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Article

Demand-driven digital innovation for cultural heritage tourism development: A Kano model approach

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Abstract: Cultural heritage tourism requires effective digital solutions to meet evolving tourist needs and balance site preservation with sustainable development. Existing research predominantly focuses on technical feasibility and functionality, with limited attention to diverse tourist demands. This study addresses this gap by investigating tourists' multi-dimensional needs for cultural heritage tourism applications using the Kano model. Through a case study of Sancai Town, a renowned cultural heritage site in China, 22 demand items were initially identified through semi-structured interviews. A questionnaire survey of 422 tourists was then conducted to categorize these demand items into must-be, one-dimensional, attractive, and indifferent needs. The results indicate that must-be needs, such as navigation and attraction information, form the foundation of tourist expectations. One-dimensional needs, including multimedia presentations and experience sharing, directly influence satisfaction. Attractive needs, such as immersive experiences and personalized services, enhance emotional engagement. Based on this classification, differentiation design strategies are proposed to guide the development of tourism applications that effectively address these needs and enhance the travel experience. The findings contribute to the theoretical understanding of demand-driven digital innovation in cultural heritage tourism and provide practical insights for innovative tourism development in Sancai Town and similar heritage sites. This research advances a tourist-centric perspective to balance cultural preservation and tourism growth, fostering the sustainable integration of heritage and tourism.

Keywords: cultural heritage touris; Kano model; tourist demands; digital innovation; tourism applications

1. Introduction

Cultural heritage protection and sustainable development require well-designed tourism infrastructure to support effective conservation, visitor engagement, and sustainable tourism practices (Nocca, 2017; UNESCO, 2021). Investments in transportation networks, digital tools, and site management systems enhance the capacity of heritage sites to attract visitors, promote local development, and protect cultural assets (Casillo et al., 2021; Slavec et al., 2021). Heritage towns, characterized by valuable cultural heritage, unique identities, and historic landscapes, have become distinct cultural tourism destinations that contribute to sustainable regional development while necessitating careful conservation (Liu and Shu, 2020).

The rapid advancement of information and communication technologies (ICTs) is transforming heritage tourism (Arnold and Kaminski, 2013). Digital tools are critical in enhancing visitor experiences, supporting heritage conservation, and optimizing site management (Hausmann and Schuhbauer, 2021). Integrated into smartphone, tourism applications offer personalized, contextualized, and high-

quality information, helping tourists navigate unfamiliar locations and engage with cultural destinations more meaningfully (Ammirato et al., 2022; Palumbo et al., 2014).

Tourists' motivations for visiting cultural heritage sites differ fundamentally from those for other destinations. Research highlights that gaining knowledge and receiving education is among the most anticipated experiences for cultural heritage tourists (Zhao and Agyeiwaah, 2023). Further research indicates that tourist interest has a significant impact on aesthetic pleasure in heritage settings (Cao et al., 2024). However, traditional methods of information delivery at heritage sites often fail to engage visitors or effectively convey cultural knowledge, leaving a gap in fulfilling these expectations. This creates an opportunity for digital tools, particularly tourism applications, to integrate education and entertainment. Studies have shown that incorporating elements such as interactive storytelling and gamification can significantly enhance visitor engagement and satisfaction (Chen et al., 2023; Zhao and Agyeiwaah, 2023). By leveraging these features, tourism applications can provide an engaging way to deliver cultural and historical knowledge while enriching the visitor experience. Aligning digital solutions with cultural heritage tourists' educational and entertainment needs is key to improving visitor experience and preserving cultural heritage.

Despite these advancements, existing research has focused mainly on supply-side factors such as technical feasibility and functional design, with limited attention to aligning these solutions with tourist needs. Addressing this gap requires investigating how tourism applications can better cater to tourists' expectations, optimizing their experiences while supporting cultural heritage conservation (Meng and Liu, 2021).

To address this gap, this study investigates tourists' core needs for tourism applications in the context of Tri-colored Glazed Pottery Town: Sancai Town, a renowned cultural heritage site in China. Specifically, it seeks to understand what tourists expect from tourism applications in cultural heritage towns, and how these needs can inform the development of demand-driven digital solutions. By aligning tourism applications with tourist preferences, this research aims to optimize visitor experiences while supporting cultural heritage conservation. Moreover, the findings contribute to the theoretical understanding of demand-driven digital innovation in cultural heritage tourism and provide practical insights for innovative tourism development in Sancai Town and similar heritage sites. By fostering a tourist-centric perspective, this study bridges the gap between cultural preservation and tourism growth, offering actionable guidance for sustainable integration of heritage and tourism. These insights also illuminate the future development of digital tourism in heritage towns, contributing to sustainable practices and balanced regional development.

