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Visitor-Centered Digital Transformation in Traditional Museum Spaces: Evidence from an AR-Enabled Digital Visitor Service in China

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Abstract

Traditional Museum spaces (TMS) remain vital for conserving and communicating cultural heritage, yet static interpretation can limit visitor engagement and flexible service delivery. This study investigates how an AR-enabled digital visitor service supports visitor-centered digital transformation in TMS and identifies key factors shaping visitors' overall evaluation of the experience. A quantitative cross-sectional survey was conducted on-site at the Life Evolution Hall of the Geological Museum of Guilin University of Technology (China). Using systematic intercept sampling, 418 valid visitor responses were collected immediately after the visit. Data were analyzed with IBM SPSS Statistics, including reliability and validity screening, Pearson correlation analysis and multiple regression modelling. Overall evaluation (OVE) was measured by Q8 as the dependent variable. The results show that visitors generally reported positive perceptions of the AR-enabled service. Multiple regression indicated that OVE is significantly influenced by both utilitarian perceptions and experiential engagement. Functional usefulness emerged as the strongest determinant of OVE, while interactivity, immersion, information accessibility and enjoyment also showed significant positive effects. Perceived ease of use did not demonstrate a significant direct effect in the final model. This study provides management-oriented evidence to guide sustainable digital transformation in traditional museum environments. The findings suggest that museums should prioritize functional interpretive value alongside immersive and interactive experience design when deploying AR-enabled visitor services, rather than focusing primarily on technological novelty or content volume.

Keywords: Traditional Museum Spaces, Digital Transformation, Augmented Reality (AR), Digital Visitor Services, Visitor Experience, Sustainable Engagement, Survey-Based Evaluation

Introduction

Museums worldwide are undergoing rapid digital transformation as they respond to shifting visitor expectations, technological innovation, and policy-driven modernization agendas. Traditional museum spaces, historically characterized by object-centered displays and static interpretive panels are increasingly challenged by digitally literate audiences who expect interactive, personalized, and immersive experiences. While digital technologies offer new possibilities for engagement, their integration into conventional exhibition environments raises critical questions about effectiveness, sustainability, and visitor value.

In many institutions, digital transformation has been implemented through the adoption of mobile applications, multimedia kiosks, and, more recently, augmented reality (AR) systems. These technologies promise to enrich interpretation, enhance accessibility, and extend narrative depth without physically altering heritage artifacts. However, the mere introduction of digital tools does not guarantee improved visitor experience. Emerging research suggests that the success of museum digital initiatives depends less on technological sophistication and more on how visitors perceive and evaluate the service provided (Falk & Dierking, 2016; Marty, 2008).

This challenge is particularly salient in traditional museum spaces, where exhibition structures were not originally designed for digital interaction. In such contexts, AR and related technologies must coexist with established curatorial practices and spatial constraints. Consequently, digital systems may risk becoming peripheral add-ons rather than integrated components of the visitor journey. Despite substantial investment in “smart museum” initiatives, especially in rapidly modernizing cultural sectors such as China, empirical evidence on what truly drives visitor evaluation remains limited.

Existing studies on AR in museums have primarily focused on technical implementation, usability testing, or isolated experiential outcomes. While these approaches contribute valuable insights, they often overlook the combined influence of functional service performance and affective engagement on visitors’ overall evaluation. In practice, museum managers must make strategic decisions about resource allocation: Should priority be given to improving information accessibility? Enhancing immersion? Increasing interactivity? Without integrated empirical models, such decisions are frequently guided by technological trends rather than evidence.

To address this gap, the present study adopts a visitor-centered perspective to examine how multiple dimensions of AR-enabled digital services influence overall visitor evaluation (OVE) in a traditional museum context. Drawing from information systems theory and experiential research, the study integrates functional dimensions, such as information accessibility, perceived ease of use, and functional usefulness with experiential dimensions, including enjoyment, immersion, and interactivity. By empirically testing this framework using survey data collected from visitors to an AR-enabled museum in China, the study aims to identify which factors most strongly shape visitor judgment.

The findings contribute to both theory and practice. Theoretically, the study advances an integrated evaluation framework that bridges service performance and experiential engagement within traditional museum environments. Practically, it provides evidence-based

guidance for museum managers seeking sustainable digital transformation strategies under resource constraints.

