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Digital Technologies and Visitor Engagement in Museums: A Systematic Review of Emerging Trends and Experiences

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Abstract: Digital technologies have changed the relationship between museums and their visitors and the ways in which cultural experiences are offered. Technical advancements such as virtual reality (VR), augmented reality (AR), mobile applications, artificial intelligence (AI), interactive screens, and virtual exhibitions are being progressively implemented by modern museums to improve visitor engagement and educational experience. This study reviews the existing literature on digital technologies in museums and assesses their impact on visitor engagement, satisfaction, learning, and experience, analysing the role of digital devices in improving immersive narrative, tailored understanding, accessibility, and audience engagement. The review also accounts for key advancements in museum digitisation, including the adoption of hybrid museum experiences and the expanding use of data-driven technologies to manage visitors, and discusses difficulties related to the deployment of technology such as cost, digital proficiency, maintenance, and technical obsolescence. The results show that digital technology greatly influences visitors' relationships with museums by offering engaging and enriching cultural experiences while expanding museums' reach beyond their physical limits. The findings imply that, by carefully utilising digital technology, museums may achieve their educational and cultural missions while safeguarding their long-term viability in a developing digital environment.

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1. Introduction

Museums have been important institutions for the preservation, interpretation, and dissemination of information across the domains of culture, history, art, and science throughout human history. Traditionally, museums have been custodians of tangible legacy, collecting, conserving, and displaying items that represent the identities, values, and histories of different civilisations, while carrying a conservation responsibility that encourages learning, research, and public involvement with heritage assets. The rapid progress of digital technology in the twenty-first century has brought significant change to the museum industry, opening new pathways to communicate, interpret, interact, and engage with guests, and placing museums under increasing pressure to adapt the way they deliver services, display exhibitions, and run their operations to satisfy technology-literate visitors [1].

The contemporary museum environment is a far cry from the conventional model based on static displays, detailed labels, and guided tours. Today's visitors want highly engaging, personalised, and immersive experiences that exceed passive observation. The rapid adoption of smartphones, tablets, high-speed internet, artificial intelligence, cloud computing, virtual reality, and augmented reality has revolutionised consumer behaviour and expectations across industries such as tourism, education, and cultural heritage, leading museums to progressively adopt digital technology as a strategic instrument to improve visitor experience, boost accessibility, and stay relevant in an increasingly competitive leisure and cultural marketplace [1].

One of the most important developments affecting museums worldwide has been digital transformation — the adoption of digital technologies within business processes, offerings, and strategies to generate value and improve performance. Within the museum field, digital transformation encompasses digitised collections, virtual exhibitions, mobile applications, interactive kiosks, virtual reality experiences, augmented reality interpretation systems, AI-driven guides, social media interaction, and online educational platforms. These technologies have gone beyond being mere auxiliary tools and have become core components of museum services, allowing organisations to reach audiences in unique and meaningful ways [1].

The application of digital technologies in museums has changed significantly over the past decade, allowing museums to reach local, national, and global audiences beyond geographical boundaries. The digital revolution has led museums to establish online repositories and digital archives that allow scholars, educators, students, and the general public to access collections irrespective of physical location, while interactive multimedia presentations support understanding of exhibits by offering contextual information through film, animation, and immersive storytelling techniques — an illustration of how digital technology is transforming the relationship museums have with their visitors [1].

Engaging visitors has become a major concern for museum staff and researchers. In the past, visitors often experienced rather passive viewing of objects on display with little interaction, but today's museum-goers increasingly demand meaningful participation, active engagement, and possibilities for personal discovery. Digital technologies have emerged as useful tools to meet these shifting expectations: interactive software can be used to promote active learning at museums rather than passive observation, and visitors can interact with information in dynamic and engaging ways that improve learning, enjoyment, and knowledge retention through virtual reality simulations, augmented reality overlays, touch-screen displays, gamification features, and mobile applications [2].

Among the most important technical advances affecting museums is the advent of virtual reality (VR). Through a digitally produced world, users can participate in immersive re-enactments of historical events, archaeological sites, cultural landscapes, and museum displays, touring recreated cultural sites and exploring historical environments that would otherwise be impossible to grasp. Such immersive interactions have the potential to significantly improve educational outcomes and cognitive engagement, and museums can also use virtual reality software to recreate inaccessible, damaged, or destroyed cultural locations, facilitating both educational and preservation efforts [3][4].