2. Literature review

2.1. Heritage tourism and sustainable development

The relationship between heritage tourism and sustainable development has been widely studied. Heritage tourism plays a crucial role in balancing economic

development and cultural heritage conservation (Garrod and Fyall, 2000; Silberberg, 1995). Scholars have explored this relationship from various perspectives, including tourism infrastructure, social systems, and public policies (Katsoni and Spyriadis, 2020). Recent research on Thai-Chinese temples demonstrates how identifying and prioritizing attraction factor categories can guide sustainable improvement strategies, highlighting the practical role of heritage tourism in achieving balanced growth (Zhu et al., 2020). Visitor satisfaction, shaped by authenticity and cultural experience, further enhances conservation intentions, highlighting the role of heritage tourism in supporting cultural preservation efforts (Cao et al., 2024).

From a macro perspective, responsible tourism infrastructure is essential in promoting cultural heritage protection, attracting visitors, and fostering sustainable development (Nocca, 2017). In the Chinese context, heritage tourism has demonstrated its potential in balancing cultural protection and tourism development, generating economic benefits, and encouraging community participation, as exemplified by case studies of Lijiang Ancient Town (Song et al., 2020) and Pingyao Ancient City (Weng et al., 2019). Furthermore, developing tourism infrastructure, such as transportation networks and innovative digital tools, can enhance the accessibility and experiential appeal of Chinese heritage sites like Mount Lushan while fostering sustainable local economic growth through integrated heritage protection and tourism initiatives (Cai et al., 2021).

In recent years, the application of digital technologies in cultural heritage tourism has gained significant attention, highlighting their potential to promote sustainable development. Digital tools have been found to improve visitor engagement in museums (Solima and Izzo, 2017) and sustain public participation in heritage despite lockdowns during the pandemic, highlighting their social value (Ginzarly and Srour, 2022). Immersive technologies like VR/AR also show promise in providing engaging heritage experiences, but their application must strike a balance between technological innovation and cultural sensitivity (Lian et al., 2021).

However, challenges remain in effectively integrating digital technologies into heritage tourism to maximize their potential for sustainable development. Balancing the preservation of cultural authenticity with technological innovation is a key consideration (Jia et al., 2023). Ensuring equal access to digital heritage experiences across diverse visitor segments is also crucial for promoting social equity (Maietti, 2023). To fully harness the potential of innovative tourism solutions, it is essential to adopt a user-centered perspective that considers the diverse needs and preferences of visitors (Li and Kim, 2023). By systematically integrating digital tools, public services, and user needs, heritage tourism can balance cultural preservation and technological innovation, thereby contributing to the sustainable development of local communities and economies.

2.2. Smart tourism infrastructure for cultural heritage sites

Smart tourism infrastructure is pivotal in cultural heritage tourism, underpinned by key pillars such as governance, innovation, technology, sustainability, and universal accessibility. Governance establishes policies and frameworks to integrate digital tools into cultural heritage sites responsibly. Innovation drives the creation of

solutions that enhance visitor experiences while protecting sensitive cultural assets. Sustainability ensures that smart tourism practices align with long-term conservation goals and promote efficient resource management. Universal accessibility provides equal opportunities for all visitors to engage with cultural heritage, regardless of physical abilities or cultural background. For example, interactive digital maps and intelligent navigation systems play a key role in fostering inclusion and breaking down barriers for diverse audiences (Marconcini, 2018). Among these, technology serves as the central driver, enabling the seamless integration of services and enhancing visitor experiences. Advanced technologies empower personalized and adaptive tourism solutions, including real-time data analytics, AI-driven recommendations, and AR/VR tools. By leveraging innovative technologies such as 3D modeling, virtual reality, and augmented reality, heritage sites can offer immersive experiences to visitors while minimizing the physical impact on sensitive cultural assets (Todorova-Ekmekci, 2021). This approach aligns with the principles of sustainable tourism, allowing for the responsible use of heritage resources while ensuring their long-term conservation. Additionally, digital platforms optimize resource management and improve accessibility, supporting governance and sustainability efforts. By leveraging these technological innovations, smart tourism infrastructure ensures a balance between cultural heritage preservation and tourism development, fostering sustainable and inclusive tourism practices.

The experiences of Chinese heritage sites in developing smart tourism infrastructure highlight the crucial role of digital organizational innovation, smart data platforms, multi-stakeholder collaboration, and the creation of imaginative tourism scenarios in driving sustainable development (Xu et al., 2024). For instance, Mount Lushan, a UNESCO World Heritage Site, has successfully integrated digital technologies to digitize its cultural landscape (Cai et al., 2021). The resulting virtual tourism subsystem not only offers immersive experiences, popular science education, and recommended tour routes, but also enhances the site's tourism marketing efforts while minimizing physical impacts on the fragile environment. Similarly, the Dalongdong Bao'an Temple in Taipei has employed mobile augmented reality to enrich its guided tours (Chiu et al., 2019). By digitizing the temple's murals and historical information, the AR application enables visitors to interact with cultural heritage more engagingly and educationally, leading to better learning outcomes than traditional oral narratives.

