findings revealed in this study may also have potentials to motivate local residents' behavior to inherit and transmit their local culture. Therefore, future work should be done to explore and observe the effects of the VR experience on the behavioral changes of the young generations of the indigenous community. Moreover, these findings could also motivate future HCI practices to design virtual CH experience for young generations to engage in the heritage inheritance.

7.2. Understanding and adapting to the ever-evolving dynamics in CH context through designing interactive experiences

Heritage undergoes a dynamic, cyclical process of transformation, characterized as a "renewable resource" (Fouseki, 2022) and shaped by interrelated factors such as materials, values, emotions, place, time, resources, and skills, as outlined in the "heritage dynamics framework" by Kalliopi Fouseki (Fouseki, 2022). In a rapidly changing world, digital technologies significantly influence societal dynamics, enabling innovative and distributed practices across sectors, including CH context (Borowiecki et al., 2016). For example, the emergence of VR has posed significant challenges for scientists who started investigating the way VR changes social dynamics (Aitamurto et al., 2021) as well as social attitudes (Schwabe et al., 2022). Especially during the COVID-19 pandemic, CH and tourism adapted to travel restrictions by exploring virtual tourism, which proved effective in promoting sites, aiding post-pandemic recovery, and engaging remote audiences with cultural content (Tennent et al., 2021).

In this study, we aim to explore how can HCI approaches be embedded in interpreting the dynamics in CH context. On the one hand, we adopted a participatory design approach to co-design and evaluate with multi-stakeholders. Their perspectives enabled us to gain a clear and deep understanding of how multi-stakeholders perceive, comprehend, and emotionally engage with local CH amidst dynamic changes. On the other hand, based on their feedback, we developed this interactive CH experience adapting to the ever-evolving dynamics in CH context that can change the meanings and values of CH (Fouseki, 2022). Not only does this VR experience present the "materiality" aspects of local CH, but also convey their values and community spirit they embody through interactions and narratives.

This study emphasizes the need to examine the fundamental transformations occurring within CH amidst evolving societal dynamics. Adopting a value-based approach (Lupo, 2023; Tong et al., 2024), it identifies "heritage values" as key elements that adapt in response to social change. As proposed by Kalliopi Fouseki (Fouseki, 2022), heritage values emerge through dynamic interactions between materials, values, and emotions, with historical contexts endowing CH with era-specific meanings. The study advocates documenting these shifts and engaging multi-stakeholders to achieve a nuanced understanding of CH, thereby identifying opportunities to reinterpret its dynamic values. Ultimately, embracing the evolution of heritage values can enhance perceptions of CH and reinforce heritage identity.

7.3. Reflecting on how digital technologies change the nature of CH (experiences)

In this study, VR is adopted as a digital technology to create an emotion-triggering CH experience. Through synthesizing the experiences from the design practice and user study, we reflect on the changes of the nature of CH (experiences) caused by digital technologies.

7.3.1. Reconfiguring user engagement

Digital technologies redefine user experiences and engagement (Capece et al., 2024; Peter & Labadin, 2024; Valderas et al., 2015; Zhang & Stewart, 2017) by shifting from passive observation to active participation. Traditional approaches often rely on static displays or guided tours, limiting user engagement to visual or textual interactions. In contrast, technologies like VR immerse users in reconstructed environments, allowing them to "inhabit" the past, while AI personalizes these experiences (Pietroni & Ferdani, 2021), adapting narratives to individual preferences. In this study, we engaged multi-stakeholders in the design and evaluation

process, providing more opportunities for uses to engange in CH experiences. Although these tools have potentials to foster deeper emotional and sensorial connections, challenges remain in balancing technological integration with authenticity (Zhao et al., 2025), ensuring cultural narratives are preserved amidst innovation.

7.3.2. Democratizing access to CH resources through digital documentation and presentation

By digitizing various CH artifacts, we can create enduring, high-resolution records that safeguard them from the ravages of time and natural disasters. Digital preservation ensures the accessibility of these cultural treasures for generations to come, enabling scholars, artists, and the general public to study, appreciate, and share them with ease (Buragohain et al., 2024; Gaudêncio, 2019; King et al., 2016). In this study, in order to also provide opportunity for remote visitors who cannot visit local community offline, we thus used VR to democratize the access to experience local CH for different users.