Likewise, augmented reality (AR) has acquired substantial popularity as a museum technology. Unlike virtual reality, which immerses users in an entirely digital world, augmented reality superimposes digital content over the physical environment, providing additional information related to exhibitions — animation, 3D reconstructions, historical studies, and multimedia components — through smartphones, tablets, or wearable technologies. This integration of physical and digital components helps improve contact with visitors, increase engagement, and lead to greater awareness of cultural heritage assets [5][6].

Mobile technology has slowly acquired a place in museum activities, with mobile applications popular as a way of providing personalised services to guests before, during, and after their visit. These applications generally feature interactive maps, audio guides, exhibition information, educational material, language translation, and social sharing, giving visitors an opportunity for autonomous learning by tailoring their experience to their interests and preferences. Location-based services and beacon technologies further enable museums to provide contextually relevant information as visitors traverse display spaces, boosting pleasure and engagement [7].

Artificial intelligence (AI) is a breakthrough technology that significantly affects the museum visitor experience. AI-based systems can evaluate visitors' choices, behaviours, and engagement to offer personalised recommendations and explanatory content; chatbots and virtual assistants can answer enquiries, assist with navigation, and make information easy to access; and machine learning algorithms can support collection curation, optimisation of exhibition methods, and analysis of visitor data to improve institutional decision-making. As these technologies develop further, AI applications in museums are expected to grow dramatically, creating more flexible and visitor-oriented experiences [8].

Digital technologies are also important for improving museum teaching and the visitor experience. Museums have always served as informal learning venues alongside traditional educational institutions, and the availability of diverse means of disseminating and understanding knowledge has increased the educational function of digital technology. Multimedia presentations, digital storytelling tools, interactive displays, and online educational materials make complex knowledge more interesting, intelligible, and accessible to a variety of audiences and learning styles, facilitating the democratisation of information and amplifying the educational value of museum visits [6].

Accessibility has become an important part of contemporary museum administration, as institutions have grown more aware of the importance of creating inclusive experiences for people from varied physical, cognitive, linguistic, and cultural backgrounds. Mobile applications can offer multilingual information, audio narration, sign-language translation, and tailored interfaces for people with disabilities, while virtual tours allow those without the physical, geographic, or financial capacity to attend museum exhibits in person to experience them virtually, helping museums meet their social responsibilities by providing broader and more equal access to cultural materials [9].

The COVID-19 pandemic, which severely affected museum operations globally, underlined the significance of digital technologies. Periodic closures, travel restrictions, and social-distancing measures limited physical access to museums, forcing institutions to adopt alternative engagement tactics such as digital tours, social media campaigns, online educational projects, and virtual exhibitions. These projects demonstrated the value of digital platforms for cultural interaction, enabling museums to sustain their relationships with audiences despite physical limits, and confirmed the importance of digital resilience and the strategic role of technology in museum functioning [10].

Digital technology has also brought considerable benefits for the preservation of cultural assets. Museums are responsible for preserving cultural assets for future generations, and digitisation has emerged as one of the strongest preservation strategies: modern imaging technology, 3D scanning, and digital archiving systems allow museums to create precise digital representations of artefacts, documents, artworks, and historical objects, reducing the handling of fragile originals while preserving access to essential information should the physical object become damaged or lost. Digitised collections also promote global research collaboration, knowledge sharing, and educational access [11].

The relationship between museums and tourists has also been profoundly changed by digital technology. Museums are among the most popular cultural sites in the world, drawing millions of visitors annually and playing an important role in destination competitiveness and local economic growth. Digital experiences can add to destination

attractiveness by providing unique and memorable encounters with cultural treasures: interactive displays, virtual reality experiences, and personalised interpretation systems can enhance visitor satisfaction and stimulate repeat visitation, while virtual encounters can generate interest in physical visits by previewing museum collections and exhibitions [12].