These case studies align with recent research on how interactive technologies revolutionize cultural heritage interpretation and visitor engagement. AR-enhanced paper maps enable seamless integration between physical and virtual information, significantly enhancing visitors' cultural understanding and spatial cognition (Ma et al., 2018). A theoretical framework was developed showing how different interaction layers, from sensory to emotional, contribute to deeper cultural engagement (Lv et al., 2020). Moreover, integrated digital tools, from AR to virtual reconstruction, both enhance visitor experiences and contribute to sustainable heritage preservation (Todorova-Ekmekci, 2021). Together, these findings underscore how the integration of digital technologies, careful content curation, and visitor-centric design can simultaneously enhance cultural heritage interpretation, visitor engagement, and site

conservation, thereby contributing to the sustainable development of innovative tourism at heritage sites.

While interactive technologies offer significant potential for heritage tourism, their successful implementation faces various technical and practical challenges. Understanding user needs and expectations is fundamental (Jia et al., 2023). Heritage site managers must consider the diversity of visitors, including differences in age, cultural background, and digital literacy, to ensure that the adopted technologies are accessible and user-friendly. Given these challenges, it is essential to gain a holistic understanding of visitors' acceptance, experience, and expectations of digital interpretation and presentation to improve digital display design at heritage sites (Liu, 2020). Through this understanding, heritage sites can create more targeted, hierarchical, and customizable digital display content that satisfies the diverse needs of different visitor categories.

2.3. Demand-driven analysis for digital innovation in cultural heritage tourism

The sustainable development of cultural heritage tourism relies on a deep understanding of tourists' needs. Scholars employ various demand analysis methods to study tourists' preferences, motivations, and behavioral patterns, providing valuable references for smart tourism planning. Traditional qualitative methods, such as in-depth interviews and focus groups, offer rich contextual insights into tourists' perceptions and expectations of heritage sites, enabling researchers to uncover the deeper reasons behind tourists' needs. However, these methods are limited by small sample sizes and do not allow for the generalization of results (Bender et al., 2024). Quantitative methods, such as surveys and statistical analyses, enable a broader examination of the distribution characteristics of tourists' needs. By comparing the needs of tourists across different demographic characteristics, quantitative studies provide a basis for market segmentation strategies. Nevertheless, tourist needs surveys that employ standard lists can only identify surface requirements but cannot provide insights into deeper underlying needs (Jewell and Crotts, 2002).

In cultural heritage tourism, tourists' needs often extend beyond general satisfaction, encompassing a deep cultural connection and an understanding of the historical and emotional context. The Kano model (**Figure 1**) provides a unique framework for uncovering these aspects by categorizing service quality attributes into five types—must-be, one-dimensional, attractive, indifferent, and reverse—revealing the non-linear relationships and hierarchical structure of tourist needs (Pandey et al., 2022; Żywiołek et al., 2023). The model highlights how tourist satisfaction relates non-linearly to service quality attributes. It provides actionable insights for heritage site managers, enabling them to prioritize key needs and enhance visitor satisfaction and loyalty (Kano et al., 1984; Gregory and Parsa, 2013). For example, the application of the model in Singapore's tourism industry identified "friendly locals", "unique attractions", and "memorable experiences" as key attributes expected by tourists (Pawitra and Tan, 2003). In cultural heritage tourism, the Kano model proves particularly effective in uncovering deeper cultural and emotional dimensions of tourist needs. Its combination with value mapping has been

used to explore nostalgic experiences at the Song Jiang Cultural Festival, identifying the "challenge of new experiences", "appreciation of culture and art", and "emotional connections to history" as key drivers (Yeh and Lin, 2017). Compared to traditional methods, the Kano model addresses their shortcomings and offers actionable insights for designing innovative tourism applications that foster cultural engagement.

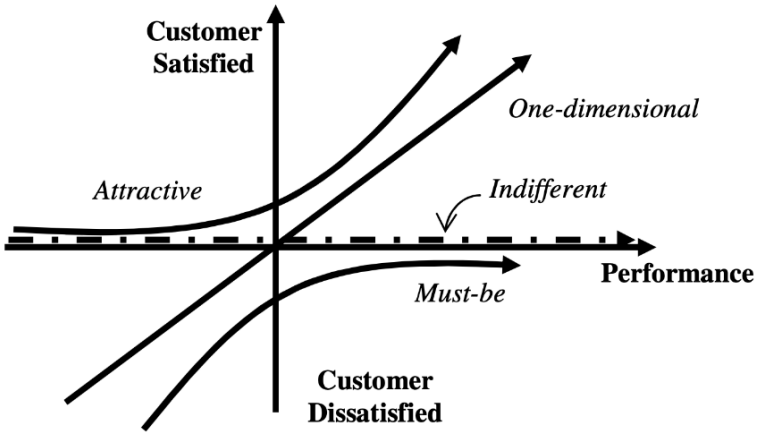

Figure 1. Kano model.

Source: Kano et al. (1984).

