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AI+XR Technology-Driven Research on the Digital Communication Effects of Cultural Heritage

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Abstract: This paper takes the "Eternal Splendor of the Tang Dynasty" immersive exhibition at the Anhui Museum as a practical case to explore the digital communication effects of AI+XR technology in museum displays. By integrating the Technology Acceptance Model (TAM) and User Experience Theory, the study constructs a research model around three dimensions: technological implementation, content innovation, and user experience. The study reveals a chain mechanism of digital cultural communication, encompassing "digital experience - emotional experience - acceptance - revisit intention." Empirical analysis based on 436 valid questionnaires shows that aesthetic experience, interactive experience, immersive experience, cultural content experience, and cultural value experience all have a significant positive impact on emotional experience. Emotional experience significantly positively influences acceptance, which in turn significantly positively affects revisit intention. The user clustering analysis based on the K-means algorithm identifies three types of groups: basic, conservative, and deep experience types. This research provides a theoretical basis and practical reference for the digital transformation of museums in the era of artificial intelligence.

Keywords: Digital communication, Cultural heritage revitalization, AI+XR technology, Technology acceptance model, User experience theory

1. Introduction

Under the dual policy drivers of the cultural digitization strategy and the "14th Five-Year Plan" for cultural heritage, the integration of Artificial Intelligence and Extended Reality (AI+XR) technologies is reshaping the cultural heritage narrative system, driving the paradigm shift in the cultural heritage sector from "heritage preservation" to "heritage revitalization." The "Eternal Splendor of the Tang Dynasty" immersive exhibition, relying on AI-driven 3D modeling technology, achieves high-precision digital restoration of cultural relics such as the Lu-Shena Buddha of Longmen Grottoes, dynamically reconstructing historical scenes from the Tang Dynasty, such as the Hu Xuan dance and poet dialogues. Through a "human-machine-history" triadic interaction mechanism, the exhibition breaks through the traditional one-way communication model, transforming the audience into empathetic participants in historical contexts. Based on the concept of the experience economy, the study focuses on the user's digital experience dimension, integrating the digitization characteristics of cultural relics with the audience's aesthetic interaction needs, and constructs a model of "digital experience - emotional experience - acceptance - revisit intention." The construction

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of this model provides a new perspective for digital communication effects in cultural heritage and relic revitalization, offering a practical reference for industry practices.

2. Literature review

2.1. Model theory

2.1.1. Digital communication

Digital communication is an interactive cultural communication model built on a foundation of digital technology and digital resources as core elements. It constructs user-centered immersive scenarios through technologies like 3D/VR, driving cultural heritage into shareable and regenerative digital forms [1]. Compared to traditional exhibitions, XR technology reconstructs narrative logic and knowledge systems, achieving multidimensional extensions of historical cognition in virtual spaces, while enhancing audience identity recognition and expanding the possibilities of digital narratives [2]. Existing studies focus on the technological applications and case practices of cultural relic revitalization, but in digital museum exhibitions, there is still a theoretical gap in understanding the roles of user perception dimensions and communication effects. This study constructs the "digital experience - emotional experience - acceptance - revisit intention" model to analyze the relationships between these factors and provide reference suggestions for optimizing digital communication effects in cultural heritage.

2.1.2. User experience theory

The User Experience (UX) theory is framed by Norman's Three-Level Model [3]: the visceral level of experience originates from sensory stimuli, such as the visual aesthetics and sound design of digital exhibitions; the behavioral level concerns operational effectiveness, including interface interaction fluidity and content immersion; and the reflective level triggers emotional resonance and cultural cognition reconstruction, reflecting educational functions and social value. Further, user experience is the total psychological perception of the entire interaction process between a product, service, and the user. Based on the AI+XR "Eternal Splendor of the Tang Dynasty" immersive exhibition system, this paper analyzes its features from five dimensions: aesthetic experience (visceral level), interaction and immersion experience (behavioral level), and emotional and cultural cognition experience (reflective level), such as the usability of navigation logic and the deepening of cultural identity in narrative content.