7.3.3. Creating or blurring boundaries between real and virtual experience

VR inherently establishes a boundary between digital and physical worlds, as seen in this study, where the lack of a physical takeaway (e.g., a virtual handkerchief) highlighted this division and occasionally diminished user engagement. In contrast, AR and MR blur these boundaries by overlaying digital elements onto real-world settings, fostering a seamless blend of virtual and physical experiences (Bekele et al., 2018). This integration enhances the sense of presence and allows for more intuitive interactions. However, while VR excels in creating deeply immersive, isolated digital spaces, AR and MR prioritize contextual continuity. A balanced approach should consider both the strengths of creating distinct virtual realms and the benefits of blurring boundaries to deliver enriched and context-sensitive CH experiences.

7.3.4. Empowering minority voices and marginalized communities

Digital technologies empower minority voices and marginalized communities to share their CH and perspectives widely (Bynum Boley and Johnson Gaither, 2016; neurosky, n.d). In our participatory design workshop with six local residents, participants expressed their views on local CH and indigenous culture, which were integrated into a VR experience for diverse user groups. This demonstrated how VR effectively transmitted indigenous voices and culture to broader audiences. Additionally, interactions with journalists filming a TV show when we were in the village for field study highlighted growing audience interest in CH programs and the residents' belief that such initiatives promote culture, attract tourists, and boost the local economy. These findings suggest that digital technologies, such as VR, online platforms, and social media, serve as powerful tools to connect indigenous communities with global audiences, fostering diversity, inclusion, and cultural understanding (Artificial Paintings Artmaster., 2024).

7.4. Design implications for creating virtual CH experiences

7.4.1. Using scene theory as a systematic framework/tool to capture, map and integrate tangible and intangible CH

Recent research has explored integrating tangible and intangible CH within interactive experiences. For instance, Park et al. (Ostrom, 1969) utilized MR to combine Maori meeting houses (tangible CH) with historical religious customs (intangible CH), while Selmanović et al. (Roued-Cunliffe & Copeland, 2017) employed VR to merge a local bridge (tangible CH) with diving practices (intangible CH). However, these approaches lack a systematic framework to guide the selection and integration of CH elements, leading to inconsistencies in design processes. This study addresses this gap by adopting Scene Theory, which provides a structured method for organizing and prioritizing CH elements for integration. Beyond enhancing systematicity, this framework facilitates stakeholder discussions, particularly with indigenous communities.

7.4.2. Ethical considerations of using digital technology to communicate CH

Firstly, during our field study, we directly observed a notable reluctance among local residents to engage with this VR experience, stemming from unfamiliarity and fear. This reaction underscores the critical need for practitioners to address community perceptions when introducing new technologies for CH revitalization. Such firsthand insights emphasize the importance of involving local residents—both as CH creators and primary stakeholders—in decisions about technological interventions, ensuring their voices are heard and their cultural values respected. Secondly, regarding the potential loss of cultural context, it is crucial to consider whether digitization might overlook the deep historical narratives of CH, reducing them to commercialized applications. Thirdly, in balancing technological dependence and cultural authenticity, attention should be given to how the pursuit of advanced technologies can coexist with preserving the original authenticity and integrity of cultural heritage. Finally, the collection and utilization of user experience data in digital CH scenarios raise important privacy concerns that warrant critical examination (Shu et al., 2018).

7.5. Limitations and future work of this study

7.5.1. Expanding stakeholders involvement in the design process and user study

On the one hand, during the VR experience design process, a participatory workshop was conducted with limited stakeholder involvement, including three tourists and three local residents, to capture CH elements. While this small sample may introduce personal biases, decisions were supplemented by questionnaire and interview findings. Post-experiment

feedback indicated alignment with local culture for residents and an engaging experience for visitors, validating the design's quality. Future research should aim to broaden stakeholder participation in co-design efforts. On the other hand, as an exploratory study and the obstacles of recruiting participants in the village, we did not involve enough participants for each user group in the user study, which may also influence the statistical results. Meanwhile, as the measurement of heritage identity was conducted using a self-developed questionnaire, the insights that can be deducted on heritage identity enhancement from a small sample size are limited, which requires larger-scale user studies in the future. Moreover, although questionnaire and interview results provide initial evidence that the virtual CH experience can help enhance young generations' heritage identity, such changes would need to be also observed over time after the interaction experience. Therefore, more in-depth user studies should be conducted, while also referencing scales/frameworks from other field (e.g., place attachment theory from environmental psychology field (Boley et al., 2021)) to measure and interpret empirical findings.