The insights provided by the Kano model can be effectively leveraged through digital solutions, especially interactive technologies, which are crucial in meeting the diverse needs of tourists in cultural heritage tourism. Among these technologies, tourism applications are particularly notable for addressing needs at multiple levels. At the perceptual level, interactive multimedia features, including AR, VR, and 3D models, enable tourists to co-create immersive travel experiences, enhancing perceptions of authenticity and destination appeal (Lee et al., 2017). On an emotional level, storytelling and gamification features strengthen tourists' bonds with cultural heritage, fostering a sense of connection to the history and culture of the site. To support cultural understanding, tourism applications can deliver multilingual and multicultural content, catering to diverse tourists and promoting cross-cultural communication. However, few studies have classified the actual service requirements and improved customer satisfaction in mobile tourism applications (Choedon and Lee, 2018). The Kano model has the potential to address this research gap by identifying key service attributes that drive tourist satisfaction, offering actionable insights for designing innovative tourism applications that not only meet basic needs but also create deeper cultural experiences.

3. Methods

3.1. Study site and respondents

This study focuses on Sancai Town (**Figure 2**), located southwest of Luoyang, China. It is renowned as the birthplace and center of Tri-colored glazed pottery. With its rich cultural heritage, Sancai Town is a key cultural tourism destination and an

ideal setting for exploring innovative digital solutions in heritage preservation and tourism.

The town presents unique opportunities and challenges. On the one hand, its abundant cultural resources require effective preservation alongside tourism growth. On the other hand, evolving tourist expectations and advancements in information technology demand more innovative, more engaging tourism services. However, current digital tourism initiatives in Sancai Town fail to address these needs. Existing tools often fail to integrate cultural narratives effectively, limiting their ability to provide meaningful visitor experiences. Tourists have limited channels and ways to understand the Sancai craftsmanship, and the inheritance and display of this art form remain relatively simple. Additionally, the lack of systematic research on tourists' digital preferences hampers the development of targeted, impactful solutions. The potential of digital applications, which can better showcase and popularize the Sancai craftsmanship through interactivity, multimedia presentation, and personalized recommendations, to balance heritage conservation with sustainable tourism remains largely unexplored. Building on these identified gaps, this study investigates tourists' needs for digital tourism applications in Sancai Town. Through this case, it offers transferable insights for other cultural heritage destinations facing similar challenges.

Figure 2. Sancai town.

Source: Google maps.

To achieve this, respondents were selected in two stages, applying unified inclusion criteria: Tourists visiting Sancai Town, aged 18–70, willing to use digital tourism tools, and with basic ability to use smartphones. In the first stage, semi-structured interviews were conducted with 12 tourists in Sancai Town, which is generally sufficient to reach data saturation in qualitative studies (Guest et al., 2006). The findings from these interviews informed the design of the second stage, which

involved a large-scale questionnaire survey. Based on the Xinhua-Luoyang Cultural and Tourism Integration Development Index Report (2023), the annual tourist volume of Sancai Town in 2023 was approximately 113,000. According to Krejcie and Morgan's (1970) formula, the minimum required sample size for a population exceeding 100,000 is 384. To account for potential invalid responses, the sample size was increased by 20% (Rattray and Jones, 2007), resulting in a target of 460 respondents. Overall, the selected sample demonstrates strong representativeness, providing reliable data for understanding tourists' needs for tourism applications in Sancai Town.

3.2. Questionnaire design

The questionnaire design in this study is based on the Kano model, an effective tool for classifying and prioritizing user needs, introduced by Professor Noriaki Kano of Tokyo University of Science in 1984. The model categorizes customer needs into five types based on their relationship with customer satisfaction. Must-be qualities refer to attributes that customers consider essential. Failing to meet these needs leads to dissatisfaction, but fulfilling them does not necessarily increase satisfaction. One-dimensional qualities are needs that significantly enhance satisfaction when fulfilled and cause significant dissatisfaction when unmet. Attractive qualities bring high satisfaction when fulfilled, even if imperfect, but their absence does not necessarily cause dissatisfaction. Indifferent qualities are features that do not impact customer experience, whether present or absent. On the other hand, reverse qualities are needs that customers do not desire; fulfilling these needs can reduce satisfaction (Kano et al., 1984).

Each question in the Kano questionnaire includes both positive and negative phrasing to assess and classify customer perceptions of product features. In this study, positive questions evaluate tourists' perceptions of tourism applications with specific features, while negative questions assess their reactions to the absence of these features.

The questionnaire design involved three main steps. Firstly, tourists' needs for tourism applications were collected through semi-structured interviews. Next, demand points directly related to the design of tourism applications were extracted from the interview results to form a demand list. Finally, these demand points were translated into specific Kano questionnaire items, each consisting of a positive question (functional) and a negative question (dysfunctional). For each question, respondents could choose from the following options: "I like it", "I expect it", "I am neutral", "I can tolerate it", or "I dislike it", as shown in **Table 1**.

Table 1. Kano questionnaire.

