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From fragmentation to immersion: A responsible metaverse framework for cultural heritage and tourism

Rian S. Attallah, *University of Mosul*, rayan.24bap97@student.uomosul.edu.iq

Amir A. Abdulmuhsin, *The University of Jordan*, dr.amir_alnasser@uomosul.edu.iq

Abeer F. Alkhwaldi, *Dakota State University and Mutah University*, Abeer.Alkhwaldi@dsu.edu

Abstract

This study investigates the factors influencing the adoption of responsible metaverse technologies in museums, archaeological institutions, and tourism organisations. Immersive technologies such as virtual reality, augmented reality, and artificial intelligence offer significant opportunities for enhancing cultural heritage preservation, visitor engagement, and sustainable tourism experiences. However, fragmented digital infrastructures and limited interoperability remain major barriers to effective metaverse implementation. To address this issue, the study integrates the Unified Theory of Acceptance and Use of Technology (UTAUT) with the responsible metaverse perspective. The proposed model examines the effects of performance expectancy, effort expectancy, social influence, and facilitating conditions on behavioural intention and metaverse usage. In addition, unification is introduced as a moderating variable representing interoperability and seamless technological integration across immersive environments. The study contributes theoretically by extending UTAUT into responsible metaverse ecosystems and highlighting the importance of interoperability in sustainable digital transformation within museums and tourism organisations.

Keywords: Responsible Metaverse, Unification, Museums and Cultural Heritage, Archaeological Tourism, UTAUT, Metaverse Adoption

Introduction

The rapid evolution of immersive digital technologies is fundamentally transforming how organisations preserve cultural heritage, deliver tourism experiences, and engage with users in virtual environments (Lu et al., 2025; Tamim et al., 2025). Among these technologies, the metaverse has emerged as one of the most disruptive innovations capable of integrating virtual reality, augmented reality, and artificial intelligence into persistent digital ecosystems (Buragohain et al., 2024; Lu et al., 2025; Zawish et al., 2024). Museums and archaeological institutions increasingly face pressure to modernise their services and digitally preserve cultural assets while maintaining sustainability, accessibility, and user trust (Sánchez-Martín et al., 2025; Spennemann, 2025). However, the fragmented nature of digital systems and the absence of interoperable metaverse environments continue to hinder the effective adoption of responsible immersive technologies within tourism and heritage organisations (Zainal Abidin et al., 2025).

The metaverse has attracted substantial academic and organisational attention due to its ability to create immersive and interactive digital experiences that transcend physical and geographical boundaries. Recent

studies (e.g. Kılıçarslan et al. (2024); Linh et al. (2025); Prados-Castillo et al. (2024); and Skandali (2025)) suggest that metaverse technologies have significant implications for tourism, cultural heritage preservation, customer engagement, and virtual collaboration. Within museums and archaeological institutions, immersive technologies such as virtual reality (VR) and augmented reality (AR) have been increasingly employed to reconstruct historical sites, preserve endangered heritage artefacts, and enhance visitor experiences through interactive storytelling and digital simulations (Asobayire et al., 2026; Jiang et al., 2025; Lu et al., 2025; Marto et al., 2022).

The growing integration of metaverse technologies into cultural heritage and tourism environments has also encouraged researchers to investigate the determinants influencing technology adoption and usage behaviour (Abukarki, 2025; Kılıçarslan et al., 2024; H. Wang et al., 2025). The Unified Theory of Acceptance and Use of Technology (UTAUT) remains one of the most widely utilised theoretical frameworks for examining users' intentions towards emerging technologies (Venkatesh et al., 2003; Venkatesh et al., 2012). Previous studies, such as Almasooudi (2024); Guangju et al. (2026); (Lu et al., 2025); Mosbeh (2025); and Zarouali (2024) have demonstrated that performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC) significantly affect individuals' acceptance of immersive technologies and virtual environments.

At the same time, concerns regarding digital governance, interoperability, trust, and sustainability have contributed to the emergence of the responsible metaverse concept (Babb, 2026; Massaro et al., 2023). Responsible metaverse environments emphasise ethical governance, secure digital interaction, technological integration, and sustainable digital ecosystems (Giannelos, 2026; Kamasak et al., 2026). Recent literature increasingly recognises that fragmented digital systems and disconnected platforms may weaken users' engagement with immersive technologies despite technological advancements (Fusaro et al., 2025). Consequently, the importance of interoperability and technological unification (F3) has become central to the successful implementation of metaverse ecosystems within tourism and cultural heritage contexts (Anwar et al., 2025; Maden & Yücenur, 2024).

Despite the rapid growth of metaverse-related research, several theoretical and contextual gaps remain insufficiently explored within the literature. First, existing studies on metaverse adoption have primarily focused on commercial sectors such as retailing, gaming, hospitality, and virtual collaboration environments (Chakraborty et al., 2024; Pillai et al., 2025), while limited attention has been devoted to museums, archaeological institutions, and heritage tourism organisations. Cultural heritage environments possess unique operational and strategic characteristics that differ substantially from commercial digital ecosystems, particularly regarding heritage preservation, public accessibility, and historical authenticity (Lu et al., 2025; Sánchez-Martín et al., 2025). Consequently, the direct applicability of existing metaverse adoption findings to archaeological and tourism organisations remains questionable.