The museum experience has therefore shifted from an object-oriented to a visitor-oriented approach. Traditional museums were collection-based and curatorial in orientation, while contemporary museums are more concerned with visitor engagement, interaction, and satisfaction — a transition that reflects broader shifts in cultural consumption where audiences choose active involvement over passive spectating. Digital technologies that allow two-way communication, co-creation of information, and user-generated interaction underpin this transition, making visitors active participants in the museum experience and increasing both personal relevance and emotional connection to exhibits [13].

The growth of social media platforms has radically changed the dynamics between museums and their audiences. Platforms such as Facebook, Instagram, YouTube, TikTok, and X allow museums to stay in touch with their audience continuously rather than limiting participation to face-to-face visits, promoting educational content, advertising exhibitions, encouraging discourse, and involving users in virtual communities. User-generated content and digital interactions further offer museums important insight into visitors' tastes and behaviours, allowing institutions to design far more effective engagement tactics [14].

There are many advantages associated with digital technology, but the digital transformation of museums also presents challenges. Financial limits remain one of the primary obstacles: the creation, maintenance, and upgrading of digital systems may require large financial inputs beyond the capacity of many museums, particularly smaller ones, and the adoption of immersive technologies, digital platforms, and digitisation initiatives may involve significant costs in hardware, software, infrastructure, and specialist knowledge [15].

A major hurdle concerns technological infrastructure: successful digital deployment requires dependable internet connectivity, robust information systems, cybersecurity practices, and technical assistance resources, and museums in disadvantaged communities often face infrastructural deficits, limited technological assets, and little government support. Rapid technological change may also pose issues of technical obsolescence, meaning that museums must constantly upgrade systems and adapt to evolving digital environments [15].

Human resources are no less important to digital transformation. The effective application of digital technologies depends on the availability of both technological assets and capable staff, and museum professionals increasingly require expertise in digital content management, data analysis, multimedia production, information technology, and digital marketing. Many museums nonetheless face problems of staff training, career progression, and resistance to institutional change, underscoring the need for sustained investment in capacity-building and digital competence at all levels of museum operation [15].

As museums accelerate their digital efforts, cybersecurity and data-privacy concerns come increasingly to the fore. Digital platforms collect large amounts of visitor data, including personal information, behavioural trends, and online interactions, and protecting this information is important both for public trust and for legal compliance. Data breaches, hacking incidents, and ransomware attacks threaten museum operations and can endanger valuable digital resources, meaning that museums need to employ rigorous security measures and develop clear data-management and privacy policies [16].

Another concern relates to over-dependence on technology. While digital applications have much to offer, their impact on the authenticity of museum visits remains debated: some researchers worry that excessive reliance on technology may detract visitors' attention from the real artefacts and reduce opportunities for direct engagement with cultural goods, while others feel that technology should support rather than substitute traditional interpretative approaches, requiring museum administrators and curators to find a proper balance between technological advancement and genuine cultural experience [17].

The digital divide also continues to affect the accessibility and inclusivity of museums. Digital technologies can improve access to cultural resources, but access to digital devices, internet connectivity, and technological literacy is not equally distributed, and groups such as seniors, low-income populations, and those who are geographically remote may have difficulty connecting with digital museums. Museums therefore need to adopt inclusive practices to ensure that digital developments do not inadvertently create new forms of exclusion [18].

The scholarly literature on digital transformation frames it not merely as the adoption of new tools but as a fundamental change in how museums operate, interact with visitors, and communicate, shifting institutions from object-based repositories toward visitor-based facilities that emphasise contact, involvement, and engagement [19]. Digital technologies are described as enabling audiences to interact with collections in both physical and virtual worlds and to reach beyond geographic limitations, a shift accelerated by globalisation, changing patterns of cultural consumption, and rising competition among cultural organisations, and reinforced by the COVID-19 pandemic, during which virtual exhibitions, online educational activities, and digital archives became crucial tools for sustaining visitor engagement [20][21].

