Exploring User Participation Intention and Behavior in Immersive Intangible Cultural Heritage Digital Museums

Zhongnan Yan, Mengni Wang, Jinfeng Zhang*

College of Artificial Intelligence and E-Commerce, Zhejiang Gongshang University Hangzhou College of Commerce, Hangzhou, 311599, China
Zhongnan Yan and Mengni Wang are con-first authors

*www.8848afeng@163.com

Abstract. This paper explores the user requirements of immersive digital museum of intangible cultural heritage with Kano model, 28 questions were identified through interviews and expert consultation, divided into four categories, 318 valid questionnaires were collected through questionnaire star, and the reliability was tested by SPSS 27. The results show that museum design optimization should prioritize the improvement of necessary and expected attributes, increase charm attributes, and flexible treatment of non-differentiated attributes, which provides a basis for user demand analysis and product optimization, improves user experience and satisfaction, and provides reference guidance for demand understanding and service optimization.

Keywords: Digital museum; Kano model; User willingness; Intangible cultural heritage.

1 Introduction

1.1 Background of the Study

Intangible Cultural Heritage (ICH), as the crystallization of human wisdom and creativity, carries rich historical, cultural, social and scientific values, and is the treasure of national culture and an important part of human civilization. However, under the impact of the wave of globalization and modernization, ICH is facing serious challenges to its survival, such as the aging of the inheritors, the shrinking of the audience, and the single channel of transmission. In order to better protect and pass on ICH, the application of digital technology has become a new trend and means. Among them, immersive ICH digital museum, as an emerging cultural communication platform, provides users with a new way of experience and learning, which has important research value and practical significance.

L. Chang et al. (eds.), *Proceedings of the 2024 8th International Seminar on Education, Management and Social Sciences (ISEMSS 2024)*, Advances in Social Science, Education and Humanities Research 867,
https://doi.org/10.2991/978-2-38476-297-2_115

1.2 Research Significance

In terms of theoretical significance, this paper uses digital technology for the study of intangible cultural heritage protection and inheritance and explores the participation, willingness, and behavior of users of the immersive digital museum of intangible cultural heritage so as to provide a new perspective and method for the theoretical study of intangible cultural heritage protection and inheritance. Taking the users of the museum as the object, we analyze their participation, willingness, and behavior, enrich the theoretical system of user behavior research, and provide references for related research. In terms of practical significance, this paper provides the basis and guidance for the construction and operation of the immersive non-heritage digital museum by understanding the expectations of users' needs and analyzing the law of factors affecting participation, so as to improve the quality of service and user satisfaction and promote its sustainable development. In addition, it can also promote the protection and inheritance of non-heritage, raise the importance of society, promote the application and popularization of digital technology, provide new ideas and methods, and promote the innovative development and creative transformation of non-heritage.

2 Literature Review

2.1 Related Concepts

(1) KANO model

Kurt M. and Hans H. [8](1998) pointed out that the Kano model is an evaluation method based on the two-factor theory proposed by the Japanese scholar Noriaki Kano in 1984, which is based on the analysis of user needs to build a two-dimensional cognitive model of "function-user" and can classify and rank the importance of user needs (Fig.1). Kano N, Seraku N (1984), and others proposed the Kano model, which suggests that there is a nonlinear relationship between functional attributes and user satisfaction and that not every function affects user satisfaction [7]and categorizes the factors affecting user satisfaction into five types: M, A, O, I, R.