Second, although the UTAUT framework has been extensively employed in technology adoption studies, most prior research (e.g. Abdulmuhsin et al. (2024); Abdulmuhsin, Owain, Dbesan, Bhat, et al. (2025); Abdulmuhsin, Owain, Dbesan, Alkhwaldi, et al. (2025)) have concentrated on traditional technological determinants without adequately integrating the emerging concept of responsible metaverse properties. Existing literature predominantly examines users' perceptions of usefulness and ease of use while paying limited attention to how digital ecosystem characteristics influence adoption and usage behaviour (L. Huang et al., 2025; Tao et al., 2025). In particular, interoperability and technological integration remain underexplored despite their increasing importance in immersive digital environments (Kostadimas et al., 2025). Fragmented systems, disconnected digital platforms, and inconsistent technological infrastructures continue to create operational barriers that reduce the effectiveness of immersive technologies within organisational contexts (Asobayire et al., 2026; Del Vecchio et al., 2025; Deng et al., 2025).

Third, the moderating role of unification as a responsible metaverse property remains theoretically underdeveloped in current literature. Most existing studies examine metaverse technologies as isolated technological tools rather than interconnected ecosystems requiring seamless interoperability across platforms and organisational systems (Liu et al., 2026; Sadeghi-Niaraki et al., 2025). This limitation is particularly critical within museums and tourism organisations, where immersive experiences depend heavily on integrating heritage databases, virtual exhibitions, tourism services, and digital communication infrastructures (Z. Xu et al., 2025). Without technological unification, organisations may encounter operational inefficiencies, inconsistent user experiences, and reduced technological sustainability.

The primary objective of this study is to understand the determinants influencing the adoption and usage of responsible metaverse technologies within archaeological and tourism organisations – see Figure 1. Specifically, the study investigates the effects of PE, EE, SI, and FC on behavioural intention (BI) and metaverse usage (MU). Furthermore, the study aims to explore the moderating role of unification as a responsible metaverse property affecting the relationships between FC, BI, and MU. This study is important because it addresses the growing need for sustainable and integrated immersive technologies capable of supporting digital transformation within museums and tourism organisations. The research contributes to the emerging responsible metaverse literature by emphasising the strategic role of interoperability and technological integration in shaping metaverse adoption and usage behaviour. Unlike previous studies (e.g. Firman et al. (2025); Hao et al. (2025); and Žilak et al. (2025)) that primarily focus on technological functionality, the present study highlights the importance of unified digital ecosystems capable of enhancing operational continuity, accessibility, and sustainability.

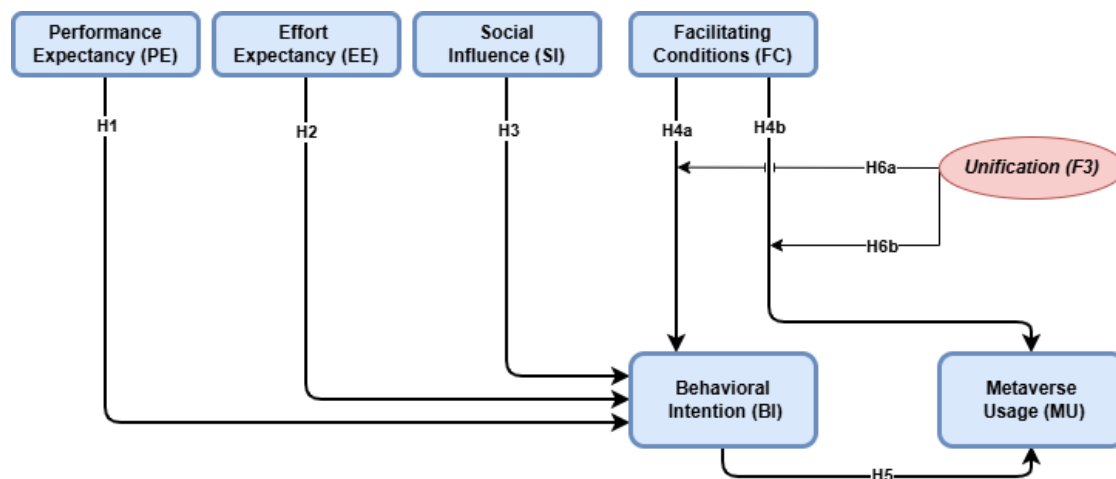


Figure 1. Conceptual Model of Study

Source(s): Authors' own work

The remainder of this paper is organised as follows. Section 2 presents the theoretical background and proposition development. Finally, section 3 outlines the conclusion and theoretical implications.

Theoretical Background

Theoretical Basis

The present study is theoretically grounded in the UTAUT, which represents one of the most influential frameworks for explaining individuals' behavioural intentions and actual use of emerging technologies