The remainder of this paper is structured as follows. The next section reviews relevant literature on digital transformation and AR in museum contexts. This is followed by the development of the conceptual framework and hypotheses. The methodology and empirical findings are then presented, and the paper concludes with a discussion of implications and future research directions.

Literature Review

The digital transformation of museums has evolved significantly over the past two decades. Early efforts focused primarily on digitization and technological deployment, emphasizing collection databases, online archives, and multimedia installations (Parry, 2007). However, as digital technologies matured, scholarly attention gradually shifted from technological capability to visitor experience. Museums increasingly began to evaluate digital initiatives not by their novelty, but by their contribution to interpretive quality and audience engagement (Marty, 2008; Falk & Dierking, 2016).

This transformation reflects a broader conceptual shift from collection-centered management toward visitor-centered service models. Within this paradigm, digital systems are understood as mediating tools that shape how visitors access, interpret, and emotionally respond to cultural content. Rather than treating technology as an end, contemporary research frames digital services as part of an integrated experience ecology in which cognitive, emotional, and spatial dimensions interact (Bitgood, 2013; Hein, 2000).

From a service evaluation perspective, two major strands of research have informed museum digital studies. The first originates from information systems theory, particularly the Technology Acceptance Model (TAM), which emphasizes perceived usefulness and perceived ease of use as determinants of user evaluation (Davis, 1989; Venkatesh & Davis, 2000). These constructs have been widely adopted in museum contexts to assess digital guides, mobile apps, and AR systems (Jung & Han, 2014; tom Dieck & Jung, 2017). In museum environments, perceived usefulness is often associated with improved interpretive clarity, navigational support, and contextual enrichment, while ease of use reduces cognitive load and technological anxiety during visits.

A related dimension concerns the accessibility of interpretive information. Museums traditionally rely on static labels and panels, which may limit engagement for diverse audiences (Hornecker & Ciolfi, 2019). Digital systems, particularly mobile and AR-based services, expand interpretive access by enabling layered storytelling, multilingual support, and adaptive information retrieval. Research suggests that such accessibility enhances visitor autonomy and supports self-directed learning (Economou & Meintani, 2011).

Alongside functional service considerations, a second strand of scholarship emphasizes experiential and affective dimensions. Drawing from flow theory (Csikszentmihalyi, 1990) and experiential consumption research (Pine & Gilmore, 1999), museum scholars argue that enjoyment, immersion, and interactivity significantly influence visitor satisfaction and memorability (Van der Heijden, 2004; Slater & Wilbur, 1997). In digital museum settings,

enjoyment is linked to emotional engagement and curiosity stimulation, immersion reflects cognitive absorption within augmented environments, and interactivity denotes the degree of participatory control visitors exercise over content exploration (Steuer, 1992).

Augmented Reality (AR) occupies a distinctive position at the intersection of these functional and experiential paradigms. Unlike traditional multimedia displays, AR overlays digital information directly onto physical artifacts, enabling simultaneous engagement with material heritage and digital augmentation (Wojciechowski et al., 2004). Empirical studies demonstrate that AR can enhance interpretive depth, stimulate curiosity, and increase time spent at exhibits (tom Dieck & Jung, 2017). However, the effectiveness of AR is not inherent in the technology itself; rather, it depends on design quality, contextual integration, and alignment with visitor expectations (Damala et al., 2008).

Despite growing adoption, existing research often isolates either usability variables or experiential outcomes. Few studies integrate both functional service dimensions and affective engagement factors within a single evaluative framework, particularly in traditional museum environments where digital interventions must coexist with established exhibition practices. This fragmentation limits theoretical coherence and reduces the practical utility of findings for museum management.

Accordingly, there remains a need for empirically grounded, visitor-centered models that examine how multiple dimensions of digital service performance jointly shape overall visitor evaluation. Addressing this gap is particularly important for traditional museum spaces undergoing digital transformation, where resource allocation decisions must be informed by evidence rather than technological enthusiasm.