Theoretically, this literature draws on several complementary frameworks. The Experience Economy Theory holds that visitors increasingly seek memorable experiences rather than simply consuming products or services, prompting museums to design participatory rather than passive encounters [22]. Constructivist Learning Theory, in turn, frames knowledge as discovered through active participation and personal interpretation, with digital tools providing opportunities for exploration, experimentation, and personalised engagement that support this kind of learning [23]. The Technology Acceptance Model (TAM) further proposes that individuals' acceptance of digital tools — mobile applications, virtual reality systems, interactive displays — is largely determined by perceived usefulness and perceived ease of use, with technology acceptance shown to significantly affect engagement and satisfaction, while Uses and Gratifications Theory adds that visitors actively choose technologies that fulfil particular needs such as information, entertainment, social interaction, and self-actualisation [3][24].

Within immersive technologies specifically, virtual reality research documents strong effects on engagement, satisfaction, and educational effectiveness, particularly through its ability to reconstruct lost or inaccessible heritage sites and provide experiential rather than passive learning, although the literature also notes real costs in equipment, software, and technical support, along with risks such as visitor discomfort [25][26][27]. Augmented reality research emphasises AR's capacity to blend physical and digital experience without displacing original artefacts, offering contextual and interpretive content while keeping the object itself central to the encounter, though challenges remain around software development cost, device interoperability, and the need to avoid overwhelming the exhibit with digital layers [28][29].

Studies of mobile and smart-museum applications describe how location-aware technologies and personalised content increase visitor autonomy, engagement, and accessibility, including for visitors with disabilities or language needs [30][31]. Research on artificial intelligence highlights its growing role in visitor services, collection

administration, and data analysis, from AI-driven chatbots and recommendation systems to natural-language virtual assistants, alongside persistent concerns about data privacy, ethics, and public trust [32][33][34]. Digital storytelling and interactive exhibition research shows that narrative techniques strengthen emotional and intellectual engagement, aid retention, and support the presentation of multiple cultural perspectives [35][36], while research on virtual museums documents their expanding role in breaking down geographical, financial, and physical barriers to access, a role that became especially prominent during pandemic-related closures [37][38][39].

Finally, the literature frames digital technology as an increasingly important vehicle for museum education and accessibility, supporting constructivist, gamified, and multimedia-based learning for diverse audiences [40][41], while also cautioning that unresolved challenges around funding, infrastructure, workforce capacity, cybersecurity, authenticity, and the digital divide continue to shape how successfully these benefits are realised across institutions of different sizes [42][43][44][45][46].

Given this substantial and growing body of scholarship, a broad synthesis of the relevant literature is essential to obtain a thorough grasp of the present state of digital technology and visitor interaction in museums, to identify key technology developments, evaluate their effects on visitor experience, consider implementation challenges, and indicate prospects for further development [36]. This paper accordingly reviews and synthesises existing literature on the role of digital technology in boosting visitor engagement in museum contexts, investigating virtual reality, augmented reality, artificial intelligence, mobile applications, interactive displays, digital storytelling platforms, virtual exhibitions, and social media tools, and examining their effect on visitor involvement, learning, satisfaction, accessibility, and museum experience more broadly, while presenting emerging trends and discussing obstacles in the adoption and management of digital technologies in museums [1]. In doing so, the study aims to add to a better understanding of the dynamic relationship between museums, technology, and the people who visit them, and to support museums in remaining relevant, accessible, and engaging as digital transformation continues to reshape cultural institutions worldwide [20].

2. Materials and Method

This paper investigates the impact of digital technology on visitor engagement in museums using a literature review methodology. The review synthesises existing academic information on digital transformation and its impact on museum experience, education, accessibility, and cultural heritage interpretation. A literature review technique was chosen because it provides an in-depth grasp of current advancements, issues, and upcoming trends in the discipline. The analysis is based entirely on secondary data sources such as peer-reviewed journal articles, books, conference papers, book chapters, and institutional reports, collected from well-known academic databases including Scopus, Web of Science, ScienceDirect, SpringerLink, Emerald Insight, Taylor & Francis, and Google Scholar.

A systematic search was undertaken using keywords such as digital museums, museum technology, visitor engagement, visitor experience, virtual reality, augmented reality, artificial intelligence, mobile applications, interactive exhibitions, virtual museums, digital transformation, and cultural heritage. Only studies directly relevant to museum digitisation and visitor interaction were included, while unrelated or non-academic sources were excluded. The synthesised material was critically evaluated to provide an in-depth analysis of the impact of digital technologies on visitor engagement and museum experiences, and the paper also identifies research gaps and relevant subjects for future research.