(Alkhwaldi et al., 2025). The UTAUT model proposes that PE, EE, SI, and FC are key determinants shaping users' intentions and technology usage behaviour (Venkatesh et al., 2003). The theory has been extensively employed in studies examining immersive digital environments, virtual reality, and metaverse adoption across tourism, education, and organisational settings (Abdulmuhsin, Owain, Dbesan, Alkhwaldi, et al., 2025; Abdulmuhsin, Owain, Dbesan, Bhat, et al., 2025; Merz et al., 2025; Mosbeh, 2025; Zarouali, 2024). In addition, this study incorporates the concept of the Responsible Metaverse to explain how ethical, trustworthy, and integrative digital environments influence technology acceptance within museums and tourism organisations. Responsible metaverse environments are characterised by secure digital governance, credibility, interoperability, and reduced uncertainty, all of which enhance users' confidence and engagement with immersive systems (Behera et al., 2024; Massaro et al., 2023; Sadeghi-Niaraki et al., 2025; Singh et al., 2025). Although interoperability, unification, and digital governance are closely related concepts within metaverse ecosystems, they represent distinct dimensions of responsible digital transformation. Interoperability refers to the technical capability of different systems, platforms, and applications to exchange, interpret, and utilise data seamlessly. It focuses primarily on compatibility and communication between technological components (De Martino et al., 2025). Unification, in contrast, represents a broader ecosystem-level property that integrates interoperable technologies, databases, services, and user experiences into a coherent and seamless environment. While interoperability enables systems to communicate, unification ensures that these interconnected systems function as a single, integrated ecosystem from the users' perspective (Anwar et al., 2025; Maden & Yücenur, 2024). Finally, digital governance refers to the policies, standards, regulatory mechanisms, ethical principles, and managerial structures that guide the operation, security, accountability, and sustainability of digital environments (Hanisch et al., 2023). Therefore, digital governance establishes the rules and oversight mechanisms governing the ecosystem, interoperability provides the technical foundation for connectivity, and unification represents the outcome of successfully integrating these technological and organisational elements into a cohesive metaverse environment. Distinguishing these concepts is important because each addresses a different aspect of responsible metaverse implementation while collectively contributing to sustainable, efficient, and user-centred digital heritage ecosystems.

Unification and interoperability represent foundational requirements for the effective functioning of immersive digital ecosystems because metaverse environments are inherently composed of multiple interconnected technologies, platforms, databases, and service providers (Tukur et al., 2023). Unlike traditional standalone information systems, metaverse ecosystems depend on continuous interaction among virtual reality applications, augmented reality platforms, artificial intelligence services, digital heritage repositories, tourism systems, and user identity management infrastructures (Dwivedi et al., 2022). When these systems cannot exchange information seamlessly, users encounter fragmented experiences, duplicated processes, inconsistent content, and operational inefficiencies. Such fragmentation reduces the perceived value of immersive technologies and limits their ability to deliver coherent digital experiences. Within museums, archaeological institutions, and tourism organisations, interoperability is particularly important because visitors often interact with diverse digital resources simultaneously, including virtual exhibitions, heritage databases, multimedia archives, and tourism services (Sánchez-Martín et al., 2025). Therefore, interoperability provides the technical foundation that enables communication, information sharing, and continuity across digital environments, thereby enhancing usability, accessibility, and long-term sustainability. The integration of UTAUT with responsible metaverse properties provides a comprehensive theoretical lens for understanding how technological and environmental factors jointly shape BI and MU in museums and archaeological tourism institutions.

Research Methodology

Research Design

This study adopts a conceptual research design aimed at developing a theoretical framework for understanding responsible metaverse adoption in museums, archaeological institutions, and tourism organisations. Unlike empirical studies that test hypotheses using primary or secondary data, conceptual studies seek to advance theory by synthesising existing knowledge, identifying research gaps, and proposing new relationships among constructs (Lim, 2026). Accordingly, the present study extends the Unified Theory of Acceptance and Use of Technology (UTAUT) by integrating the responsible metaverse perspective and introducing unification as a moderating construct within digital heritage ecosystems.

Literature Identification and Selection

The conceptual model was developed through a comprehensive narrative review of the literature relating to metaverse technologies, cultural heritage digitisation, immersive tourism, responsible innovation, interoperability, and technology adoption theories. Relevant studies were identified using major academic databases, including Scopus, Web of Science, ScienceDirect, SpringerLink, Emerald Insight, Wiley Online Library, Taylor & Francis, IEEE Xplore, and Google Scholar. The search process employed combinations of keywords such as “metaverse adoption”, “responsible metaverse”, “virtual reality”, “augmented reality”, “cultural heritage”, “digital museums”, “archaeological tourism”, “unification”, “technology acceptance”, “UTAUT”, and “digital governance”. The review primarily focused on peer-reviewed journal articles, review papers, and highly cited conference proceedings published in leading information systems, tourism, cultural heritage, and digital innovation journals. Particular emphasis was placed on recent publications (2023–2026) to ensure that the conceptual framework reflects contemporary developments in metaverse technologies and responsible digital transformation.

Narrative Review Approach

This study employs a narrative literature review approach rather than a systematic literature review (SLR). A narrative review was considered more appropriate because the objective of the study is theory development rather than evidence aggregation or effect-size estimation. Narrative reviews enable researchers to integrate insights from diverse disciplines, compare theoretical perspectives, identify emerging concepts, and develop novel conceptual relationships (Sukhera, 2022). Given the interdisciplinary nature of metaverse research, which spans information systems, tourism, cultural heritage, virtual reality, artificial intelligence, and digital governance, a narrative approach provided the flexibility required to synthesise fragmented streams of literature and construct an integrated theoretical framework. Although a formal systematic review protocol involving predefined inclusion and exclusion criteria was not employed, the literature selection process remained guided by relevance, scholarly quality, conceptual contribution, and alignment with the study's research objectives. This approach ensured comprehensive coverage of the most influential and recent contributions within the field.

