An Integrated Framework for Digital Immersive Experiences in Cultural Heritage Presentation

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Abstract. This study presents an integrated conceptual framework for digital immersive experiences in cultural tourism, consisting of technological, cultural, behavioral, and management layers. The framework systematically connects these layers through dynamic feedback loops, focusing on cultural authenticity, institutional accountability, and measurable social, educational, and tourism impacts.

Keywords: Digital Immersion, Cultural Heritage, Integrated Framework, Adaptive Technologies, Visitor Engagement.

1 Introduction

The empirical results of a study (Nikolova & Ruseva, 2025) examining the role of digitalization as a factor in the sustainable development of cultural tourism on the Bulgarian Black Sea coast testify to a lack of comprehensive models for its digital presentation in a tourism context. The accelerated digitalization of cultural and historical heritage and the growing demand for tourist experiences have drawn attention to the development of an integrated framework for digital immersive experiences in cultural tourism. The focus in developing such a model is on combining technological innovations with interpretive and educational value to achieve a marketing effect or visual impact.

The main goal of the study is to propose a conceptual structure that describes the relationships between technological, cultural, behavioral, and managerial-ethical dimensions. To achieve this goal, the following tasks have been formulated: systematization of modern scientific approaches, identification of key deficits in existing models, and conceptualization of a sustainable, measurable, and adaptive framework. In this publication, only the conceptual model is presented, while an illustrative usage scenario and an adaptive cycle for organizing and processing data flows are further developed and will be subjected to subsequent empirical validation in a real institutional context.

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2 Methodology

The process of developing the integrated conceptual framework took place in three stages: systematic literature review, conceptual modeling, and analytical synthesis. The methodological approach is based on studying and analyzing existing models, empirical observations, technological trends, and cultural specificities to reveal new conceptual structures.

The first stage includes a systematic review of literature extracted from reference and citation databases for the period 2022–2025, focusing on immersive technologies, digitization of cultural heritage, user experience, and sustainable management. The main keywords with which the search was carried out are immersive heritage, XR cultural experience, digital museology, visitor engagement analysis, and heritage interpretation frameworks. The analysis of contemporary scientific literature outlines several interconnected areas of research interest, namely: (1) immersive technologies and the transformation of the tourist experience; (2) digitization of tangible and intangible cultural heritage through interactive platforms; (3) personalization and the role of intelligent systems; (4) co-creation of value and social communication; and (5) the economic, ethical, and managerial implications of digital interventions. The review indicates a lack of a unified conceptual perspective, which necessitates the development of an integrated theoretical framework.

Based on the identified thematic areas in the second stage, conceptual modeling, a four-layer model is built (technological, cultural, behavioral and management-ethical). Each layer is constructed by systematizing the relevant theoretical concepts such as approaches to immersiveness, narrative interpretation, behavioral analytics and sustainable management of cultural heritage. Within this stage, the interrelationships between the individual layers are determined through an analysis of functional dependencies to build a comprehensive integrative framework.

In the third stage, analytical synthesis, a logical check of the structure and compatibility of the layers is carried out. The final version of the formulated framework is checked through a comparative analysis with leading models in literature whether it offers a comprehensive approach that can be used practically for the design and evaluation of immersive digital experiences. This synthesis ensures that the framework is both theoretically consistent and applicable in different museum and tourism contexts.

3 Digital Immersive Experiences in Cultural Tourism: An Integrative Scientific Review

Over the past decade, digital technologies have emerged as a transformative factor in the way cultural heritage is preserved, interpreted, disseminated and experienced. The development of virtual (VR), augmented reality (AR) and mixed reality (MR), combined with interactive interfaces, mobile platforms and intelligent systems, has led to fundamental changes in the tourist experience, transforming it from a passive act of consumption into a dynamic, personalized and co-created process. In this context, the concept of “digital immersion” is being established as an interdisciplinary framework,

uniting technological, social, cultural, economic and managerial dimensions. This review aims to present an integrated analysis of the reviewed research areas, creating a comprehensive conceptual perspective.