Conceptual Model and Hypotheses

To examine visitor-centered digital transformation in traditional museum spaces, this study proposes an integrated conceptual framework that explains visitors' overall evaluation (OVE) of an AR-enabled digital visitor service. The model draws upon information systems theory and experiential consumption research to capture both instrumental service value and affective engagement. OVE is conceptualized as visitors' global evaluative judgment regarding the extent to which the AR-enabled service enhances the quality and value of their museum visit.

Functional Service Dimensions

The first group of predictors reflects the instrumental and utilitarian aspects of digital service performance. These dimensions are grounded in the Technology Acceptance Model (Davis, 1989) and subsequent extensions (Venkatesh et al., 2003), which emphasize the role of perceived usefulness and ease of use in shaping user evaluations.

Information Accessibility (IA) refers to the degree to which the AR-enabled service facilitates efficient retrieval of interpretive content and supports autonomous exploration of exhibition spaces. In traditional museum environments, where interpretive information is often fixed and static enhanced accessibility reduces informational barriers and empowers visitors to construct individualized learning pathways. Improved access is therefore expected to positively influence visitors' evaluative judgments.

Perceived Ease of Use (PEOU) describes the extent to which visitors perceive the AR-enabled system as easy to learn and operate. Museum visits are typically time-constrained and involve diverse audiences with varying digital competencies. Systems perceived as intuitive reduce cognitive friction and increase the likelihood of sustained engagement. Although ease of use may operate indirectly through perceived usefulness in some contexts, prior research suggests it can also directly influence evaluative outcomes, particularly in experiential environments.

Functional Usefulness (FU) captures the perceived practical value of the AR-enabled service in enhancing interpretive clarity, supporting navigation, and deepening understanding of exhibits. Within applied digital contexts, usefulness consistently emerges as a central determinant of user satisfaction and system evaluation (Davis, 1989). In museum settings, where digital tools serve interpretive purposes, perceived usefulness is expected to be a primary predictor of overall evaluation.

Accordingly, the following hypotheses are proposed:
H1: Information accessibility (IA) positively influences overall evaluation (OVE).
H2: Perceived ease of use (PEOU) positively influences overall evaluation (OVE).
H3: Functional usefulness (FU) positively influences overall evaluation (OVE).

Experiential Engagement Dimensions
Beyond instrumental performance, digital services in museums also function as experiential mediators. Drawing from flow theory (Csikszentmihalyi, 1990) and hedonic information systems research (Van der Heijden, 2004), experiential dimensions are expected to play a critical role in shaping visitors' global evaluations.

Enjoyment (ENJ) refers to the degree of pleasure and intrinsic satisfaction derived from interacting with the AR-enabled service. Enjoyable digital interactions can enhance positive affect, increase curiosity, and strengthen emotional attachment to the exhibition context. In experiential cultural settings, emotional gratification often contributes substantially to overall evaluative judgments.

Immersion (IMM) describes the extent to which visitors feel absorbed, engaged, and cognitively involved while using the AR service. Immersive experiences foster sustained attention and deeper interpretive engagement. In traditional museum spaces, where exhibits are physically static, immersive digital overlays may compensate for environmental limitations and enhance perceived experiential value.

Interactivity (INT) captures the degree of user control, responsiveness, and participatory engagement enabled by the digital service (Steuer, 1992). Interactive systems allow visitors to customize content exploration and actively shape their interpretive journey. Increased perceived control is associated with higher satisfaction and perceived value in digital environments.

Thus, the following hypotheses are proposed:
H4: Enjoyment (ENJ) positively influences overall evaluation (OVE).
H5: Immersion (IMM) positively influences overall evaluation (OVE).

H6: Interactivity (INT) positively influences overall evaluation (OVE).

Conceptual Model Overview

Figure 1 presents the proposed conceptual model. The framework posits that visitors' overall evaluation of an AR-enabled digital visitor service is jointly shaped by functional service performance and experiential engagement. Functional dimensions—information accessibility, perceived ease of use, and functional usefulness—represent the instrumental value of the system. Experiential dimensions—enjoyment, immersion, and interactivity—capture affective and participatory qualities of engagement. All six constructs are hypothesized to exert direct positive effects on OVE.