Conceptual Model Development

The conceptual model was developed through an iterative process of theory synthesis and conceptual integration. First, UTAUT was selected as the foundational theoretical framework because of its extensive application in explaining technology adoption and usage behaviour across a wide range of digital contexts (Abdulmuhsin et al., 2026). The core UTAUT constructs - i.e: PE, EE, SI, FC, BI, and MU - provided the baseline structure of the model. Second, the responsible metaverse literature was examined to identify ecosystem-level characteristics that are increasingly recognised as critical for sustainable metaverse implementation (Jiang et al., 2025; Li et al., 2024). This review highlighted interoperability and technological integration as recurring themes across responsible metaverse, digital heritage, and smart tourism studies. Building upon these insights, the study conceptualised unification as a higher-level

ecosystem property representing seamless integration across immersive technologies, digital platforms, databases, and organisational systems. Finally, the model was contextualised within museums, archaeological institutions, and tourism organisations, where digital heritage preservation, visitor engagement, accessibility, and sustainability represent key strategic priorities (Tamim et al., 2025).

Proposition Development

The study's propositions were derived deductively from established theoretical foundations and prior empirical findings. Propositions P1-P5 were formulated based on the original UTAUT framework and supported by recent studies examining metaverse adoption, virtual reality applications, immersive tourism, and digital heritage technologies. Existing literature consistently demonstrates positive relationships between PE, EE, SI, FC, BI, and MU. Propositions P6a and P6b emerged from the responsible metaverse literature, particularly studies emphasising interoperability, digital integration, and ecosystem coherence. The literature suggests that facilitating conditions may produce stronger behavioural outcomes when technological environments are unified and interoperable rather than fragmented. Consequently, unification (F3) was theorised as a moderating mechanism that enhances the influence of facilitating conditions on both behavioural intention and metaverse usage. The resulting propositions collectively reflect the integration of established technology adoption theory with emerging responsible metaverse principles, thereby extending current understanding of metaverse adoption within cultural heritage and tourism contexts.

Discussion

Metaverse Technology and Museums

The metaverse has emerged as a transformative technological paradigm capable of redefining digital interaction, cultural engagement, and tourism experiences (Zeqiri et al., 2026). It combines immersive technologies such as virtual reality (VR), augmented reality (AR), artificial intelligence (AI), and decentralised digital platforms to create persistent and interactive virtual environments - see Figure 2 (Muñoz-Saavedra et al., 2020; Skandali, 2025). Within museums and tourism establishments, metaverse technologies provide innovative opportunities to digitally preserve heritage assets while simultaneously enhancing visitors' experiences through immersive interaction and real-time engagement (Buragohain et al., 2024; Lu et al., 2025; Tamim et al., 2025).

Museums and archaeological institutions increasingly utilise virtual and augmented environments to reconstruct historical sites, display digital artefacts, and facilitate remote access to cultural heritage resources (Cai & Ch'ng, 2025; Ramtohul & Khedo, 2024). Such technologies allow visitors to experience historical narratives interactively regardless of geographical limitations, thereby supporting heritage sustainability and accessibility (Marto et al., 2022). In tourism contexts, metaverse applications enable tourists to preview destinations, participate in virtual cultural events, and interact with historical environments through highly immersive simulations (Zhang & Quoquab, 2023).

The integration of metaverse technologies into tourism organisations also contributes to destination competitiveness and digital innovation (Chen, 2024b; Hao et al., 2025). Virtual environments support personalised experiences, social interaction, and enhanced customer engagement, which significantly influence tourists' satisfaction and behavioural intentions (Guangju et al., 2026; Zeqiri et al., 2026). Furthermore, the metaverse creates new strategic opportunities for cultural institutions by extending their services beyond physical boundaries and enabling hybrid tourism experiences that merge physical and digital interactions (Ahmadi Zahrani et al., 2025; Chen, 2024a; Prados-Castillo et al., 2024; Zaman et al., 2024).

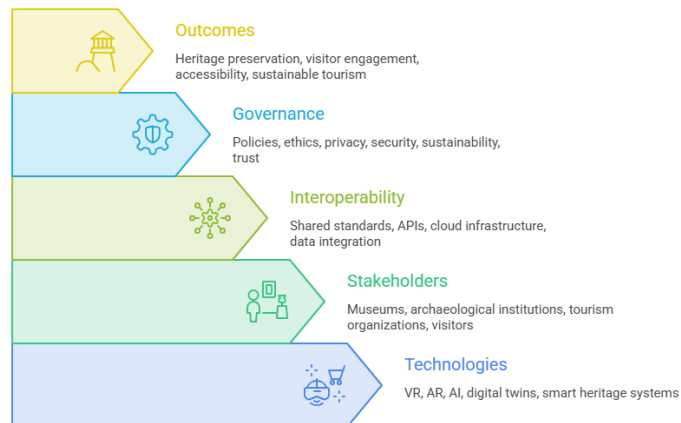


Figure 2. Responsible Metaverse Ecosystem Framework
Source(s): Authors' own work

Despite these opportunities, adopting metaverse technologies within museums and tourism establishments remains dependent on users' perceptions of usefulness, ease of use, institutional support, and trust in digital environments (Guangju et al., 2026; Kontis & Ioannidis, 2025; Moghavvemi & Huang, 2025). Thus, understanding the behavioural determinants influencing metaverse adoption is essential for ensuring successful implementation in archaeological and tourism organisations.