3.1 Immersive Technologies and the Transformation of Tourist Experience

One of the most intensively researched topics is the role of VR and AR in enhancing tourists' cognitive, emotional, and sensory engagement. Empirical studies by Jung and his co-authors (2016) show that immersive environments significantly increase the sense of presence, emotional resonance and depth of perception of cultural content. In museum and archaeological contexts, these technologies allow for the reconstruction of historical scenes, the visualization of lost or destroyed objects and the creation of interactive narratives that go beyond the limitations of traditional exhibition. More recent research focuses on the factors determining tourists' acceptance of immersive technologies. Liang et al. (2025) emphasizes the importance of cultural background, technological literacy, and perceived authenticity, showing that VR and AR are evaluated positively when integrated into a meaningful and emotionally engaging cultural context. In this sense, immersive technologies do not function as stand-alone innovations, but as mediators between cultural content and the visitor's experience.

3.2 Digitization of Cultural Heritage and Interactive Approaches

The second main line of research is related to the digitization of cultural heritage and the development of interactive platforms for its presentation. In the work (Wang, et al., 2025) Wang's team identified several challenges to the implementation of immersive technologies in the cultural sector, such as the lack of technological standards, high requirements for expert capacity, problems with the long-term preservation of digital artifacts and the need for multidisciplinary collaboration. The results obtained show that digitization should be considered not only as a technological process, but as a complex sociotechnical transformation. The use of interactive platforms for the digital dissemination of intangible cultural heritage is perceived as a tool for the preservation and transmission of traditions, rituals and oral histories (Guo, 2026). According to Xu et al. (2025), human-computer interaction (HCI) approaches that combine technological innovations with cultural sensitivity are key to the development of experiences that combine educational value and emotional impact. The use of 3D models and virtual reconstructions improves the interpretive representation of historical sites and expands access to cultural resources with limited physical accessibility (Stewart & Stewart, 2023). Research on applications of augmented reality (AR) for the interpretation of cultural and historical heritage shows that mobile AR solutions can improve interactivity and access to content, which reveals their potential as a tool for the development of immersive forms of cultural tourism (Tatić & Stanković, 2024).

3.3 Personalization, Intelligent Systems and Tourist Behavior

Personalized tourism experiences and the role of intelligent systems are the focus of the third group of studies. Already in 2015, Neuhofer, Buhalis and Ladkin (2015) considered "intelligent" technologies as the basis for creating dynamic and contextually sensitive services that adapt to individual tourist preferences. The creation of personalized itineraries and content is driven by the development of mobile applications and real-time recommendation systems. Narrative and game mechanisms used in the interpretation of intangible cultural heritage reveal the potential of interactivity and co-creation of content to deepen the immersiveness and enrich the cultural value of digital experiences (Artese et al., 2023). According to Lee et al. (2025), the main factors for the perception of virtual cultural experiences as authentic and meaningful are emotional engagement and digital media literacy. Despite positive attitudes towards personalization, there are significant concerns about privacy and control over personal data (Tussyadiah & Wang, 2016), which requires balancing technological innovations with ethical standards.

3.4 Co-creation of Value and Social Dimensions

Co-creation is becoming an increasingly important part of contemporary tourism practices. In 2017, Jung and tom Dieck (Jung & tom Dieck, 2017; tom Dieck & Jung, 2017) showed that VR and AR encourage the active participation of visitors in the creation and interpretation of cultural content. This process leads to deeper engagement and a stronger emotional connection between the tourist and the cultural site.

Key mechanisms in the modern tourism cycle for discovering destinations, planning trips and subsequently sharing experiences are social media and user-generated content. In this way, tourists move from passive consumers to active creators and disseminators of information, which is a central thesis in the discussion of "smart tourism" (Gretzel et al., 2015). Social interaction models such as shared AR scenes and participatory curation support community building but require effective mechanisms to protect cultural authenticity (Panhale et al., 2023, Spadoni et al., 2022).

3.5 Integrative Frameworks: Technological, Curatorial, Economic and Ethical Layers

Digital immersion in cultural tourism should be seen as a multi-layered phenomenon. The concept of the Reality–Virtuality continuum (Milgram et al., 1995) provides a useful taxonomy for classifying technological implementations according to the level of immersion. From a UX perspective, key indicators are the feeling of presence, cognitive comfort and accessibility, which can be measured using a combination of quantitative and qualitative methods.