3. Results

Synthesis of the reviewed literature identifies six principal themes describing how digital technologies affect museum visitor engagement: immersive experience through VR and AR, personalisation through mobile and AI-driven systems, narrative and educational engagement, accessibility and inclusion, the growth of virtual museums, and the barriers that continue to constrain digital adoption. Each is summarised below.

A. Immersive Engagement through Virtual and Augmented Reality

Across the reviewed studies, virtual reality is consistently associated with high levels of visitor immersion, presence, and emotional engagement, particularly when used to reconstruct lost civilisations, inaccessible sites, or historical environments, with immersive experiences reported as more memorable and better understood than static displays [25][26]. Augmented reality was found to produce comparable engagement gains while preserving contact with the original physical artefact, layering digital animation, 3D reconstruction, and interpretive content onto real exhibits rather than replacing them, which the literature associates with a favourable balance between innovation and authenticity [28][29].

B. Personalisation through Mobile Applications and Artificial Intelligence

Mobile applications were found to increase visitor autonomy by allowing self-paced, interest-driven exploration supported by digital maps, audio guides, multilingual content, and location-aware beacon technology [7][30]. Artificial intelligence extends this personalisation further: AI-driven recommendation systems, chatbots, and virtual assistants were reported to tailor content to individual visitor preferences and improve operational efficiency in collection management and data analysis, mirroring broader consumer expectations of personalisation shaped by e-commerce and social media [8][32][33].

C. Narrative and Educational Engagement

Digital storytelling and interactive exhibition design were found to strengthen emotional and intellectual engagement by embedding artefacts within larger narratives rather than presenting them as isolated objects, improving knowledge retention and supporting multiple cultural perspectives [35][36]. This effect aligns with constructivist learning principles, under which interactive and gamified digital tools were reported to support active, self-directed learning and to be particularly effective for younger audiences [40][41].

D. Accessibility and Inclusive Engagement

Digital technologies were consistently linked to improved accessibility, including multilingual content, audio description, sign-language interpretation, and adaptable interfaces for visitors with disabilities [9][31]. Virtual platforms in particular were found to extend access to visitors facing mobility, financial, or geographic barriers, positioning accessibility as a core institutional responsibility rather than a purely technical add-on [37].

E. Growth of Virtual Museums and Online Engagement

Virtual museums were reported to have expanded significantly, breaking down geographical, financial, and physical barriers to cultural access, a role that proved especially valuable during COVID-19-related closures, when online exhibitions, virtual tours, and digital events sustained public engagement despite the physical closure of institutions [38][39][47]. While virtual encounters were not found to replace in-person visits, the literature indicates that they can enhance traditional visitation by increasing accessibility and encouraging future travel to physical sites [12].

F. Barriers to Digital Engagement

Across the reviewed literature, four recurring barriers were identified: financial constraints that limit smaller museums' ability to acquire and maintain digital systems;

infrastructural limitations, including unreliable internet access and inadequate technical support, particularly in under-resourced regions; workforce capacity gaps in digital content management, data analysis, and technical skills; and cybersecurity and data-privacy risk associated with the growing volume of visitor data collected through mobile applications and AI systems [15][16]. A further recurring concern involves the risk that heavy reliance on digital layers could reduce the perceived authenticity of museum visits, requiring institutions to balance technological innovation with direct engagement with original artefacts [17][48].

4. Discussion

The findings reported in Section III indicate that digital technologies have become indispensable tools for the operations of contemporary museums and the way museums communicate with visitors. The widespread embedding of virtual reality, augmented reality, artificial intelligence, mobile applications, interactive displays, digital storytelling platforms, and virtual museums reflects a broader shift from traditional object-focused institutions toward visitor-oriented environments that promote involvement, participation, accessibility, and customised experience [42][49].

The strong engagement effects associated with VR and AR are consistent with experiential learning theory, which holds that active participation promotes the acquisition and retention of knowledge more effectively than passive observation. VR's capacity to reconstruct lost or inaccessible heritage appears particularly significant for both educational effectiveness and emotional engagement, while AR's preservation of contact with the original artefact helps address concerns about authenticity that arise more acutely in fully virtual environments [28][42].