A practical example of metaverse implementation through virtual reality (VR) can be observed in museums, archaeological institutions, and tourism organisations seeking to provide immersive cultural heritage experiences. In this scenario, visitors access a virtual museum or archaeological site using VR headsets and interact with digital artefacts, historical environments, and virtual guides through realistic three-dimensional avatars. Rather than being limited to physical visits, users can explore reconstructed ancient cities, temples, palaces, and monuments from anywhere in the world including Iraq. For example, a visitor can walk through a digitally reconstructed archaeological site (BABYLON) – see Figure 3, examine historical artefacts in detail, and participate in guided cultural tours led by virtual experts within the same immersive environment.



Figure 3. VR and museums
Source(s): Create using Chatgpt.com

The effectiveness of this experience emerges from the integration of multiple technologies. VR provides immersion and a strong sense of presence, enabling visitors to feel as though they are physically located within the heritage site (Tamim et al., 2025). Artificial intelligence supports intelligent virtual guides that answer questions, personalise tour routes according to visitor interests, and provide real-time historical interpretations (Düz & Kavak, 2026). Cloud computing enables scalable access to digital heritage content for global audiences, while digital knowledge management systems store, organise, preserve, and retrieve archaeological records, historical narratives, and multimedia resources (Li et al., 2024). Together, these technologies create a unified metaverse ecosystem that supports cultural education, heritage preservation, and interactive tourism experiences.

Moreover, consider a visitor exploring an archaeological site such as ancient Babylon, Nineveh, Hatra, or Ur. Using AR-enabled smart glasses or a mobile application, the visitor can view digital reconstructions superimposed directly onto the physical ruins – see Figure 4. As the visitor moves through the site, collapsed structures are virtually restored, allowing temples, palaces, statues, and city walls to appear as they existed thousands of years ago. Visitors can also interact with virtual historical characters, access multimedia information about artefacts, and participate in immersive storytelling experiences that bring ancient civilisations to life.



Figure 4. VR and museums
Source(s): Authors' own work

In this integrated metaverse environment, AR serves as the bridge between the physical heritage site and the digital world (Muruganantham & Kumar, 2024). Artificial intelligence personalises recommendations based on visitors' interests, language preferences, and previous interactions, while intelligent virtual guides provide real-time explanations and answer questions (Singh et al., 2026). Geolocation technologies continuously identify the visitor's position and deliver context-specific historical content relevant to nearby landmarks. Knowledge management systems organise, preserve, and update archaeological records, historical documents, and cultural narratives, ensuring that users receive accurate and authoritative information (Mitrea et al., 2025). Cloud-based infrastructure supports real-time content delivery and synchronisation across multiple devices and locations (Li et al., 2024).

These examples illustrate that the metaverse is not a single technology but an integrated digital environment in which VR and AR serve as the primary interface connecting visitors with other technological capabilities. By providing realistic interaction with cultural assets and historical environments, these technologies

enhances visitor engagement, improves learning and cultural awareness, and strengthens behavioural intentions to adopt metaverse-based tourism and heritage platforms.

The Moderating Role of Unification in Responsible Metaverse Adoption

While interoperability enables technical compatibility, unification represents a higher-order ecosystem property that integrates multiple interoperable systems into a seamless and coherent user experience (Memon et al., 2025). From the perspective of technology adoption theory, users are more likely to develop favourable behavioural intentions when they perceive a technology environment as consistent, reliable, and easy to navigate. Unified metaverse environments reduce cognitive burden by eliminating the need to repeatedly switch between disconnected platforms, learn multiple interfaces, or manually transfer information across systems (Boztas et al., 2025). This reduction in complexity enhances perceived convenience, accessibility, and overall user satisfaction. Consequently, users become more willing to adopt and continuously engage with metaverse technologies. Within cultural heritage and tourism contexts, unification enables visitors to move seamlessly between virtual museums, archaeological reconstructions, augmented reality experiences, digital archives, and tourism services, thereby creating an integrated heritage journey. Such continuity strengthens users' perceptions of usefulness and convenience, increasing both behavioural intention and actual metaverse usage.

Unification represents one of the fundamental properties of the responsible metaverse, referring to the degree of integration, interoperability, and seamless connectivity across immersive digital environments, technological systems, and virtual platforms (Sadeghi-Niaraki et al., 2025). Unlike fragmented digital ecosystems, unified metaverse environments enable users to transition smoothly between applications, services, and virtual experiences without technical disruption or compatibility barriers (Singh et al., 2025; Tukur et al., 2023; X. Xu et al., 2025). This property is particularly important in museums and tourism organisations, where users interact with multiple digital resources, heritage databases, virtual exhibitions, and immersive communication platforms simultaneously (Hou, 2024; X. Huang et al., 2025).

Within responsible metaverse environments, unification contributes to establishing coherent and user-centred digital ecosystems that improve technological accessibility and operational consistency (Tukur et al., 2023). Integrated virtual systems enhance the efficiency of information exchange, facilitate real-time interaction, and support collaborative digital experiences among visitors, employees, and tourism stakeholders (Berta et al., 2025; Xu et al., 2024). In cultural heritage contexts, unification enables museums and archaeological institutions to connect digital artefacts, immersive exhibitions, and tourism services within a single interoperable environment, thereby enhancing visitor engagement and preserving continuity in the digital experience (Lu et al., 2025; Wang & Ametefe, 2026; Z. Xu et al., 2025).