Curatorial and metadata frameworks, such as CIDOC CRM and the Europeana Data Model, provide an ontological basis for the integration of cultural knowledge into digital platforms (Doerr, 2003). Economic analysis, inspired by the concept of the Experience Economy, allows for the assessment of the impact of digital interventions through

indicators such as willingness to pay, return on investment and increased attendance (Ezeh & Dube, 2024; Zhu et al., 2025).

Floris et al. (2026) examines the impact of the metaverse on cultural tourism through a model that integrates awareness, cultural sensitivity, and digital immersive experiences, assessing their impact on tourists' behavioral intentions. They emphasize that immersive experiences on digital platforms are not just a technological addition, but a strategic tool for emotional connection and behavioral impact that bridges the virtual and real experience. Tian and Lee's (2025) study, based on the case of Xunji Luoshenfu, complements this perspective through a conceptual model that combines multidimensional digital representation, immersive space, immersive performance, and interactivity. The model shows that effective digital immersion requires the integration of content, space, and performance, so that visitors move from passive observation to active participation and cultural reconstruction. Attention is paid to co-design approaches with the participation of local communities that enhance authenticity and tourist satisfaction while simultaneously providing emotional and cognitive immersion. Zhang, Zou and Shi (2024) complement the framework through a mechanism of interaction between digital technologies and tourists, focusing on interactivity, personalization and the perception of cultural sites. Their approach shows that well-designed digital interventions can stimulate behavioral intentions to visit real destinations and participate in local cultural practices, while increasing engagement and satisfaction with the experience. In 2025, Chen and Xu formulated a "Technology-Consumer-Market" framework (2025) that connects technological capabilities, consumer perception, and market transformations, positioning VR/AR/MR as tools for marketing, branding, and market sustainability. The advantage of this approach is the integration of technological, consumer, and market dimensions, making it applicable to value and commercialization strategies; its limitation is the strong marketing focus that marginalizes educational, social, and cultural dimensions and requires broader empirical validation in different cultural contexts. Research on immersive VR/AR tourism experiences highlights the importance of personalization, interactivity, and user engagement mechanisms for enhancing motivation and behavioral responses among tourists. Meta-analytic evidence suggests that presence, interactivity, and value perception are central to tourists' immersive experiences with AR/VR (Fan et al., 2022). VR interactivity and sense of presence significantly influence emotional responses and behavioral intentions, underscoring the role of interactive UX design in driving tourist engagement (Song & Lu, 2024). Studies on personalized mobile and proactive systems in tourism demonstrate that personalization influences attitudes and technology adoption, which is directly relevant to immersive tourism applications (Tussyadiah & Wang, 2016). Roodposhti and Esmaeelbeigi's (2024) hybrid review summarizes the impact of AR/VR on tourism engagement in a heritage context, mapping trends in UX and motivation; the contribution is broad in scope but lacks a new integrative framework suitable for cultural tourism. In their paper, G. Wang and D. Men propose an S-O-R-based model that links authenticity, immersiveness, and repeat behavior within the framework of sustainability and social sustainability (Wang & Men, 2025); this approach is valuable for linking immersiveness

to sustainable outcomes, but empirical evidence shows complex, often nonlinear relationships, necessitating careful contextualization and abandoning simplistic causal assumptions.

The analysis of publications from the last three years suggests the need for a comprehensive framework for digital immersive experiences in cultural tourism, which integrates technological innovation, cultural authenticity, educational value and sustainable management. The recommendations for the content of digital platforms from the studies studied are that it should be culturally sensitive and relevant, reproducing the historical and social specificity of cultural sites, while promoting active cognition and emotional immersion of visitors. In them, intelligent personalization, implemented through artificial intelligence systems, is defined as a key factor for increasing engagement and satisfaction, allowing dynamic adaptation of routes, stories and interactive elements according to interests and user profiles. The analyzed literature can also formulate a requirement for the inclusion in the integrated framework of an educational component that supports a deeper understanding of cultural heritage and activates cognitive and emotional participation through interactive activities, visual aids and simulations. A key principle when choosing an interface design should be human-computer interaction and UX to ensure a low barrier to entry, intuitive navigation and accessibility for different demographic groups. In addition, the conceptual framework needs to ensure the authenticity of the presentation by recommending the active participation of local communities and the protection of intangible cultural heritage from commodification.