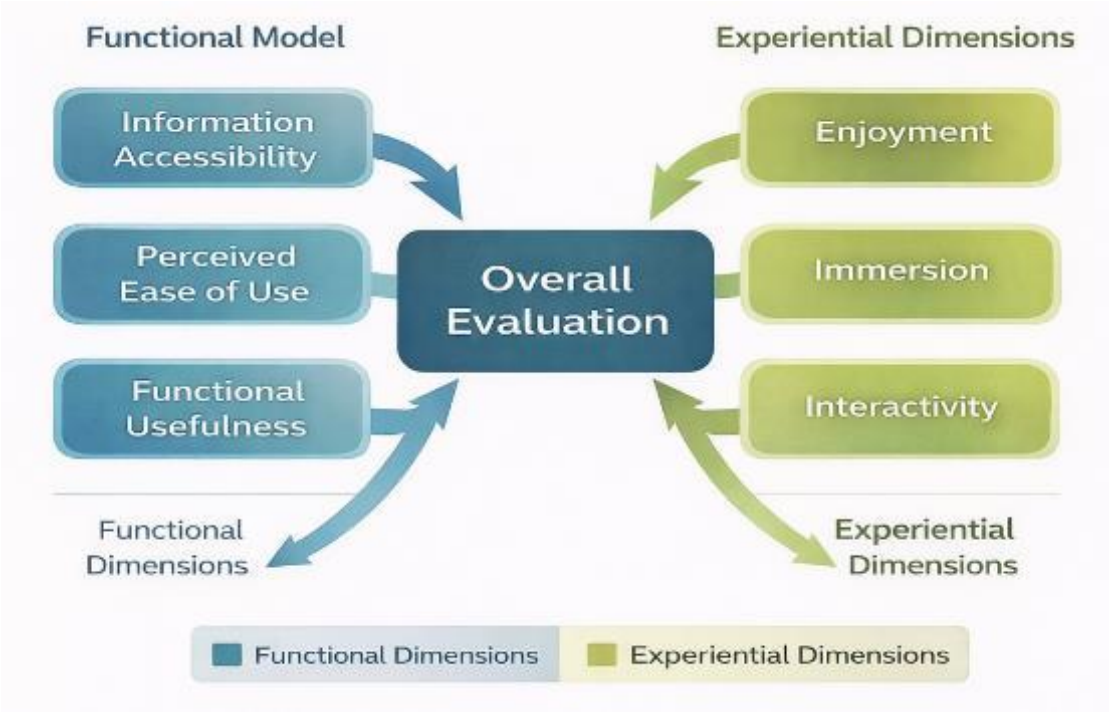

Figure 1: Conceptual Model of Visitor-Centered Digital Transformation

Methodology

Research Design and Study Context

This study employed a quantitative, cross-sectional survey design to test the proposed conceptual model. Data were collected in a real-world museum environment to ensure ecological validity.

The study site was the Life Evolution Hall of the Geological Museum of Guilin University of Technology (GLUT), China. The exhibition primarily relies on physical displays, specimen cabinets, and explanatory panels. The AR-enabled digital visitor service was introduced as a supplementary interpretive tool. Visitors accessed the AR content through a mobile-based application by scanning designated markers placed near selected exhibits. The system provided augmented visual overlays, multimedia explanations, and interactive content.

Visitors were encouraged by museum staff to try the AR service during their visit, but usage remained voluntary. Only visitors who had used the AR service were invited to participate in the survey.

Sampling Procedure and Data Collection

A systematic intercept sampling method was implemented near the exhibition exit area. Every third visitor exiting the AR-supported section was approached by trained research assistants and asked whether they had used the AR-enabled service. Those who confirmed usage were invited to complete a brief questionnaire.

The survey was administered in paper format to ensure accessibility for visitors of different age groups. On average, completion required approximately 3–5 minutes. Research assistants remained nearby to clarify any procedural questions but did not influence responses.

Data were collected over a three-month period, covering both weekdays and weekends to reduce temporal bias. A total of 421 questionnaires were distributed. After removing incomplete responses and questionnaires with patterned answering (e.g., identical responses across all items), 418 valid responses were retained for analysis, yielding a valid response rate of 99.3%.