2.1.3. Technology acceptance model

The Technology Acceptance Model (TAM) centers around perceived usefulness (functional fit) and perceived ease of use (operational convenience) as core variables, revealing the driving mechanism of user attitudes toward technology use on behavioral intentions [4]. This paper focuses on the "Eternal Splendor of the Tang Dynasty" AI+XR immersive exhibition system, innovatively improving the traditional TAM model: by introducing "emotional experience (positive/negative)" and "acceptance levels (high/low)," a dual-dimensional intermediary variable is constructed. This model tracks the transmission path of "emotional experience → acceptance → revisit intention," accurately analyzing the phased cognitive transition of users under the intervention of XR technology, thereby achieving a detailed evaluation of the experiencer's cognitive process.

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2.2. Key factors

2.2.1. Aesthetic experience

Aesthetic experience, as a basic perception layer, reduces cognitive load through visual appeal, information architecture, and interface consistency design [5] , utilizing LED screens and real-time rendering technology to create a visual spectacle of time-space traversal, triggering positive emotional resonance driven by visual pleasure.

2.2.2. Technological experience

Technological experience strengthens emotional connection through a bidirectional path. In the interaction experience dimension, Norman's emotional design theory and Huang Sheng's [6] empirical research together show that ease of learning, voice interaction error tolerance, and the transference design of social functions positively impact user pleasure. The immersive experience brought by technology has the same effect, as Blumenthal V [7] pointed out, that tourists form emotions, feelings, perceptions, and insights during tourism immersion experiences, which enhance emotional experience. This paper divides technological experience into interaction experience and immersion experience, revealing the triggering and deepening mechanisms of emotional experience empowered by technology.

2.2.3. Cultural cognition experience

Cognitive psychology reveals that cognition and emotion are closely linked and influence each other, with cognition even driving emotions and emotional states [8]. Cultural value theory suggests that users' sense of identity with cultural symbols conveyed by exhibitions can enhance a sense of belonging and emotional attachment [9]. The digital reconstruction of cultural content can simultaneously improve cognitive understanding and emotional intensity [10]. Based on this, this paper deconstructs cultural cognition experience into two dimensions: cultural content experience and cultural value experience.

2.2.4. Acceptance

Cross-cultural communication research shows that the emotional-cognitive system of the audience plays a decisive role in their information acceptance, a principle that has been verified in the dissemination of red classic songs [11]. In the context of digital exhibitions, AR treasure hunt games, through physical interaction, stimulate multi-sensory emotional experiences. This entertaining approach not only enhances cognitive immersion but also, through the transmission of positive emotions, encourages visitors to re-examine the value of the exhibition, thereby spontaneously conducting a cognitive reconstruction of its educational value, ultimately forming a stable acceptance attitude.

2.2.5. Revisit intention

Based on the decision-making mechanism framework of the Theory of Planned Behavior (TPB), behavioral attitude serves as the core antecedent variable influencing behavioral intentions [12]. The study operationalizes acceptance as "the degree of recognition of the exhibition's value and the willingness for continued engagement," forming the attitude foundation for revisit decisions. When the audience forms a "positive digital experience" cognitive judgment and adds positive emotions, three behavioral driving forces emerge: first, reinforcing value recognition through self-persuasion; second, it should be widely promoted; and third, stimulating the continuous need for knowledge

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acquisition. This composite attitude significantly enhances the perception of behavioral control, transforming revisit decisions from a possible option to a priority choice.

3. Methodology

3.1. Hypothesis design

H1: Aesthetic experience significantly positively influences emotional experience.
H2: Technological experience significantly positively influences emotional experience.
H2a: Interactive experience significantly positively influences emotional experience.
H2b: Immersive experience significantly positively influences emotional experience.
H3: Cultural cognitive experience significantly positively influences emotional experience.
H3a: Cultural content experience significantly positively influences emotional experience.
H3b: Cultural value experience significantly positively influences emotional experience.
H4: Emotional experience significantly positively influences acceptance level.
H5: Acceptance level significantly positively influences revisit intention.