Thus, the moderating role of unification can be explained through several complementary mechanisms. First, unification enhances the effectiveness of facilitating conditions by transforming isolated technological resources into an interconnected ecosystem (Shonubi, 2025). Even when organisations invest in digital infrastructure, technical support, and training, these resources may produce limited outcomes if systems remain fragmented. Second, unification reduces technological complexity by providing common standards, shared interfaces, integrated databases, and seamless access across platforms. This simplification lowers users' effort requirements and increases confidence in interacting with immersive technologies. Third, unification improves information continuity and service integration, allowing users to access resources without disruption while maintaining a consistent digital identity across environments. Finally, unification strengthens trust in the technological ecosystem by creating predictable and reliable user experiences (Mehmood et al., 2025). As a result, these mechanisms amplify the positive effects of FC on BI and MU, thereby explaining why unification functions as a critical moderator within responsible

metaverse adoption. In this sense, unification acts as the bridge that converts technological availability into meaningful user engagement and sustained participation in immersive digital ecosystems.

The moderating role of unification becomes particularly significant when examining the influence of FC on BI and MU. FC alone may not guarantee successful adoption if technological environments remain fragmented or poorly integrated (Abdulmuhsin, Owain, Dbesan, Bhat, et al., 2025; Xiao et al., 2024). Even when organisations provide technical infrastructure, users may still experience operational difficulties caused by incompatible systems, disconnected platforms, or inconsistent interfaces (Sánchez et al., 2025). However, when the metaverse environment demonstrates high levels of unification, the effectiveness of FC increases substantially because users perceive the technological ecosystem as coherent, accessible, and easy to navigate (Al-Kfairy et al., 2024; Dwivedi et al., 2022).

Furthermore, unified metaverse environments reduce technological complexity and enhance users' confidence in interacting with immersive systems (Abdulmuhsin, Owain, Dbesan, Alkhwalidi, et al., 2025). This contributes to strengthening BI and encouraging continuous technology usage within museums and tourism establishments (Berta et al., 2025; Moghavvemi & Huang, 2025). The ability to integrate multiple virtual services into a cohesive ecosystem also supports sustainable digital transformation and improves the overall quality of virtual tourism experiences (Kaleli, 2026; Kürüm Varolgüneş et al., 2025; Zhang & Huang, 2025). Therefore, we believe that the unification property acts as an enabling mechanism that amplifies the positive impact of organisational and technological support on responsible metaverse adoption and usage behaviour.

Conceptual Model and Hypothesis Development

The conceptual model of this study is developed based on the UTAUT framework integrated with the responsible metaverse perspective. The model proposes that PE, EE, SI, and FC influence BI towards adopting responsible metaverse technology in museums and tourism organisations. Furthermore, FC and BI are expected to directly influence MU. In addition, the study introduces the unification (F3) property as a moderating variable affecting the relationships between FC, BI, and MU.

PE refers to the degree to which individuals believe that using metaverse technology will enhance their job performance, efficiency, and service delivery (Alkhwalidi et al., 2025). In tourism and museum contexts, immersive metaverse systems can improve visitor engagement, digital heritage preservation, and interactive cultural experiences (Buragohain et al., 2024). Previous studies such as Ariya et al. (2025); Lu et al. (2025); and Mosbeh (2025) indicate that users are more likely to adopt immersive technologies when they perceive significant performance-related benefits. Therefore, the following is proposed:

P1: PE has a positive impact on BI to adopt the responsible metaverse.

EE reflects the degree of ease associated with using metaverse technologies (Venkatesh et al., 2003). Systems characterised by simplicity, accessibility, and user-friendly interaction are more likely to encourage adoption intentions among employees and visitors (Chedrawi et al., 2025; Shin & Jo, 2024). Prior studies have shown that perceived ease of use significantly influences acceptance of immersive digital technologies (Abdulmuhsin, Owain, Dbesan, Bhat, et al., 2025; Zarouali, 2024). Thus, the following is proposed:

P2: EE has a positive impact on BI to adopt the responsible metaverse.

SI refers to the extent to which individuals perceive that important others believe they should use the technology (Saeed et al., 2026). Within museums and tourism organisations, managerial support, peer influence, and societal trends towards digital transformation can significantly shape adoption behaviour (Bekele & Raj, 2024; Mosbeh, 2025). Existing literature (e.g.: Al-Kfairy et al. (2024); Raman et al. (2025);

and Tao et al. (2025)) confirms the importance of SI in encouraging acceptance of metaverse technologies and virtual collaboration systems. Accordingly, the following is proposed:

P3: SI has a positive impact on BI to adopt the responsible metaverse.

FC represent the availability of organisational and technological resources necessary for supporting technology adoption and usage (Venkatesh et al., 2003). Adequate digital infrastructure, technical support, and institutional readiness positively influence users' confidence in adopting immersive technologies (Abdulmuhsin, Owain, Dbesan, Bhat, et al., 2025; Wang & Ametefe, 2026). Previous studies such as Mosbeh (2025); (F. Wang et al., 2025); and Zhu and He (2025) emphasise that FC directly affect both BI and actual usage behaviour in emerging digital environments. Then, the following are proposed:

P4a: FC have a positive impact on BI to adopt the responsible metaverse.

P4b: FC have a positive impact on responsible MU.

BI represents individuals' willingness and readiness to use responsible metaverse technologies within their professional and tourism-related activities (Saeed et al., 2026). According to the UTAUT framework, BI is considered one of the strongest predictors of actual technology usage behaviour (Abdulmuhsin, Owain, Dbesan, Alkhwalid, et al., 2025; Venkatesh et al., 2012). Users who demonstrate strong intentions towards immersive technologies are more likely to engage continuously with metaverse applications in museums and tourism environments (Anwar et al., 2025; Chang & Suh, 2025; Mosbeh, 2025). Therefore, the following is proposed:

P5: BI has a positive impact on the responsible MU.