Question	I like it	I expect it	I am neutral	I can tolerate it	I dislike it
How do you feel if there is this feature in the application?					
How do you feel if there is not this feature in the application?					

Source: Author (2024).

3.3. Data collection

This study used interviews and questionnaire surveys in two stages to collect data. Data collection was conducted in July 2024 at Sancai Town, leveraging the peak tourist season to ensure sufficient respondent availability. Stratified random sampling was adopted, with age groups (18–30, 31–45, 46–60, and 61–70) serving as stratification variables. Respondents were randomly selected proportionally from each age group to ensure representativeness. All respondents signed informed consent forms.

In the first stage, conducted in early July, semi-structured interviews were carried out with 12 respondents. The interviews, guided by an outline, explored respondents' functional and design requirements for tourism applications. The transcribed and coded data underwent thematic analysis, identifying key user needs (**Table 2**). Insights from these interviews informed the development of a structured questionnaire using the Kano model for subsequent data collection. The second stage began in the third week of July and lasted ten days. A total of 460 respondents participated in the online questionnaire survey, which was conducted using the Wenjuanxing platform. Respondents accessed the anonymous survey by scanning a QR code, facilitating efficient and large-scale data collection.

Table 2. Tourists' demands.

Dimension	Demand Category	Demand Item	Code
Content Demands	Attraction Information	Introduction	A1
		Graphical Presentation	A2
	Tri-color Knowledge	Historical Introduction	A3
		Production Techniques	A4
		Multimedia Presentations	A5
Functional Demands	Guidance Services	Navigation	B1
		Search	B2
		Favorites	B3
		Thematic Route Planning	B4
		Voice Guidance	B5
		Beginner's Guide	B6
	Craft Game	Craft Technique Simulation	B7
		Personalized Customization	B8
Social Demands	Tourist Interaction	Route Recording	C1
		Experience Sharing	C2
	Task Incentives	Task Check-in	C3
		Reward points	C4
		Virtual Souvenirs	C5
Style Demands	Design Style	Tri-color Elements	D1
		Simplified Layout	D2
		Clear Hierarchy	D3
		Interface Personalization	D4

Source: Author (2024).

The entire data collection process adhered to strict ethical standards. Data were de-identified, stored with restricted access, and used exclusively for this study to ensure respondent confidentiality and privacy. These measures aligned with ethical guidelines and minimized potential risks to respondents.

4. Results

4.1. General information

The survey collected 422 valid responses, primarily from younger and middle-aged groups, with 18–45-year-olds comprising over 70% of the sample. The gender distribution was balanced, with 51.90% male and 48.10% female participants. Respondents exhibited a high level of education, with 59.00% holding a bachelor's degree or higher, and 11.37% reporting a high school education or below.

Tourism app usage showed that while over 80% of respondents had some experience with such apps, the frequency was relatively low: 40.28% reported occasional use, and 36.02% reported sometimes using them. Only 6.63% frequently used tourism apps, indicating potential barriers to adoption despite overall familiarity.

These demographic characteristics suggest that the study's findings provide insights into the needs and preferences of educated, tech-savvy younger and middle-aged users, who are an important segment of the target audience for digital tourism solutions. Detailed data are provided in **Table 3**.

Table 3. Sample demographics.

Demographic	Category	Number	Percentage (%)
Age	18–30	162	38.39%
	31–45	137	32.46%
	46–60	98	23.22%
	61–70	25	5.92%
Gender	Female	203	48.10%
	Male	219	51.90%
Highest Qualification	High School or below	48	11.37%
	Associate's Degree/Diploma	125	29.62%
	Bachelor's Degree	214	50.71%
	Master's degree or higher	35	8.29%
Frequency of Tourism Application Use	Never	72	17.06%
	Rarely	170	40.28%
	Sometimes	152	36.02%
	Often	28	6.63%

Source: Author (2024).

4.2. Demands analysis

4.2.1. Classification of tourist demands using the Kano model

To gain deeper insights into tourists' needs for the Sancai Town tourism app, this study applied the Kano model to categorize and analyze 22 demand points

collected through interviews. This approach enables understanding how different requirements influence tourists' perceptions and their nonlinear relationships with satisfaction (Kano et al., 1984).

As shown in **Table 4,** the analysis revealed that must-have requirements constituted the largest proportion, with 9 items (40.9%). These are the basic expectations for using the product, and their absence directly leads to dissatisfaction (Mkpojiogu and Hashim, 2016). One-dimensional requirements accounted for 6 items (27.3%), where satisfaction increases proportionally with the degree to which these needs are met, making them key drivers for enhancing user satisfaction (Matzler and Hinterhuber, 1998). These two categories accounted for over 60% of the demands, highlighting their significance in tourism app development.

Also highlighted in **Table 4**, attractive requirements comprised 5 items (22.7%). These innovative and differentiated features are not essential but significantly enhance user satisfaction when provided (Shahin et al., 2013). In contrast, indifferent requirements were relatively minimal, accounting for 9.09% of the total.