Measurement and Instrument Design

The questionnaire was designed to minimize respondent burden in an on-site museum setting. All constructs were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The instrument included seven constructs:
Information Accessibility (IA)
Perceived Ease of Use (PEOU)
Functional Usefulness (FU)
Enjoyment (ENJ)
Immersion (IMM)
Interactivity (INT)
Overall Evaluation (OVE)

Each construct was measured using a single-item indicator that captured visitors' overall perception of the respective dimension (e.g., "The AR service made exhibit information more accessible"). This approach was adopted to ensure brevity and maintain response quality in a time-constrained museum environment. The items were phrased in clear, non-technical language to ensure comprehension across diverse visitor groups.

Prior to formal data collection, the questionnaire was pilot tested with 20 visitors to assess clarity and wording. Minor revisions were made based on feedback.

Data Analysis Procedure

Data were analyzed using IBM SPSS Statistics. Preliminary analyses included descriptive statistics to summarize respondent characteristics and assess distributional properties of the study variables. Skewness and kurtosis values indicated that the data met assumptions for parametric analysis. Relationships among constructs were examined using Pearson correlation analysis, followed by multiple linear regression to test the hypothesized effects of IA, PEOU, FU, ENJ, IMM, and INT on OVE. Multicollinearity was assessed through Variance

Inflation Factors (VIF), with all values falling below the threshold of 5, indicating no significant collinearity concerns. Statistical significance was determined at the 0.05 level.

Ethical Considerations

Participation was entirely voluntary. Respondents were informed of the purpose of the study and assured that their responses would remain anonymous and confidential. No personally identifiable information was collected. The study complied with institutional ethical guidelines for academic research.

Results

Sample Profile

A total of 421 valid responses were included in the final analysis. The sample consisted primarily of young adult visitors. More than half of the respondents (51.54%) were aged between 21 and 25 years. Female respondents accounted for 59.38%, while male respondents represented 40.62%. Most participants were undergraduate students (68.17%).

Regarding prior exposure to AR technology, 81.24% reported limited or no previous experience. This indicates that most respondents were first-time or novice AR users, providing an appropriate empirical context for evaluating AR-enabled digital services in traditional museum spaces.

Table 1

Table 1: Demographic Profile of Respondents (N = 421)

Variable	Category	N	%
Gender	Male	171	40.62%
	Female	250	59.38%
Age	15–20	40	9.5%
	21–25	217	51.54%
	26–30	97	23.04%
	31–40	43	10.21%
	41–50	17	4.04%
	51–60	5	1.19%
	60+	2	0.48%
Education	Undergraduate	287	68.17%
AR Familiarity	Never used	342	81.24%

The sample primarily consisted of young adults aged 21–25 (51.54%) and undergraduate students (68.17%), with most respondents reporting little prior experience with AR technology (81.24%).

Descriptive Statistics

Descriptive statistics for the study constructs are presented in Table 2. All mean values exceeded 4.0 on a five-point Likert scale, indicating highly positive visitor perceptions of the AR-enabled digital visitor service.

Table 2
Table 1: Demographic Profile of Respondents (N = 421)

Construct	Mean	SD
Information Accessibility (IA)	4.561	0.556
Perceived Ease of Use (PEOU)	4.819	0.403
Functional Usefulness (FU)	4.542	0.599
Enjoyment (ENJ)	4.397	0.634
Interactivity (INT)	4.558	0.564
Immersion (IMM)	4.468	0.623
Overall Evaluation (OVE)	4.249	0.562

Perceived ease of use received the highest mean score (M = 4.819), suggesting that visitors found the AR system highly intuitive. Information accessibility and interactivity also demonstrated strong evaluations. Overall evaluation (OVE) maintained a high mean score (M = 4.249), reflecting general satisfaction with the AR service.

Correlation Analysis
Pearson correlation analysis was conducted to examine relationships among the constructs. As shown in Table 3, overall evaluation (OVE) was positively and significantly correlated with all explanatory variables.