The present study further introduces unification as a responsible metaverse property moderating the relationships between FC, BI, and MU. Unification refers to the degree of interoperability, integration, and seamless connectivity across digital platforms, systems, and immersive environments (Deng et al., 2025; Sadeghi-Niaraki et al., 2025). A unified metaverse environment allows users to interact across multiple systems without fragmentation, thereby enhancing usability and reducing technological complexity (Tukur et al., 2023). When metaverse systems are highly unified, the positive influence of FC on BI becomes stronger because users perceive greater technological consistency, compatibility, and accessibility. Integrated digital ecosystems also enhance institutional readiness and reduce operational barriers associated with fragmented technological environments (Al-Kfairy et al., 2024). Therefore, users become more willing to adopt responsible metaverse systems when organisational resources operate within a unified infrastructure. Accordingly, the following is proposed:

P6a: Unification (F3) property positively moderates the relationship between FC and BI for adopting the responsible Metaverse.

Similarly, unification strengthens the relationship between FC and MU. Unified immersive environments improve system interoperability, simplify navigation across digital platforms, and facilitate continuous interaction within virtual tourism and museum experiences (Hao et al., 2026; Z. Xu et al., 2025). Such integration enhances users' ability to effectively utilise metaverse technologies and increases the practical value of available organisational resources (Lu et al., 2025; Vijayakumar et al., 2025). In fragmented environments, however, inconsistent systems and technical incompatibilities may weaken actual usage behaviour despite the availability of FC. Therefore, the following is proposed:

P6b: Unification (F3) property positively moderates the relationship between FC and MU for adopting the responsible Metaverse.

Practical Example of The Moderating Role of Unification

Consider a team of IT professionals working within the Iraqi Museum, the State Board of Antiquities and Heritage, and national tourism organisations to develop a responsible metaverse platform. Their objective is to integrate virtual reconstructions of heritage sites such as the Ziggurat of Ur, digital museum collections, archaeological databases, augmented reality applications, and tourism service platforms into a single interoperable digital ecosystem. Through this platform, visitors can seamlessly move between virtual site exploration, museum exhibitions, historical archives, and tourism services without experiencing technological disruption. To support implementation, the organisations provide strong FC, including advanced network infrastructure, cloud computing resources, virtual and augmented reality technologies, technical support teams, cybersecurity mechanisms, digital heritage databases, and specialised staff training. However, the effectiveness of these facilitating conditions largely depends on the degree of unification achieved across the technological environment.

From an implementation perspective, unification can be achieved through several practical technological mechanisms that enable seamless interaction across museums, archaeological institutions, and tourism organisations. One important mechanism is the adoption of standardised data formats, which allow digital artefacts, archaeological records, visitor information, and heritage metadata to be stored and exchanged consistently across different systems. Standardisation reduces compatibility issues and facilitates the integration of content originating from multiple institutions. A second mechanism involves the use of application programming interfaces (APIs), which enable real-time communication and data exchange between virtual reality platforms, augmented reality applications, museum databases, tourism booking systems, and artificial intelligence services. Through API integration, users can access interconnected services without repeatedly entering information or switching between disconnected applications.

Shared digital infrastructures, such as cloud-based repositories and centralised knowledge management platforms, further support interoperability by providing a common environment for storing, managing, and updating cultural heritage resources. These infrastructures ensure that museums, archaeological institutions, and tourism organisations access the same accurate and up-to-date information. Additionally, cross-platform authentication systems, such as single sign-on (SSO), allow users and employees to access multiple metaverse services using a single digital identity. This reduces complexity, improves user experience, and enhances security. Together, these mechanisms transform fragmented technological resources into a coherent digital ecosystem, strengthening the effectiveness of facilitating conditions and supporting the successful adoption and sustained use of responsible metaverse technologies.

High Unification Scenario

In a highly unified metaverse environment, IT professionals successfully integrate all digital heritage systems through common standards, interoperable databases, single-sign-on authentication, and shared application programming interfaces (APIs). As a result, digital artefacts stored in museum repositories can be instantly accessed within virtual reality environments, archaeological records can be linked to augmented reality applications, and tourism services can retrieve information from the same centralised knowledge base. Under these conditions, IT professionals perceive the available technological infrastructure and organisational support as highly effective because all resources operate within a coherent ecosystem. Consequently, facilitating conditions exert a stronger positive influence on their behavioural intention (BI) to adopt, support, and further develop responsible metaverse technologies. This situation illustrates P6a, where Unification (F3) strengthens the positive relationship between facilitating conditions and behavioural intention. Furthermore, because the integrated ecosystem simplifies system administration, data exchange, maintenance activities, and user support, IT professionals are more likely to continuously utilise and expand metaverse applications in their daily operations. The available facilitating conditions are therefore translated

more effectively into actual metaverse usage (MU), illustrating P6b, where Unification strengthens the positive relationship between facilitating conditions and metaverse usage.