3.2. Hypothesis model construction

Based on the literature review and the hypotheses presented above, a hypothesis model combining the five variables of user digital experience, emotional experience, acceptance level, and revisit intention is constructed as shown in Figure 1.

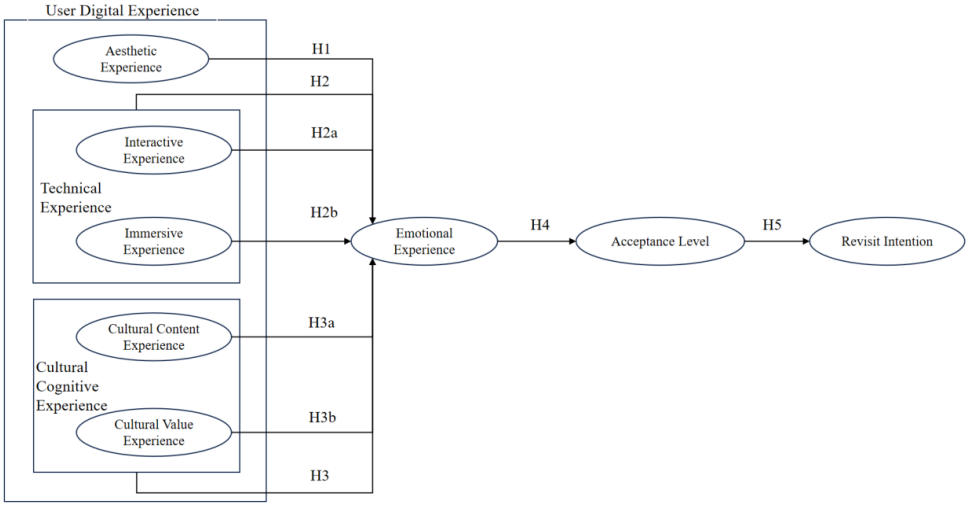

Figure 1: Research hypothesis conceptual model

3.3. Preliminary survey

The research uses a three-stage scale development method: designing independent variables, intermediate variables, and dependent variables based on the characteristics of cultural heritage, with reference to previous studies and employing a 5-point Likert scale. After optimizing the items through a preliminary survey (N=66, Cronbach's α=0.823, KMO=0.763), the formal survey gathered 436 valid samples (February-March 2025) through a filtering mechanism, and the data integrity met the analysis requirements. Descriptive statistics, model fitting, hypothesis testing via confirmatory factor analysis based on structural equation modeling, and user clustering analysis based on the K-means algorithm were performed using SPSS 22.0 software.

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4. Results

4.1. Descriptive statistics

The gender distribution of respondents was balanced (54.59% female), with the majority aged 18-35 years (66.42%). 30.28% had a bachelor's degree or higher. The most common occupations were corporate employees (42.43%) and freelancers (30.73%). In the analysis of multiple responses for digital exhibition formats, the most common technology was virtual reality (VR) (260 respondents, 28.14%), followed by web/app browsing (249 respondents) and 3D panoramic exhibition halls (235 respondents), with augmented reality (AR) applications being relatively less common. The data indicates that VR technology is more favored due to its strong immersive experience, while web/app and 3D exhibition halls are more widely used for their convenience. This trend reflects the current situation where VR is the core of digital exhibitions, with multiple formats coexisting, also confirming the increasing public acceptance of new cultural experience methods.

4.2. Reliability and validity testing & exploratory factor analysis

The overall reliability of the questionnaire, measured by Cronbach's α coefficient, was 0.974, indicating excellent internal consistency. The reliability of each dimension passed the test ($\alpha > 0.7$), with aesthetic experience (0.808), interactive experience (0.856), immersive experience (0.848), cultural content experience (0.859), cultural cognitive experience (0.864), emotional experience (0.820), acceptance level (0.825), and revisit intention (0.832) all meeting the high reliability standard. The deletion of any items did not significantly improve the α coefficient, indicating that no items needed to be removed and the scale structure was stable and reliable.