Table 3
Pearson Correlation Matrix

Construct	Mean	SD
Information Accessibility (IA)	4.561	0.556
Perceived Ease of Use (PEOU)	4.819	0.403
Functional Usefulness (FU)	4.542	0.599
Enjoyment (ENJ)	4.397	0.634
Interactivity (INT)	4.558	0.564
Immersion (IMM)	4.468	0.623
Overall Evaluation (OVE)	4.249	0.562

Interactivity (r = .468) and immersion (r = .462) showed the strongest correlations with overall evaluation, followed by enjoyment (r = .410). Functional usefulness and information accessibility demonstrated moderate correlations, while perceived ease of use showed a comparatively weaker association.

Regression Analysis and Hypothesis Testing
Multiple linear regression analysis was performed with OVE as the dependent variable and IA, PEOU, FU, ENJ, INT, and IMM as independent variables.

The regression model was statistically significant:
$R^2 = 0.387$
Adjusted $R^2 = 0.379$
$F(6, 414) = 43.64$
$p < 0.001$

The model explains 38.7% of the variance in overall evaluation

Table 4
Multiple Regression Results

Predictor	B	t	p	Standardized β	Hypothesis
IA	0.139	3.136	0.002	0.137	Supported (H1)
PEOU	0.001	0.017	0.986	0.001	Not Supported (H2)
FU	0.073	1.715	0.087	0.078	Not Supported (H3)
ENJ	0.195	5.164	<0.001	0.220	Supported (H4)
INT	0.260	5.948	<0.001	0.261	Supported (H6)
IMM	0.199	4.922	<0.001	0.221	Supported (H5)

Summary of Findings

Four of the six hypotheses were supported. Interactivity emerged as the strongest predictor of overall evaluation, followed by immersion and enjoyment. Information accessibility also had a significant positive effect.

In contrast, perceived ease of use and functional usefulness did not demonstrate significant direct effects when experiential variables were included in the model. These results suggest that experiential engagement factors exert stronger influence than purely functional perceptions in shaping visitor evaluations of AR-enabled digital services in traditional museum environments.

Discussion and Conclusion

This study examined how functional service dimensions and experiential engagement dimensions jointly influence visitors' overall evaluation (OVE) of an AR-enabled digital visitor service in a traditional museum space. The findings provide important insights into visitor-centered digital transformation.

The results reveal that experiential engagement factors interactivity, immersion, and enjoyment exert stronger influence on overall evaluation than functional service dimensions. Interactivity emerged as the strongest predictor, followed by immersion and enjoyment. These findings suggest that in traditional museum environments, AR systems are evaluated primarily as experiential mediators rather than purely informational tools. Visitors appear to value participatory control, immersive engagement, and emotional stimulation more strongly than operational convenience.

While information accessibility demonstrated a significant positive effect, perceived ease of use and functional usefulness did not significantly predict overall evaluation when experiential variables were included in the model. Given the very high mean score for ease of use, it is likely that usability functions as a baseline expectation rather than a differentiating factor. Once basic usability is achieved, visitors shift their evaluative focus toward experiential richness.

These findings extend prior research grounded in the Technology Acceptance Model by demonstrating that in experiential cultural settings, affective engagement may outweigh purely utilitarian perceptions. The results also align with flow theory and experiential consumption theory, emphasizing immersion and interaction as central determinants of visitor evaluation.

From a practical perspective, the study suggests that digital transformation strategies in traditional museums should prioritize experience-oriented design. Investments in interactive features, immersive storytelling, and participatory engagement mechanisms may yield stronger improvements in visitor satisfaction than incremental enhancements in technical functionality. AR technologies appear to create value not only by improving access to information, but by reshaping the quality of visitor engagement.

This study contributes to the literature by integrating functional and experiential constructs within a unified empirical framework applied to a real-world museum context. It demonstrates that experiential dimensions may play a dominant role in shaping overall evaluation in traditional exhibition environments.

Several limitations should be acknowledged. The study was conducted in a single museum context, which may limit generalizability. In addition, constructs were measured using single-item indicators to accommodate field constraints. Future research could employ multi-item scales and structural equation modeling to provide deeper construct validation and explore potential mediating relationships among variables.

In conclusion, visitor-centered digital transformation in traditional museum spaces appears to be driven more by experiential engagement than by functional efficiency. Museums seeking sustainable digital innovation should therefore balance technological reliability with immersive and interactive experience design.

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