Low Unification Scenario

In contrast, imagine that virtual reality systems, museum databases, archaeological repositories, augmented reality applications, and tourism platforms operate independently using incompatible technologies and isolated data structures. Despite the availability of technological resources and organisational support, IT professionals must repeatedly manage duplicate databases, perform manual data transfers, resolve compatibility issues, and maintain multiple disconnected systems. Although facilitating conditions remain available, the fragmented technological environment reduces their effectiveness. IT professionals may perceive metaverse implementation as complex, inefficient, and difficult to sustain, resulting in lower behavioural intention to support the technology and reduced actual usage of metaverse applications. Therefore, Unification (F3) functions as an enabling mechanism that transforms facilitating conditions from isolated technological resources into an integrated digital heritage ecosystem. The greater the level of interoperability and system integration, the stronger the positive effects of facilitating conditions on both behavioural intention and actual metaverse usage among IT professionals working in museums, archaeological institutions, and tourism organisations.

Conclusion and theoretical Implications

The integration of responsible metaverse technologies within museums, archaeological institutions, and tourism organisations represents a transformative opportunity for enhancing cultural heritage preservation, visitor engagement, and sustainable digital tourism experiences. The literature confirms that immersive technologies such as virtual reality, augmented reality, and artificial intelligence are increasingly redefining how organisations create, preserve, and deliver cultural experiences in digitally connected environments (Buragohain et al., 2024; Lu et al., 2025; Tamim et al., 2025). At the same time, the successful implementation of these technologies depends not only on technological capabilities but also on users' behavioural intentions, organisational readiness, and the interoperability of digital ecosystems.

Drawing upon the Unified Theory of Acceptance and Use of Technology (UTAUT), this study proposes that performance expectancy, effort expectancy, social influence, and facilitating conditions play essential roles in shaping behavioural intention and metaverse usage within museums and tourism establishments (Venkatesh et al., 2003; Venkatesh et al., 2012). The findings from the theoretical review further indicate that fragmented technological infrastructures and disconnected immersive environments remain significant barriers limiting the effectiveness and sustainability of metaverse adoption in heritage organisations (Del Vecchio et al., 2025; Deng et al., 2025). Consequently, the study introduces the concept of unification as a responsible metaverse property that strengthens interoperability, technological integration, and seamless interaction across immersive systems.

The proposed conceptual model contributes to the growing body of metaverse literature by extending the traditional UTAUT framework into the context of responsible immersive ecosystems. Unlike prior studies that primarily focused on conventional technology acceptance determinants in commercial or entertainment settings, the present study contextualises metaverse adoption within museums and archaeological tourism organisations, where issues of heritage preservation, historical authenticity, accessibility, and sustainability are critically important (Lu et al., 2025; Sánchez-Martín et al., 2025). This contextual extension broadens the applicability of UTAUT by demonstrating its relevance in culturally sensitive and sustainability-oriented digital environments.

From a theoretical perspective, the study makes several important contributions. First, it advances responsible metaverse theory by conceptualising unification as a critical environmental property influencing users' behavioural intentions and actual metaverse usage. Existing literature has largely examined metaverse technologies as isolated platforms or tools, whereas this study emphasises the importance of interoperable and integrated digital ecosystems in enhancing adoption behaviour (Sadeghi-Niaraki et al., 2025; Singh et al., 2025). By positioning unification as a moderating construct, the study theoretically explains how organisational and technological support mechanisms become more effective when immersive systems operate within coherent and interconnected infrastructures.

Second, the study contributes to technology adoption theory by integrating environmental ecosystem characteristics into the UTAUT framework. Previous UTAUT studies have predominantly focused on users' perceptions of usefulness, ease of use, and social influence while paying limited attention to the structural and technological qualities of digital ecosystems (L. Huang et al., 2025; Tao et al., 2025). The present framework therefore enriches the explanatory power of UTAUT by demonstrating that behavioural intention and actual technology usage are also influenced by interoperability, system integration, and digital continuity.

Finally, the study contributes to tourism and cultural heritage literature by providing a responsible digital transformation perspective for museums and archaeological institutions. The proposed framework highlights how immersive technologies can support sustainable heritage preservation and enhance digital tourism experiences while simultaneously addressing operational and technological challenges associated with fragmented systems. Accordingly, the study establishes an important theoretical foundation for future research investigating responsible metaverse ecosystems, digital heritage innovation, and sustainable immersive tourism environments.

Limitations and Future Research

This study has several limitations that should be acknowledged. First, as a conceptual paper, the proposed framework has not been empirically validated; therefore, the relationships among the constructs remain theoretical and require testing in real-world settings. Second, the model is developed within the context of museums, archaeological institutions, and cultural heritage tourism organisations, which may limit its generalisability to other metaverse application domains. Third, the study focuses primarily on unification as a responsible metaverse characteristic, while other potentially influential properties, such as privacy, security, trust, digital identity, governance mechanisms, and ethical transparency, were not explicitly incorporated into the framework.

These limitations provide several opportunities for future research. First, researchers are encouraged to empirically validate the proposed framework using quantitative approaches such as Partial Least Squares Structural Equation Modelling (PLS-SEM) or Covariance-Based Structural Equation Modelling (CB-SEM). Second, cross-country comparative studies could examine whether the proposed relationships vary across different cultural, technological, and regulatory environments. Third, comparative analyses between museums, archaeological institutions, and tourism organisations may provide deeper insights into sector-specific adoption patterns. Fourth, longitudinal studies could investigate how behavioural intentions and metaverse usage evolve over time as immersive technologies become more mature. Fifth, experimental research designs may explore how different immersive experiences influence user engagement, satisfaction, and behavioural outcomes. Finally, future studies should examine additional responsible metaverse characteristics, including privacy protection, security, trust, governance, digital identity, and ethical accountability, to further refine and extend the proposed framework.

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