Table 4. Classification of tourist demands.

Demand	Kano attribute Category					Final Category	Satisfaction Index	Dissatisfaction Index
	A	O	M	I	R			
A1	0.01	0.06	0.70	0.11	0.11	M	0.08	−0.87
A2	0.04	0.09	0.39	0.17	0.18	M	0.18	−0.70
A3	0.06	0.12	0.33	0.17	0.18	M	0.26	−0.66
A4	0.25	0.40	0.25	0.08	0.02	O	0.67	−0.66
A5	0.20	0.35	0.19	0.09	0.13	O	0.66	−0.65
B1	0.05	0.02	0.81	0.04	0.07	M	0.08	−0.90
B2	0.05	0.15	0.58	0.00	0.23	M	0.26	−0.94
B3	0.16	0.31	0.19	0.12	0.16	O	0.61	−0.64
B4	0.04	0.08	0.48	0.18	0.16	M	0.16	−0.72
B5	0.20	0.24	0.13	0.10	0.20	O	0.66	−0.55
B6	0.17	0.29	0.20	0.10	0.14	O	0.61	−0.64
B7	0.80	0.03	0.00	0.12	0.04	A	0.87	−0.04
B8	0.56	0.06	0.02	0.24	0.08	A	0.70	−0.09
C1	0.01	0.02	0.62	0.24	0.06	M	0.03	−0.72
C2	0.21	0.39	0.21	0.10	0.07	O	0.66	−0.66
C3	0.32	0.11	0.08	0.24	0.15	A	0.57	−0.25
C4	0.03	0.02	0.13	0.39	0.11	I	0.09	−0.26
C5	0.00	0.00	0.04	0.74	0.05	I	0.00	−0.05
D1	0.48	0.06	0.04	0.22	0.12	A	0.68	−0.12
D2	0.00	0.00	0.65	0.15	0.17	M	0.00	−0.82
D3	0.04	0.07	0.59	0.13	0.12	M	0.13	−0.80
D4	0.32	0.11	0.08	0.22	0.15	A	0.58	−0.26

Attractive quality (A), One-dimensional quality (O), Must-be quality (M), Indifferent quality (I), Reverse quality (R). Source: Author (2024).

4.2.2. Distribution of tourist demands within Kano model dimensions

Figure 3 visualizes the distribution of demand points along two dimensions: satisfaction improvement (Better) and dissatisfaction (Worse). The Better axis represents the degree to which fulfilling a specific need enhances customer satisfaction, with higher values indicating greater potential for satisfaction. The Worst axis reflects the degree of dissatisfaction caused when a need is unmet, with higher values indicating a stronger negative impact (Song, 2018). According to the Kano model, these needs are mapped onto a two-dimensional space, categorized into four distinct quadrants: Attractive, One-dimensional, Must-be, and Indifferent needs.

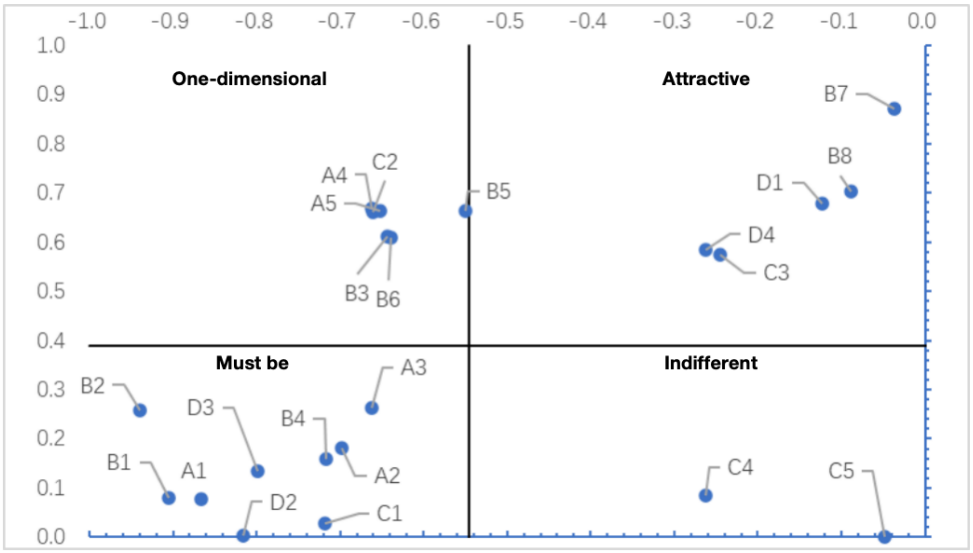

Figure 3. Distribution of tourist demands.

Source: Author (2024).

First Quadrant - Attractive Needs: The needs classified in the first quadrant include B7 (Craft Technique Simulation), B8 (Personalized Customization), C3 (Task Check-in), D1 (Tri-color Elements), and D4 (Interface Personalization). These needs share a common characteristic: A high better value and a low Worse value, indicating their “delight” attributes. They provide unexpected satisfaction and enjoyment to users but their absence will not lead to significant dissatisfaction.