The KMO value for the overall scale was 0.985 (> 0.9), and Bartlett's Test of Sphericity was significant ($p < 0.05$), indicating that the data were highly suitable for factor analysis and the validity was excellent. As shown in Table 1, there were no cross-loadings for the five user digital experience variables, and the cumulative variance explained was 71.625%, demonstrating that the original indicator information was effectively extracted. The exploratory factor analysis of the intermediate variables fixed at two factors yielded a cumulative explained variance of 70.782%, and the two extracted factors could explain most of the information of the variable indicators. The single-factor model for revisit intention explained 67.978%, also indicating it could explain most of the information of the indicator.

Table 1: Exploratory factor analysis of variables

Variable Type	Factor Naming	Eigenvalue	V.E.R. (%)
Independent Variable	Aesthetic Experience	2.327	12.246
	Interactive Experience	3.375	17.762
	Immersive Experience	1.649	8.679
	Cultural Content Experience	4.298	22.62
	Cultural Value Experience	1.961	10.319
	Total		71.625
Intermediate Variable	Emotional Experience	2.422	40.371
	Acceptance Level	1.825	30.411
	Total		70.782
Dependent Variable	Revisit Intention	2.039	67.978
	Total		67.978

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4.3. User clustering analysis based on the K-means algorithm

The user clustering based on the K-means algorithm divides users into three categories, with the proportions being Basic Users 19.1%, Conservative Users 3.8%, and Deep Experience Users 77.1%. By comparing the average values of the cluster centers, it is evident that the three user groups exhibit significant differences in behavioral characteristics, as shown in Table 2. Cluster 1 mainly consists of males aged 26-35, with most employed as civil servants or employees in public institutions. Although they have been exposed to basic digital exhibition forms such as websites and VR, their experience ratings are generally low, especially in terms of interface design, operation fluency, and the depth of cultural content, where they express clear dissatisfaction. This group shows limited interest in interactive functions of exhibitions, such as social interaction and AR technology, and exhibits low willingness to revisit or recommend the exhibitions, preferring passive, task-based browsing. Their core demand is to improve the usability and efficiency of basic functions. Cluster 2 mainly comprises females aged 36-45, mostly freelancers. They prefer web-based and basic VR forms but have limited acceptance of complex technologies such as AR and 3D exhibitions. The user experience ratings are moderate, with recognition of the social significance of the exhibitions and the natural transition between scenes. However, they are sensitive to issues like unclear operation guidance and poor device compatibility. This group values the cultural value conveyed but is conservative in technology use, relying more on recommendations from acquaintances. Cluster 3 is primarily composed of highly educated females aged 26-35, with most employed in cultural heritage and new media fields. They actively explore innovative forms like AR and 3D exhibitions, with significantly higher experience ratings compared to other groups, particularly highly appreciating the exhibition's immersion, cultural depth, and social attributes. This group actively shares their experiences and exhibits characteristics of "cultural dissemination nodes" but expects more open technological interfaces, such as custom tags and user co-curation.

Table 2: Final cluster centers

Variable	Cluster 1	Cluster 2	Cluster 3	Sig. Diff.
Gender	1	2	2	.011
Age	**3**	**4**	**3**	**.003**
Education	4	4	4	.092
Occupation	**3**	**4**	**3**	**.001**
Accessed Web/App	1	1	1	.187
Accessed VR	1	1	1	.350
Accessed AR	**1**	**0**	**0**	**.020**
Accessed 3D Pan.	**1**	**0**	**1**	**.000**
Understanding of "The Eternal Prosperous Tang"	2	2	2	.157
Aesthetic Experience	**2**	**3**	**4**	**.000**
Interactive Experience	**2**	**2.75**	**4**	**.000**
Immersive Experience	**2**	**3.5**	**4**	**.000**
Cultural Content Experience	**2**	**3**	**4**	**.000**
Cultural Value Experience	**2**	**3**	**4**	**.000**
Emotional Experience	**2**	**3.33**	**4**	**.000**
Acceptance Level	**2**	**3.33**	**4**	**.000**
Revisit Intention	**2**	**3.33**	**4**	**.000**

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4.4. Hypothesis testing and model modification

This study reveals users' emotional experiences through five variables of digital experience, then explores user acceptance and revisit intention. Based on the relationships between variables, a SEM model was established. As shown in Table 3, the values of Chi-square/df ratio, RMSEA, GFI, AGFI, NFI, TLI, CFI, PGFI, and PNFI all meet the standard criteria, indicating good model fit.

