The Effectiveness of Digital Technologies Used for the Visitor's Experience in Digital Museums. A Systematic Literature Review from the Last Two Decades

https://doi.org/10.3991/ijim.v16i16.31811

Ahdab Najib Hijazi, Hanif Baharin(✉)
Institute of IR4.0, Universiti Kebangsaan Malaysia, Selangor, Malaysia
hbaharin@ukm.edu.my

Abstract—The rapid advancement of technology has created a vibrant digital museum services and solutions industry. There is a drive for museums to overcome interaction and engagement issues, therefore providing a favorable atmosphere for a digital heritage economy. The study's goal is to look at the digital technologies used in digital museums to improve the visiting experience. In addition, the current study investigated the technologies employed in digital museums as well as the future of digital museums. The study used the PRISMA statement 2020 to investigate the powerful technologies applied to the digital museum to develop the visitor's experience. The final 46 articles included for the investigation and VOS software and key occurrence terms find the major classification themes of the literature. The digital museums, visitors' experiences, and digital technologies. The study's findings indicated that digital technologies significantly impact visitors' experience and interest after digital technologies like AR and VR development. In addition, many new inclusions of digital technologies like Personalization/Wearable Devices, Gesture Technology/Non-touch Interactives, Mobile Technologies, Indoor GPS tracking systems, Artificial Intelligence, Flexible Technology Exhibit Platforms, Virtual Touring, and clouding are also enhancing the visitor's experience in museums.

Keywords—digital technologies, digital museums, visitors experience, virtual reality, augmented reality

1 Introduction

In recent history, digital technologies have significantly impacted the business and entertainment worlds, and human technological advancement has provided an endless supply of comfort and progress [1]. The concept "digital technologies" refers to a set and framework of many intelligence and innovative technologies that enable connection, communications, and automation in the era of Industry 4.0, such as big data analytics, the Internet of Things, and cloud computing [2]. In addition to this, the developing digital technologies are critical for the long-term conservation and sharing of cultural material to broad audiences and producing value in innovative economic growth [3]. Because of the tremendous rise of technology in this area, museums and cultural

heritage views have also altered due to the development of digital technologies [4]. According to [5] link between an exhibit and man and society is being reshaped by digital technologies and the Internet. Exponential technological advancements provide ever-faster Internet speeds and availability, increasingly connecting the physical and digital worlds through a system of interconnected devices, including smartphones, and opening new opportunities for the conservation and protection, archiving, advancement, use, and reuse of our cultural heritage.

Furthermore, the involvement of technology in the museum sector began in 1960, and a range of presenting styles have been utilized in digital museums. Initially, there was a preference for static display approaches that employed text or graphics, like digital collections or books. However, more effective, captivating, and communicative exhibition techniques have emerged because of several media and communication technologies [6].

Moreover, museums are an essential component of a business and society, and they should be able to provide a seamless experience to consumers and viewers. Museums have a significant societal impact because they provide a vital social and cultural function by hosting large-scale public displays [7]. The relevance of museums has transitioned to digital museums in the age of digital technology, and visitor expectations have completely altered [8]. In addition to this, the emergence of advanced technologies (mobile and portable devices, multitouch displays, interactive 3D, Augmented Reality, and Virtual Reality) and the more creative use of such technologies has sparked a flurry of debate. The revolutionary impact of such technologies on art and cultural heritage continues to be highlighted in academics through applications of pioneering studies [9]. Furthermore, these sophisticated technologies can help museums realize the full potential of digital technology by allowing for the effective allocation of the visitor experience and digital exhibition possibilities [10]. According to [11], digital technologies cover a variety of technologies that have to arrive that can provide answers to various troubles and stages of action, from strategic planning for the preservation and sustainable management of exhibits, archaeological sites, and historical ensembles to the creative design of rich digital museum experiences.

Besides this, digital technologies are progressing the preservation of natural and cultural sites. Also, conventional museums already have technology systems that allow visitors to engage in new forms of communication and interactive visualization [12]. Virtual Reality (VR) and Augmented Reality (AR) have both been utilized to allow users/tourists to learn new from cultural heritage on various occasions [13]. Furthermore, the digital museum is essential in how museums may employ technology to promote the growth of innovation networks, competitive advantage, and visitor experience. They also aim to answer various digitization and visitor experience issues [14].