The personalisation enabled by mobile applications and artificial intelligence reflects a broader societal trend toward customised digital experience, evident across e-commerce, entertainment, and social media, and visitors appear to expect a comparable degree of tailoring from museums [50]. At the same time, this trend raises legitimate ethical questions about data privacy and surveillance that museums must address transparently to sustain public trust as AI-driven personalisation becomes more prevalent [8].

The prominence of digital storytelling in the literature reinforces the view that effective engagement depends not only on presenting information accurately but on conveying it meaningfully. Narrative techniques appear especially well suited to museums seeking to represent diverse cultural perspectives and to make complex historical or scientific content accessible to broad audiences [36], a function that is closely aligned with the reviewed literature's emphasis on constructivist, experience-based education [51][52].

The prominence of virtual museums in the literature, and their demonstrated value during COVID-19-related closures, suggests that strong online capabilities are no longer optional but form a core part of museum resilience and long-term strategy, a conclusion reinforced by evidence that online engagement remains important even after physical reopening [47][53].

The barriers identified in the results — funding, infrastructure, workforce capacity, and cybersecurity — point to a persistent equity concern: smaller and under-resourced museums may struggle to keep pace with better-funded institutions capable of absorbing the cost of advanced digital systems, suggesting that partnerships, government support, and joint initiatives may be needed to ensure that museums of different sizes and locations can benefit from digital transformation [15]. The tension between digital innovation and authenticity, similarly, suggests that technology is most effective as a tool to enhance rather than replace direct engagement with original artefacts, and that museums must maintain this balance as immersive technologies grow more sophisticated and visually compelling [1].

Looking ahead, the literature converges on an expectation of more integrated digital environments shaped by extended reality, the Internet of Things, machine learning, blockchain, and the metaverse, with hybrid models that combine physical and digital interaction increasingly recognised as central to sustaining engagement before, during, and after a physical visit [43][45]. Realising these opportunities will require careful planning, ethical consideration, and close alignment with each institution's organisational objectives and resources.

5. Conclusion

With the rapid development of digital technology, museums have shifted from traditional artefact-centred institutions to dynamic, interactive, and visitor-oriented cultural venues, as innovations such as virtual reality, augmented reality, artificial intelligence, mobile applications, digital storytelling, interactive exhibitions, and virtual museums have transformed modern museum experiences and made digital transformation an indispensable element of contemporary museum management, enabling institutions to respond to changing visitor expectations while advancing their educational, cultural, and social purposes. These technologies have significantly increased visitor engagement through immersive, customised, and interactive experiences: VR and AR give visitors firsthand experience of historical settings and cultural storytelling, while mobile applications and AI-powered systems enable personalised experiences that boost satisfaction and improve access to information, together contributing to more meaningful and memorable museum visits. Digital technology has likewise strengthened museum education, as interactive learning tools, multimedia material, simulations, and digital storytelling platforms support active, inquisitive learning suited to diverse learning styles, while virtual museums and online platforms extend educational opportunities beyond the physical bounds of museum buildings to global audiences regardless of geographic constraints; multilingual information, audio guides, virtual tours, and remote-access platforms further reduce obstacles to participation, helping museums fulfil their public responsibilities and reach more diverse audiences. At the same time, persistent challenges remain, including budget constraints, technical infrastructure needs, cybersecurity risk, staff-training requirements, and data-privacy concerns, alongside ongoing debate about the effect of technological reliance on the authenticity of museum experiences, meaning that museums will need comprehensive strategies that embrace technology while respecting the integrity of original artefacts and cultural narratives. Ultimately, digital technologies are essential instruments for improving the visitor experience and assuring the long-term sustainability of museums, and as technology progresses, museums must remain agile and responsive to emerging trends while staying true to their primary purpose of cultural preservation and education, with future success likely depending on the ability to combine digital and physical encounters to provide accessible, engaging, and relevant cultural environments for an increasingly diverse audience, allowing museums to continue serving as vital hubs for knowledge, learning, and cultural exchange as they proactively develop their digital presence.

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