4 An Integrated Conceptual Framework for Digital Immersive Experiences in the Presentation of Cultural Heritage

This paper proposes a structurally integrated model that connects digitization processes, interpretive strategies and sustainable management of cultural heritage. The model is organized into four interconnected layers: technological, cultural, behavioral and managerial/ethical, presented in Figure 1. The relationship between them is based on observable indicators that provide feedback for adaptive change and optimization. In the context of cultural tourism development, the main role for its implementation is played by museums and cultural institutions.

The technological layer encompasses technologies for augmented, virtual and mixed reality, mobile and web-based interactive interfaces and intelligent systems for adaptive content delivery. This layer functions as an infrastructure that provides access, visualization and interactivity under different conditions and devices. The main principle that must be observed is the resilience of the user experience. This can be implemented through a hybrid client-edge-cloud architecture, including mobile, web and AR/VR clients with local caching and alternative rendering modes, reinforced by edge servers or CDN for sustainable and fast content delivery. The performance assessment is implemented through a set of parameters such as system uptime (threshold $\geq 95\%$), compatibility with multiple device types (≥ 4 types), average loading time ≤ 3 seconds and

the number of active interactive elements per module (≥ 5). Real-time monitoring of deviations from set performance and engagement metrics is implemented through a microservice layer that allows for dynamic adaptation of interfaces or adding additional visual and interactive modules. This in turn affects visitor engagement and behavior.

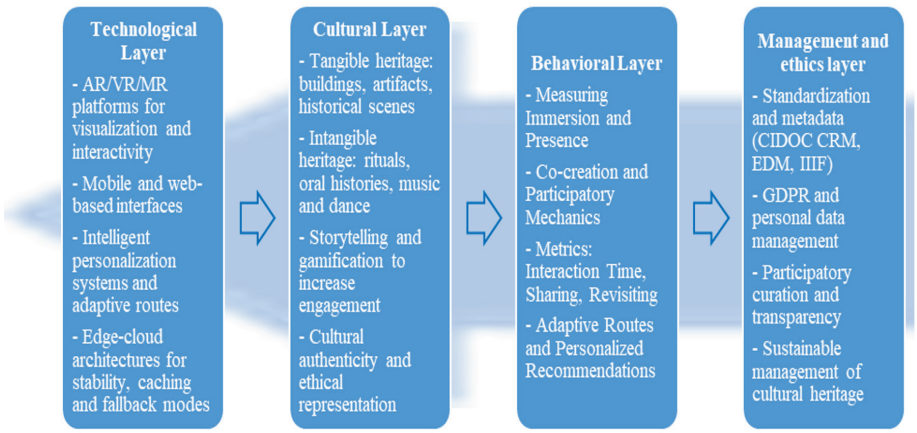

Fig. 1. An integrated conceptual framework for digital immersive experiences in the presentation of cultural heritage.

The cultural layer includes interpretive strategies based on storytelling, narrative structures and game mechanics that transform the presentation of cultural heritage into an active and engaging experience. A fundamental principle is cultural authenticity. Digital presentation should be based on scientific accuracy and institutional responsibility. The effectiveness of the cultural layer is initially ensured by expert verification of the content for scientific accuracy, historical completeness and authenticity. Adaptation through the technological layer is triggered only when the content does not meet these criteria before it reaches visitors.

The behavioral layer analyzes the user's sense of presence, the degree of immersion, the forms of interaction and the mechanisms for co-creation of value. Subsequent adaptation through the technological layer is carried out based on the data collected during interaction, completed tasks and the choice of interactive routes by users. Indicators such as time spent in interactive modules (>10 minutes per AR/VR station), percentage of successfully completed tasks (>75%), choice of different routes or engagement with additional layers of information (≥50%) are monitored. With low values of the indicators, the behavioral layer signals necessary changes in the cultural and technological layers.