Second Quadrant-One-dimensional Needs: The one-dimensional needs identified in the second quadrant include A5 (Multimedia Presentations), B5 (Voice Guidance), B6 (Beginner’s Guide), C2 (Experience Sharing), A4 (Tri-color Production Techniques), and B3 (Favorites). These needs have high Better and Worse values, meaning satisfaction increases steadily as they are fulfilled, while their absence leads to significant dissatisfaction.

Third Quadrant-Must-be Needs: The third quadrant encompasses the largest number of needs, primarily including A1 (Attraction Introduction), A2 (Graphical Presentation), A3 (Historical Introduction), B1 (Navigation), B2 (Search), B4 (Thematic Route Planning), C1 (Route Recording), D2 (Simplified Layout) and D3 (Clear Hierarchy). These needs are characterized by consistently high Worse values, indicating that they represent users’ basic expectations. The absence of any must-be needs may lead to disappointment and user attrition.

Fourth Quadrant-Indifferent Needs: The needs in the fourth quadrant include only C5 (Virtual Souvenirs) and C4 (Reward points). These needs have low Better and Worse values, indicating that their implementation or absence has minimal impact on customer satisfaction.

4.2.3. Ranking of tourist demands within Kano model dimensions

This section ranks the needs within each Kano dimension based on their scores, as illustrated in **Table 5**, to provide a clearer understanding of the relative importance of tourist demands. This approach identifies high-impact features to guide resource allocation and improve user satisfaction. Indifferent needs were excluded due to their minimal influence on satisfaction and dissatisfaction.

Table 5. Ranking of tourist demands within Kano model dimensions.

Dimensions	Demand	Index
Must-be	B1	0.81
	A1	0.70
	D2	0.65
	C1	0.62
	D3	0.59
	B2	0.58
	B4	0.48
	A2	0.39
	A3	0.33
One-dimensional	A4	0.40
	C2	0.39
	A5	0.35
	B3	0.31
	B6	0.29
	B5	0.24
Attractive	B7	0.80
	B8	0.56
	D1	0.48
	C3	0.32
	D4	0.32

Source: Author (2024).

Must-be Needs: Within the must-be dimension, B1 (Navigation), A1 (Introduction), D2 (Simplified Layout), and C1 (Route Recording) scored highest among must-be needs, reflecting their critical role in ensuring basic functionality and user satisfaction. Lower-priority needs, including D3 (Clear Hierarchy), B2 (Search), B4 (Thematic Route Planning), A2 (Graphical Presentation), and A3 (Historical Introduction), can be addressed in later stages once core requirements are met.

One-dimensional Needs: Within the one-dimensional dimension, A4 (Production Techniques) and C2 (Experience Sharing) ranked highest, highlighting users' interest in craftsmanship and interactive engagement. These were followed by

A5 (Multimedia Presentations) and B3 (Favorites). B6 (Beginner's Guide) and B5 (Voice Guidance) scored lower, suggesting they are less immediate priorities.

Attractive Needs: Within the attractive dimension, B7 (Craft Technique Simulation) and B8 (Personalized Customization) led in importance, emphasizing the value of immersive and personalized features. Lower-ranked needs, including D1 (Tri-color Elements), C3 (Task Check-in), and D4 (Interface Personalization), can be incorporated as resources allow.

5. Discussion

Understanding tourists' needs is essential for enhancing cultural heritage tourism through digital tools. This study aims to identify the multi-dimensional needs of tourists for cultural heritage tourism applications and propose design strategies based on the classification of these needs. The goal is to provide guidance for the use of tourism applications in cultural heritage tourism. Through a case study of Sancai Town, the Kano model is applied to categorize tourist needs into must-be, one-dimensional, attractive, and indifferent needs, highlighting their differentiated roles in shaping the tourist experience.

Among the identified needs, must-be needs play a foundational role, reflecting tourists' fundamental requirements, such as navigation, attraction introductions, and ensuring the application's functionality. Tourists expect digital tools to provide accurate location services, detailed attraction information, and clear interface guidance, enabling them to access the information they need during their visit easily. Design strategies for must-be needs should focus on creating a reliable digital map, enhancing the information database, simplifying the interface layout, and improving user-friendly interactions, thus providing tourists with efficient and convenient basic services.

One-dimensional needs, such as detailed descriptions of Tri-color pottery production techniques and experience-sharing features, have a straightforward impact on tourist satisfaction. Meeting these needs directly enhances satisfaction, as visitors value multimedia presentations that provide deeper insights into the pottery-making process and convenient tools for recording and sharing their experiences. To address these expectations, tourism applications should offer immersive displays of craftsmanship, user-friendly sharing options, and personalized recommendations. By effectively showcasing the appeal of Tri-color culture and enriching visitors' cultural experiences, fulfilling these needs can greatly improve tourist satisfaction and should remain a priority for ongoing refinement.