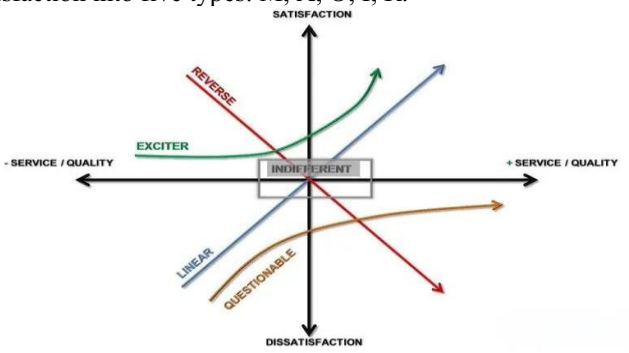

Fig. 1. Kano Model

(2) Digital Museum

Early scholars such as Zhang Wei and Ning Gang [20](2000) believe that digital museums are multimedia digital information institutions that use computer digitization technology to handle, process, sequence, and network their collections of cultural relics and specimens, as well as exhibitions, for social audiences to browse and view. Xia Jingshi [18](2000) emphasized that the digital museum is the use of current Internet technology, and broadband Internet technology will be put into the realization of a remote virtual visit to the museum, but it can also achieve interactive participation. With the development of technology and in-depth research, Chen Guoliang, Tong Yin, Hu Jiang, etc. [2] (2003) proposed that the digital museum is not only the digitization of cultural relics, and Yang Xiangming [19](2006) further proposed that the digital museum is a digital form of movable cultural relics and immovable cultural relics of all aspects of information collection, management, display, and processing, and through the Internet to provide users with digital display, education, research, and other services, is a digital museum. It is an information service system combining computer science, communication science, and museology. From the perspective of natural and cultural heritage protection, Qiu Yao [14](2024) believes that the purpose of the purpose of a digital museum is to collect, preserve, disseminate, and display natural and cultural heritage by using virtual reality technology and three-dimensional imaging technology and presenting them on the Internet in digital form. Zhou Chuanting [21](2024) points out that the goal of digital museums is to pass on and promote cultural heritage through digitized resources and rich interactive experiences, and to enhance the participation and dissemination of museums in order to satisfy people's needs for cultural knowledge and education in modern society.

2.2 User Participation and Willingness of Digital Museums

With the rapid development of information technology, digital museums, as an emerging platform for cultural dissemination and education, have gradually become the focus of research on user willingness to participate. Many scholars have studied the willingness of users to participate in digital museums from different perspectives. Some scholars believe that users' intrinsic motivation is the key factor affecting their willingness to participate. Users' desire for cultural knowledge, curiosity about history, and pursuit of artistic aesthetics drive them to actively participate in the activities of digital museums.

And the interactivity of digital museums is also an important influence on users' willingness to participate. Wang Jingjing [16](2023) Users prefer the visualization interface to the way information is presented in the cultural heritage interface. In addition, the advantages and disadvantages of the user experience also play a role in the willingness to participate. Ji Jiaran and Li Siyu [5](2024) proposed to adopt different visual elements and interaction methods to present the rich cultural information and cultural relics exhibits of digital museums to better represent the structure, style, decoration, and other characteristics of traditional residential buildings so that visitors can understand the cultural connotation and historical background of the Jiangnan region in a more intuitive and perceptive way, while Wang Zikai and Yang Abandonment (2024)

proposed a design strategy that starts from two dimensions: plot interaction and spatial experience. Wang Zikai and Yang Qiu [17](2024) proposed a design strategy based on the dimensions of plot interaction and spatial experience. Chen Juan [3] (2022) explored the innovative design paradigm of NRL exhibit content display, the optimized experience mode of user participation in interactive behaviors, and the reshaping of the relationship between NRL culture and public life in interactive narrative design from the perspective of narrative in interactive contexts and by using the technological characteristics of interactive narrative and focusing on the user.

Social factors are also not to be ignored. Qin Xinyi [13](2024) points out that the rise of social media has brought brand new opportunities and challenges for digital museums. Pan Lina[11] (2024) suggests that through the social participation of museums, the audience can not only realize the need for emotional communication and gain cultural knowledge but also discover and create meaning in the process of communication and change from passive receivers to active participants. At the same time, the publicity and promotion efforts of digital museums also have a certain impact on the user's willingness to participate. For example, Fan Fanghui [4](2024) proposed an effective communication strategy, the use of new media to improve the visibility and exposure of digital museums, to attract more users to participate.

3 Research Design

Users are the key to the success of the product. In order to ensure the comprehensiveness, scientificity, and accuracy of the research on user demand attributes, this paper mainly determines the user demand attributes of the immersive digital museum of intangible cultural heritage through the following steps:

(1) Interviewing relevant users to obtain original information. In this study, five senior digital museum users of different ages (three of them have more than two years of experience in using digital museums, two of them have more than one year of experience in using digital museums), and two of them are non-genetic inheritors, were interviewed, and the questions of the interview were: "Do all of the above attributes of the service satisfy your needs? In addition to the above, what else would you like to see added to the immersive digital museum of intangible cultural heritage?". Based on the results of the interviews, we have finalized the final version of the museum. Based on the results of the interviews, 42 preliminary questions were finalized.