Table 3: Overall model fit index

MFI	χ^2/df	RMSEA	GFI	AGFI	NFI	TLI	CFI	PGFI	PNFI
JC	<3	<0.05	>0.9	>0.9	>0.9	>0.9	>0.9	>0.5	>0.5
SV	1.395	0.031	0.925	0.91	0.947	0.982	0.984	0.770	0.846

Table 4: Results of model path analysis

Path	Std.RC	S.E.	C.R.	p
H1: Emotional Experience <--- Aesthetic Experience	0.401	0.110	3.913	0.000
H2a: Emotional Experience <--- Interactive Experience	0.224	0.099	2.299	0.022
H2b: Emotional Experience <--- Immersive Experience	0.445	0.213	2.028	0.043
H3a: Emotional Experience <--- Cultural Content Experience	0.195	0.069	2.683	0.007
H3b: Emotional Experience <--- Cultural Value Experience	0.686	0.236	2.920	0.004
H4: Acceptance Level <--- Emotional Experience	0.970	0.059	17.359	0.000
H5: Revisit Intention <--- Acceptance Level	1.000	0.054	18.306	0.000

The path analysis results in Table 4 show that Hypothesis 1 is supported ($\beta = 0.401$), indicating that aesthetic experience in immersive exhibitions has a significant positive impact on emotional experience. High-fidelity artifact images and artistic design create visual aesthetics that effectively enhance users' emotional resonance and satisfaction, confirming that the quality of visual presentation is the core factor triggering cultural immersion. In Hypothesis 2, the driving effect of immersive experience ($\beta = 0.445$) on emotional experience is significantly stronger than that of interactive experience ($\beta = 0.224$), confirming that a deeply immersive environment is more likely to stimulate emotional involvement than basic interactive functions. This highlights that technological applications should focus on environmental creation rather than merely functional realization. Hypothesis 3 reveals that cultural value experience ($\beta = 0.686$) has an impact intensity more than 3.5 times that of cultural content experience, indicating that users are more concerned with the cultural uniqueness and social significance conveyed by the exhibition than with content completeness and entertainment. This validates the need to strengthen the deep value interpretation of cultural symbols in digital dissemination. Hypothesis 4 shows the strong explanatory power of emotional experience on acceptance level ($\beta = 0.970$), suggesting that emotional resonance and satisfaction are key factors in determining users' acceptance of immersive exhibitions. As a core mediating variable, emotional experience demonstrates a nearly complete mediating effect, verifying its critical role in the chain transmission mechanism of digital cultural dissemination. Finally, Hypothesis 5 confirms the absolute positive correlation between acceptance level and revisit intention ($\beta = 1.000$), indicating that users' acceptance of immersive exhibitions directly translates into revisit and recommendation intentions, emphasizing the decisive role of enhancing acceptance in user behavior conversion.

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5. Conclusion

The empirical analysis based on 436 valid questionnaires shows that aesthetic experience, technological experience (including interactive and immersive experiences), and cultural cognitive experience (including cultural content and cultural value experiences) all positively affect emotional experience. Emotional experience significantly positively influences acceptance level, and acceptance level significantly positively influences revisit intention. The user clustering analysis based on the K-means algorithm identified the characteristics of Basic, Conservative, and Deep Experience user groups. The research results align with the predictions based on the Technology Acceptance Model and the User Experience Theory Model. This study suggests that users' acceptance of AI+XR technologies depends not only on the technological maturity but also on the depth of emotional experience and the degree of empathy with cultural values. The significance of this study lies in providing theoretical basis and practical reference for the digital transformation of museums in the age of artificial intelligence, advancing the digital narrative of cultural heritage from "instrumental expression" to "value-oriented dialogue."

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