Beyond functional requirements, attractive needs are non-essential but enhance tourist experiences by introducing surprise and delight, addressing their higher-level emotional expectations. Tourists seek immersive interactive experiences, such as role-playing or scenario simulations, to deeply engage with the unique appeal of Tri-color pottery. Additionally, personalized services cater to tourists' desire for individuality. Features like interactive craft-making activities can encourage participatory engagement and spark cultural interest, making them effective in enhancing satisfaction. Attractive needs emphasize the value of incorporating

innovative features into the design process, fostering unique and emotionally engaging tourist experiences.

Finally, indifferent needs, such as reward points, have a more limited influence on the overall tourist experience. However, they still contribute positively by diversifying application content and fostering user engagement. Basic gamification features, such as collectible rewards, can add fun and entertainment to the exploration of Tri-color culture. While not critical to the experience, indifferent needs can still support overall user engagement when thoughtfully integrated into the design.

The findings make meaningful contributions to the existing research on the application of digital technologies in cultural heritage tourism. Prior studies have focused on digital tools' technical feasibility and functional design to enhance tourist experiences (Ammirato et al., 2022; Hausmann and Schuhbauer, 2021), but they devote insufficient attention to the diversity of tourist needs, particularly in emotional and cultural dimensions. Adopting a tourist-centric perspective, this study applies the Kano model to identify the prioritization of tourist demands and align specific design strategies with distinct need categories. This approach addresses the gaps in prior research by integrating demand analysis with design practice, providing a comprehensive understanding of tourist needs to drive digital innovation. Moreover, the findings advance the theoretical understanding of the "demand-design" approach in cultural heritage tourism (Li and Kim, 2023), offering new empirical support for applying related theoretical frameworks.

6. Conclusion

Employing the Kano model, this study identifies the multi-dimensional needs of tourists for cultural heritage tourism applications in Sancai Town. These needs are categorized into four types: Must-be, one-dimensional, attractive, and indifferent, representing different focuses such as functional guarantee, satisfaction enhancement, emotional resonance, and experience enrichment. Based on this classification, the study proposes differentiated design strategies for tourism applications to meet tourists' diverse needs and improve the overall travel experience. The findings provide practical references for the digital transformation of Sancai Town and theoretical insights for developing smart tourism in other cultural heritage sites. By balancing cultural heritage protection with tourism development, this research contributes to sustainable regional growth.

The findings of this study hold significant implications for both academia and industry. Theoretically, the application of the Kano model advances the understanding of tourist needs in cultural heritage tourism by providing a robust demand-driven framework for categorizing must-be, one-dimensional, attractive, and indifferent needs. This systematic classification can serve as a foundation for future studies exploring digital innovation in various heritage contexts. Practically, the results offer actionable insights for the tourism industry, particularly in designing user-centered applications through specific strategies such as enhanced multimedia elements and personalized interfaces that enhance visitor engagement while promoting cultural preservation. As the industry undergoes rapid digital

transformation, these evidence-based approaches equip practitioners with innovative tools to address evolving tourist expectations, contributing to the sustainable integration of tourism and cultural heritage.

This study has certain limitations. First, the sample is limited to Sancai Town, focusing on intangible cultural heritage craftsmanship, and the findings may not generalize to other types of cultural heritage sites. Future research could validate this framework in other contexts, such as historical monuments, archaeological sites, or cultural landscapes. Second, data were collected through interviews and questionnaires, which may introduce self-reported biases. Triangulating these findings with methods such as observational studies or experimental designs could enhance their robustness. Moreover, this study's cross-sectional design captures a static view of tourist needs, which may change over time. Longitudinal designs could reveal temporal dynamics and support the development of adaptive digital solutions. Additionally, the sample is limited to domestic Chinese tourists visiting Sancai Town, excluding foreign visitors. While this offers valuable insights into local needs, it may overlook international perspectives shaped by different cultural contexts. Future research could include foreign tourists to understand diverse user needs better and design globally inclusive solutions. Lastly, this study primarily focused on overall tourist needs and preferences, with limited exploration of demographic factors such as age, cultural background, or digital literacy. While these demographic variables provide a starting point for understanding differences among tourist segments, the study did not investigate specific correlations, such as the relationship between education level, gender, and preference or technology usage in tourism. Future research could address this gap by examining these variables in greater detail, offering actionable insights for targeted design strategies and supporting more effective future planning.

By categorizing tourist needs using the Kano model, this research prioritizes diverse expectations and proposes practical strategies to enhance user satisfaction. These efforts aim to improve visitor experiences, support sustainable tourism practices, and integrate smart tourism infrastructure with cultural heritage preservation. Future research should explore applying this approach to other types of heritage sites and adopt longitudinal studies to track evolving needs, contributing to more targeted and adaptive solutions for the sustainable development of cultural heritage tourism.

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