(2) Two senior experts in the field of digital museums of intangible cultural heritage were invited to form a discussion group to streamline, categorize, and fully condense the above 42 specific transformations by means of expert consultation and group discussion, and ultimately identified four categories containing a total of 28 relevant questions, as shown in Table 1.

Table 1. Summary of user willingness to participate and attributes of behavioral issues

Category	Attributes	meaning
Technology and interactive experience	Virtual interaction	Interact with the real world through virtual technology.
	Real time interaction	Instant communication with non-genetic artists.
	AI guided tour	AI-based tour guide.
	Virtual Practice	Simulate non-heritage skills and provide an interactive experience.
	network connections	Stable, reliable, and smooth experience.
	Easy to use interface	Simple and clear operation interface.
	Smooth video	Lag-free video playback.
	Smooth experience	Lag-free interactive experience.
	Quick scene loading	Fast scene loading and transition.
	Voice explanation	Clear and easy-to-understand narration.
	System stability	High stability to minimize lag and failure.
	Clear interface	HD interface and scene display.
	Easy to understand operating instructions	Easy-to-understand guide.
Content and educational resources	Personalized recommendations	Recommended non-heritage content based on preferences.
	Cultural Introduction	Detailed and accurate non-heritage information.
	Content Update	Regularly updated cultural content.
	learning resource	Provision of educational and learning materials.
User experience and convenience	High definition images	High-definition exhibit presentations.
	High definition exhibits	High-definition display introduction.
	Visitor Route	Diverse path options.
	Account security	Secure login and privacy.
	Visiting Guide	Clear directional instructions.
	Advertising reduction	Reduce advertisement pop-ups to optimize the experience.
	Simplified registration	Easy registration process.
Personal preferences and feelings	Personalized Background	Customizable museum colors.
	Dynamic icon	Dynamic elements in the interface.
	Display area division	Effective display area layout.
	Page layout	Subtle page design.

4 Questionnaire Design

4.1 Questionnaire Design Based on the Kano Model

This study explores the user participation willingness and behavior of immersive intangible cultural heritage digital museums as the theme of the questionnaire to obtain evaluation feedback. After the preliminary questionnaire was formulated, it was revised by reviewing research literature, consulting senior experts, and inviting users to test it, and fixing fuzzy expressions and complex statements to form the formal questionnaire.

The formal questionnaire is divided into two parts, the first part is demographic variables, such as gender, age, etc.; the second part is the main body of the matrix scale, with 4 categories and 28 question items, including technology and interactive experience (12 questions), content and educational resources (6 questions), user experience and convenience (6 questions), personal preferences and feelings (4 questions), and each attribute is asked positively and negatively. The scale items were based on a five-point Likert scale: "I am satisfied", "I should be", "I don't care", "I can tolerate it", "I am very dissatisfied", "I don't care", "I can tolerate it", and "I am very dissatisfied". "It is convenient for users to choose intuitively, and some examples of the questionnaire are shown in Table 2.

Table 2. Sample Kano Questionnaire for Exploring User Participation Intentions and Behaviors in Immersive Digital Museums of Intangible Cultural Heritage (Part II, Technological and Interactive Experiences Category, Question 1)

Experiencing virtual reality and reality interaction in an immersive ICH digital museum.					
Title/Item	I'm satisfied	It should be like this	indifferent	Can tolerate it	Very dissatisfied
If you modify this content, do you think:					
If this content is not modified, do you think:					

4.2 Kano Questionnaire Collection

The questionnaire was created through the platform of Questionnaire Star, and the survey was conducted for the users around us or in society. The questionnaire was distributed from June 14th to June 16th, 2024, and a total of 352 questionnaires were collected in the end. After a preliminary check of the questionnaire data, 34 invalid questionnaires were excluded; most of the invalid questionnaires had the same option data or obvious contradictions in the choices; finally, 318 valid questionnaires were left, and the validity rate of the questionnaire recovery was 90.34%. In this survey, a total of 318 respondents participated. In terms of age distribution, young people aged 18–25 and middle-aged people aged 46 or above occupied a larger proportion, with 5.56% and 3.04%, respectively. In terms of gender distribution, there are slightly more women than men, accounting for 9.28% and 7.39%, respectively. In terms of city level, second-tier cities have the most respondents, accounting for 7.34%, while fourth-tier cities and below have fewer respondents, accounting for only 1.62%. The education level is dominated by high school and university college or bachelor degrees, accounting for 5.45%

and 4.56%, respectively. In the distribution of occupations, there are more school students and white-collar workers in enterprises, accounting for 5.50% and 2.57%, respectively. In addition, there are also respondents from other occupations, such as workers and institutional staff, accounting for 2.88% and 2.99%, respectively. These data provide us with a detailed distribution of the basic characteristics of the respondents, which helps to further analyze and understand the survey results.