The governance and ethics layer is based on standards for describing and sharing cultural data, privacy mechanisms, and principles of sustainable management. It ensures that digital content is protected from commercialization of cultural heritage and is durable and maintained over time, as well as the active involvement of stakeholders. Its effectiveness is assessed through indirect indicators such as metadata completeness (≥90%), digital content durability ≥ 2 years (≥ 80%), local community participation

(≥50%), accessibility and governance indicator (interactive resource usage rate ≥80%), trust and satisfaction indicator (return visit and interaction rate ≥50%), and content exploration depth (≥70%). Low values of these indicators trigger changes in the technology layer.

The interactions between the layers generate a dynamic feedback loop: content → interaction → analysis →adaptation, through which the sustainable and interactive management of cultural heritage is realized. The technology layer realizes the content provided by the cultural layer and provides interactive experiences that generate behavioral data. In turn, the behavioral layer transforms this engagement data into summarized and structured information about the behavior of visitors, which it sends to the management and ethics layer. The management layer uses this data for adaptive optimization, sustainability and long-term management of cultural heritage, based on the information, regulating changes and improvements in the technology and culture layer.

5 Implementation Challenges and Model Validation

The proposed framework is aimed at a wide range of stakeholders in the field of digital cultural and historical heritage. As the model provides the possibility to systematic digitization of collections, improved visitor engagement through immersive interfaces, as well as long-term digital sustainability, the main beneficiaries are cultural and museum institutions.

The implementation of such an integrated conceptual framework for digital immersive experiences, despite its theoretical advantages, presents significant organizational and financial constraints. One of the possible challenges in the implementation of the project will be the need for interdisciplinary expertise and adequate organizational coordination. There is a risk that the cultural and historical content will lose its depth and authenticity when using overly simplified or highly gamified approaches, especially when insufficient attention is paid to the right of local communities to preserve and interpret their own history and traditions. It is also necessary to consider ethical issues such as personal data protection, informed user consent and behavioral data management. Development costs can vary significantly depending on the complexity of the system – from more modest investments for basic applications to significant financial resources for complete platforms, including adaptive interfaces, analytical modules and server infrastructure. Additional costs related to hardware, content creation and long-term support could also be possible, which will further increase the financial burden. For these reasons, full implementation can be challenging, especially for small and medium-sized museums with limited institutional capacity. In these conditions, applicable strategies include the development of minimum viable products, a phased up-grade of the system, establishing collaborations with academic institutions and technology providers, as well as the use of open-source tools and existing platforms.

The proposed integrated framework is conceptual and has not yet been empirically validated. Although measurable indicators have been defined at all levels, their effectiveness and interdependencies require empirical validation through real-world implementation, which currently limits the practical validation of the model. The empirical

validation of the integrated framework is envisaged to rely on a mixed research approach combining quantitative and qualitative methods. The emphasis is placed on pilot implementations in selected museums and cultural institutions, which allows for comparative analysis under different usage scenarios and technological configurations. The evaluation approach integrates quantitative analysis of system-generated behavioral data with qualitative methods aimed at capturing key dimensions of the user experience, such as immersion, authenticity, and interpretive value. Expert assessment of the cultural content is incorporated to ensure alignment with scientific, historical, and ethical standards. The validation phase is intended to support the refinement of the proposed model and the assessment of its applicability across a range of cultural and museum institutions.

6 Conclusions

The proposed framework offers a systematic and sustainable architecture that combines immersive design, empirical behavioral validation, and long-term cultural management within a single coherent model. Existing research on digital immersion in cultural tourism mostly offers thematically focused models. While frameworks such as the Reality–Virtuality continuum (Milgram et al., 1995), Technology–User–Market (Chen & Xu, 2025) or S-O-R models (Wang & Men, 2025) contribute to the understanding of immersive technologies as factors of engagement, market value, and sustainability, they do not provide sufficient integration in terms of content, behavior, and management. Observable indicators of the effectiveness of each layer and the interactions between layers are introduced, allowing for empirical evaluation and adaptive optimization, extending the purely descriptive focus of Roodposhti & Esmaeelbeigi (2024).

The next step is prototype implementation, its empirical evaluation and validation through real-world studies to ensure its practical effectiveness and subsequent refinement.

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