7.5.2. The effects of visual realism on emotional responses, presence and perceived immersion

The VR system used in this study still lacks accuracy of the reconstructing and rendering of CH and the details presented in the VR scenes, and we did not explore whether this limitation would influence users' expectations, emotional responses and immersive experience. Considering this, future study should: (1) measure users' presence and perceived immersion using related scales (e.g., Presence Questionnaire (PQ) (Wikipedia contributors, 2024), Immersive Experience Questionnaire (IEQ) (Jennett et al., 2008)), to help improve the immersive experience; (2) explore the effects of different reconstruction and rendering methods on the user experience.

7.5.3. Limited accuracy of capturing emotional responses using physiological signals and future emotional design considerations

The study acknowledges the potential confounding effects of VR equipment on physiological and emotional responses, noting the absence of a non-CH VR control condition. To mitigate these effects, participants were familiarized with the VR setup to reduce novelty bias. Future research will incorporate non-CH VR controls for more reliable validity. Additionally, future designs may leverage physiological signals for real-time emotion recognition, enabling adaptive VR scenes and narratives for personalized emotional regulation and enhanced immersive CH experiences (e.g., as has been done in (Gupta et al., 2024; Karran et al., 2013; Li, 2023)).

8. Conclusion

This paper presents a design case of a VR experience, which aims to evoke users' emotional responses for heritage identity enhancement, through designing with multi-stakeholders. We conducted user study with young generations from local residents, remote and local visitors on their emotional responses and heritage identity using quantitative and qualitative methods. Our findings indicate that the virtual CH experience:

1. can significantly cause emotional arousal of local community members, while can also significantly bring emotional pleasure to the visitors.
2. can evoke users' emotional responses through interactions using the NPCs and digital representation of local cultural activities, within a VR experience.
3. can significantly improve the perceived all aspects of value-based heritage identity of local and remote visitors, while can only improve aesthetic, cultural, and social-value-based heritage identity of local residents, thus can enhance young generations' sense of identity and belongings towards the CH. We also innovatively find that:
4. young local residents' emotional responses (changes of emotional arousal) and the social-value-based heritage identity enhancement can significantly influence each other, motivating future HCI and heritage research practices to encourage young local residents to take initiatives in the inheritance and transmission of CH through designing immersive CH experiences to arouse emotions and heritage identity.

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ORCID

Yaning Li http://orcid.org/0009-0004-6305-5866
Ziyao He http://orcid.org/0000-0003-0448-5159
Teng Han http://orcid.org/0000-0001-8857-8787
Xin Tong http://orcid.org/0000-0002-8037-6301
Yiqing Zhao http://orcid.org/0000-0002-5483-556X
Meng Li http://orcid.org/0000-0002-7095-0170

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About the authors

Yaning (Jerry) Li is a junior student majoring in Industrial Design Engineering at Xi'an Jiaotong University and Politecnico di Milano. His research focuses on human-computer interaction (HCI) and design engineering, particularly XR applications in cultural heritage.

Ruoyu Qiu, currently pursuing a B.E. in Industrial Design at Xi'an Jiaotong University. Her research interest includes Virtual Reality and Human-Computer Interaction, exploring immersive interface design and user experience optimization.

Ziyao He, received a B.E. degree in Material Science and Finance from Xi'an Jiaotong University, Xi'an, China, in 2019. He is currently a Ph.D. candidate in the School of Automation Science and Technology at Xi'an Jiaotong University. His research interest includes Human-AI Cooperation, Large Language Models and Chabots.

Xue Wu is an associate professor at the School of Humanities and Social Science, Xi'an Jiaotong University, China. Her research interests include environmental design, and design-driven cultural heritage revitalization.

Teng Han is a researcher at the Institute of Software, Chinese Academy of Sciences, leading a team dedicated to embodied perception and interaction. Their research investigates multi-channel perception integration, focusing on somatosensory technologies (tactile and proprioceptive sensations) and their role in shaping interactive behavior and cognitive interventions.

Xin Tong, Assistant Professor in Computational Media and Arts (CMA) Thrust, Information Hub at the Hong Kong University of Science and Technology (Guangzhou). Her research focuses on the application of human-computer interaction (HCI) and human-AI collaboration in the fields of healthcare, wellbeing, accessibility, and digital cultural heritage.

Yiqing Zhao is an associate professor at the School of Humanities and Social Science, Xi'an Jiaotong University, China. Her research interests include urban and rural cultural heritage management and regeneration, urban planning and policy tools, and urban and regional governance.

Meng Li is a senior lecturer and master's supervisor at School of Mechanical Engineering in Xi'an Jiaotong University. With over 20 publications in top journals and conferences on human-computer interaction and ergonomics, her research focuses on spatial computing and digital preservation of cultural heritage through XR technology.