4.3 Kano Questionnaire Reliability and Validity Test

The data analysis software SPSS 27 was used to test the reliability and validity of the questionnaire data in this study, and the specific results are shown in Table 3. From the data in the table, it can be seen that the Kano questionnaire, forward and reverse questions of the clone Bach Alpha test value, are in line with the standard, indicating that the questionnaire has good reliability; its KMO value is above 0.8, and Bartlett's sphericity test value is 0.000, indicating that the validity of the questionnaire is high. In conclusion, the Kano questionnaire has good reliability and validity, and the data are reliable and meet the requirements of analysis, so it can be used in subsequent research.

Table 3. Kano questionnaire reliability test

Dimension	Clone Bach Alpha	KMO value	Bartlett sphericity test	Number of items
Technology and interactive experience	0.934	0.963	0	26
Content and educational resources	0.857		0	10
User experience and convenience	0.87		0	12
Personal preferences and feelings	0.878		0	8
Total Quantity Table	0.971		0	56

5 Data Analysis

5.1 Exploring Kano Hierarchical Analysis of User Participation, Willingness, and Behavioral Needs in Immersive ICH Digital Museums

Kurt M proposed that three statistical tools should be utilized for Kano model hierarchy identification: the Kano questionnaire, the Kano model positioning comparison table, and the Kano result analysis table. In this study, the Kano model analysis of the questionnaire data was carried out to determine the demand level, and at the same time, the Kano model positioning comparison table was combined with the comparative analysis of the user's willingness to participate in exploring immersive digital museums of intangible cultural heritage and the content of their behaviors, as shown in Table 4. On

this basis, the statistics of each attribute are organized and summarized into the Kano result analysis table, as shown in Table 5.

Table 4. Comparison table of Kano model positioning

	Function/Service	Negative Question				
		Not liked (1 point)	can tolerate (2 points)	doesn't matter (3 points)	should be like this (4 points)	likes (5 points)
Positive question	Not liked (1 point)	Q	R	R	R	R
	can tolerate (2 points)	M	I	I	I	R
	doesn't matter (3 points)	M	I	I	I	R
	should be like this (4 points)	M	I	I	I	R
	likes (5 points)	O	A	A	A	Q

A: Charm attribute, O: expected attribute, M: essential attribute, I: indifference attribute, R: reverse attribute, Q: suspicious attribute

Table 5. Kano results analysis table

Kano Category	Content
A	1. Real time interaction, 2. Virtual practice, 3. Fast scene loading, 4. Personalized recommendation, 5. Cultural introduction, 6. Content update, 7. Visiting guide, 8. Display area division
O	1. Virtual interaction, 2. Network connection, 3. Smooth video, 4. Voice explanation, 5. System stability, 6. Learning resources, 7. Account security
M	1. AI navigation, 2. Easy to use interface, 3. Smooth video, 4. Clear interface, 5. Easy to understand operation instructions
I	1. Visiting route, 2. Simplified registration, 3. Personalized background, 4. Dynamic icons, 5. Page layout

Through the analysis of these attributes, the focus in designing and optimizing the immersive digital museum of intangible cultural heritage can be clarified by prioritizing and improving the required attributes and expected attributes, as well as significantly improving the user experience by increasing the charismatic attributes, and the undifferentiated attributes can be flexibly dealt with according to the resources and strategies.

5.2 Mixed-Class Analysis of User Requirements

The above Kano model analysis is only based on the frequency of attributes to classify the demand hierarchy, but when the frequency of two attributes is close to each other, it is difficult to classify the demand categories in detail[12]. In order to more accurately analyze the relationship between each requirement attribute and user satisfaction, this paper adopts the hybrid class analysis method proposed by Lee M. [9]to make a more detailed distinction between the requirements. The mixed-class analysis method is capable of secondary confirmation of the classification results of the traditional Kano

model and aims to identify mixed-class attributes[10]. The method distinguishes attributes with the help of two quantitative indexes of total strength TS (total strength) and category strength CS (category strength). If an attribute has no dominant classification in the analysis results, it will be defined as a mixed category. When its category strength (CS) is insufficient, it will also be categorized as a mixed category. Then, the total strength (TS) becomes the criterion for judging the attribute. The formulas for TS and CS are as follows:

(1) TS = (M + O + A) / (M + O + A + I + R + Q) (2) CS = [max(M, O, A, I, R, Q) - secondmax (M, O, A, I, R, Q)] / (M + O + A + I + R + Q) When TS is greater than or equal to 60% and CS is less than or equal to 6%, the attribute is classified as a mixed category. The results of the traditional Kano classification and the analysis results after the hybrid category optimization calculation are shown in Table 6.

Table 6. Kano overall classification results of user participation willingness and behavior in immersive ICH digital museums

Function/Service	A	O	M	I	R	Q	TS value	CS value	Mixed category	Better	Worse
Virtual interaction	15	99	89	81	31	3	63.84%	3.14%	H(O,M)	40.14%	-66.20%
Real time interaction	141	52	42	45	29	9	73.90%	27.99%	A	68.93%	-33.57%
AI guided tour	19	66	151	59	14	9	74.21%	26.73%	M	28.81%	-73.56%
Virtual Practice	167	46	37	34	24	10	78.62%	38.05%	A	75.00%	-29.23%
network connections	57	148	37	39	28	9	76.10%	28.62%	O	72.95%	-65.84%
Easy to use interface	25	53	132	74	22	12	66.04%	18.24%	M	27.46%	-65.14%
Smooth video	50	127	55	60	17	9	72.96%	21.07%	O	60.62%	-62.33%
Smooth experience	52	57	147	35	16	11	80.50%	28.30%	M	37.46%	-70.10%
Quick scene loading	132	62	24	70	21	9	68.55%	19.50%	A	67.36%	-29.86%
Voice explanation	57	138	51	41	24	7	77.36%	25.47%	O	67.94%	-65.85%
System stability	49	164	42	31	25	7	80.19%	36.16%	O	74.48%	-72.03%
Clear interface	58	30	166	33	22	9	79.87%	33.96%	M	30.66%	-68.29%
Easy to understand operating instructions	48	48	147	43	24	8	76.42%	31.13%	M	33.57%	-68.18%
Personalized recommendations	170	27	35	56	23	7	72.96%	35.85%	A	68.40%	-21.53%
Cultural Introduction	174	39	47	23	29	6	81.76%	39.94%	A	75.27%	-30.39%
Content Update	179	28	53	20	29	9	81.76%	39.62%	A	73.93%	-28.93%
learning resource	90	111	49	42	17	9	78.62%	6.60%	O	68.84%	-54.79%
High definition images	55	44	122	64	24	9	69.50%	18.24%	M	34.74%	-58.25%
High definition exhibits	47	44	179	16	23	9	84.91%	41.51%	M	31.82%	-77.97%
Visitor Route	56	27	45	159	22	9	40.25%	32.39%	I	28.92%	-25.09%
Account security	56	127	37	64	25	9	69.18%	19.81%	O	64.44%	-57.75%
Visiting Guide	177	30	35	46	22	8	76.10%	41.19%	A	71.88%	-22.57%
Advertising reduction	31	43	177	27	30	10	78.93%	42.14%	M	26.62%	-79.14%
Simplified registration	52	36	44	153	24	9	41.51%	31.76%	I	30.88%	-28.07%
Personalized Background	59	32	38	156	24	9	40.57%	30.50%	I	31.93%	-24.56%
Dynamic icon	61	33	42	148	25	9	42.77%	27.36%	I	33.10%	-26.41%
Display area division	181	33	38	39	18	9	79.25%	44.65%	A	73.54%	-24.40%
Page layout	55	36	30	164	25	8	38.05%	34.28%	I	31.93%	-23.16%

As can be seen from Table 6, after the hybrid class optimization analysis, the categories to which some of the requirement attributes belong have changed. The virtual interaction is transformed into a mixed class of O (expected characteristics) and M (charming characteristics), indicating that the provision of this demand has a strong impact on the user's satisfaction and should be focused on, and related research also confirms that the user's attitude towards the demand will show a conversion cycle of I →A→O→M over time[6].

5.3 Analysis of the Better-Worse Coefficient of User Requirements

The traditional Kano model and mixed-class analysis to identify the type of demand are only done through the calculation of the frequency of each demand and combined with the proportion of the situation to classify the category[15]. There are still some limitations in the classification of some demand attribute categories. Therefore, on the basis of the above model, the Better-Worse User Satisfaction Index method proposed by Berger C et al. [1]was adopted to analyze the impact of the content attributes of user participation willingness and behaviors on user satisfaction in the immersive digital museum of intangible cultural heritage and to determine the changes in user satisfaction after adding or deleting a demand attribute to determine the actual immersive user participation willingness and behaviors in the immersive digital museum of intangible cultural heritage. The better coefficient is usually greater than 0, and the closer the value is to 1, the higher the user satisfaction is when the demand is met; the worse coefficient is usually less than 0, and the closer the value is to -1, the lower the user satisfaction is when the demand is not met. The formula for both is as follows: $Better=(O+A)/(M+O+Worse=(M+O)/(M+O+A+I)\times$-1+$O)/(M+$better $I)\times$worse4). The Better and Worse coefficients for each demand attribute are calculated using the formula above. The results are shown in Table 6. The mean value of the Better weighted coefficient is 0.51, and the mean value of the Worse weighted coefficient is 0.48. In order to visually present the distribution of each attribute more intuitively, the Better coefficient is plotted on the horizontal axis, and the Worse coefficient is plotted on the vertical axis. The mean value of the two coefficients (0.5) is used as a reference line on the graph, with the Better coefficient on the horizontal axis and the Worse coefficient on the vertical axis. In order to visualize the distribution of each attribute, we take the Better coefficient as the horizontal axis, the absolute value of the Worse coefficient as the vertical axis, and the mean values of the two coefficients (0.48, 0.51) as the origin, and establish a four-quadrant plot of the Better-Worse coefficient with the help of SPSSAU, as shown in Fig 2.

Fig. 2. Four-quadrant distribution of better-worse coefficient values for each attribute

Quadrant 1 (upper right quadrant) includes learning resources, account security, video smoothness, network connection, voice explanation, and system stability. These features have gained high satisfaction and low dissatisfaction among users. They are the strengths of the product or service and should continue to be maintained and strengthened.

Quadrant 2 (lower right quadrant): includes virtual interaction, a smooth experience, an easy-to-use interface, AI-guided tours, high-definition exhibits, and reduced advertising. Satisfaction with these features is low, but so is user dissatisfaction. This could mean that there is some room for improvement in these features, but it is not the most pressing issue.

Quadrant 3 (upper left quadrant) includes point-of-visit guides, personalized recommendations, virtual hands-on, fast scene loading, and real-time interaction. While there is some user satisfaction with these features, they are also accompanied by a high level of dissatisfaction. This may indicate that while these features meet some of the user's needs, they also have some problems or limitations that need to be further optimized.

Quadrant 4 (lower left quadrant) includes simplified registration, personalized backgrounds, tour routes, and high-resolution images. These features have a low level of satisfaction and a high level of dissatisfaction among users. This suggests that these features may be weaknesses in the product or service that need to be focused on for improvement. In summary, for the features in Quadrant 1, they should be maintained and strengthened; for the features in Quadrant 2, they can be considered for improvement in future iterations; for the features in Quadrant 3, user feedback needs to be analyzed in depth to find out where the problems lie and optimize them; and for the features in Quadrant 4, they are the most important areas that need to be paid attention to and improved at the moment. Through such analysis, the direction of product or service optimization can be more effectively guided.

6 Conclusion

This study utilizes the Kano model, combined with a questionnaire survey, to analyze in-depth user requirements for an immersive non-heritage digital museum and collect user feedback data. The results demonstrate users' expectations and satisfaction with service characteristics, identify attributes, determine the priority ranking for product development optimization, and analyze the influential characteristics on user satisfaction through a better- Worse coefficient plot. This quantitative analysis supports product improvement and demand management, reveals user demand characteristics, and provides a methodological basis, but there are limitations. The questionnaire sample cannot fully represent all target users, and user needs may change, so it may be difficult to reflect the long-term demand changes in the results of the study. Subsequent research should grasp the similarities and differences of segmented museums, and with the development of user needs and the market, the method based on user needs analysis will help digital museums improve user experience and market performance.

Funding

2022 Student Innovation and Entrepreneurship Training Programme Projects (202213290003X).

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