The research aims to examine the digital technologies utilized in digital museums to improve the visitor experience. In addition, this study determines the impact of digital technologies on visitors' experiences in high-tech digital museums to preserve cultural heritage, provide educational opportunities, and provide interactive visualization. The research will also look at the literature on digital museums, visitor experiences, and advanced digital technologies in museums. Furthermore, the study concludes the future of digital technology in museums to improve visitors' digitization experiences.

2 Methodology

The study followed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) 2020 framework for reviewing current literature [15]. Following the PRISMA criteria, the scoping approach was used to gather the most relevant literature on the museum's most frequently used digital technologies. The process included evaluating keywords and empowering the necessary directions [16]. They broadened the scope of digital technologies used in museums by conducting a comprehensive literature evaluation that used the Scopus and Web of Science databases to find relevant publications and articles. Several keyword alliance explorations were done to fold the relevant, available work from the most prominent and consistent research database—the keyword "digital technologies" and museum experience employed in the Scopus and Web of Science databases to seek the relevant literature. Predefined excellence values of PRISMA declaration 2020 inclusion and exclusion criteria were used to boost the record evaluation. We will discuss if quality criteria may be used to eliminate records in the following section. The lack of a publishing timetable distinguishes the literature search. Initially, 62 items were shown in the databases search bar. Computer science, social science, engineering, business management, environmental science, and arts and humanities are among the review's subjects; the number of records is restricted to 56, although this includes all types of records, such as research articles, reviews, conference papers, and book chapters. Only the published articles for the current investigation were included in the English records. The records were further screened for duplication and irrelevant material during the extensive screening procedure. The records were further filtered with duplication and irrelevant literature during the detailed screening process. The final 46 studies are selected for the current study, and a classification of literature is done. The PRISMA statement 2020framework execution in this review is shown in Figure 1.

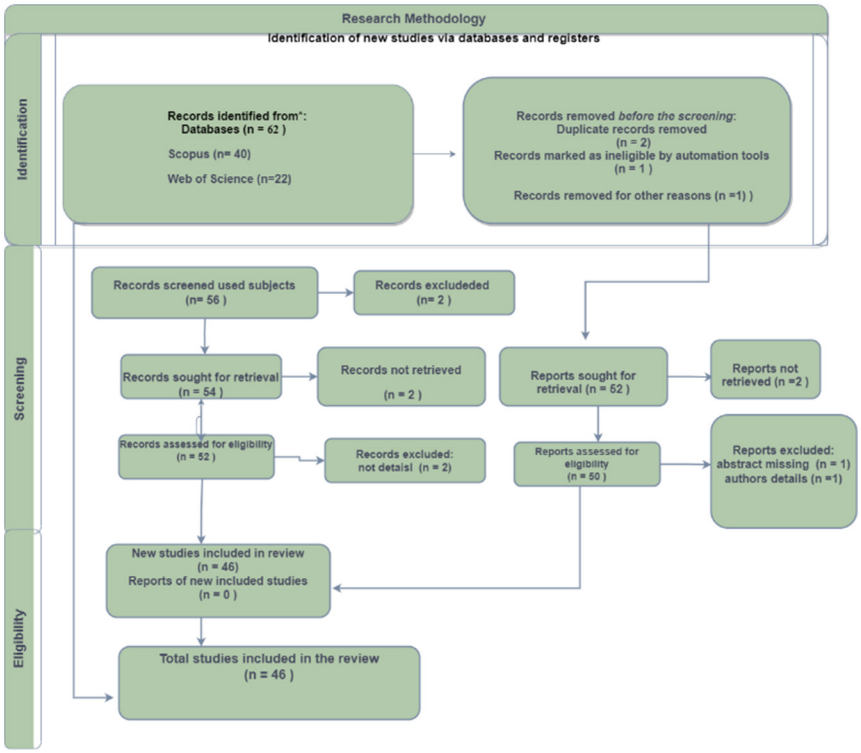

Fig. 1. PRISMA statement 2020 inclusion and excluded measures

2.1 Descriptive analysis

The final 46 records additionally distributed the subject base criteria. The distribution of the studies grounded on subject groupings designated the business, management, and accounting eleven studies for the current review. Computer Science thirteen, Arts and Humanities nine, Business, Management and Accounting contributing eight gradually, and Social Sciences choose six. The numbers are low from Engineering and Environmental Science conductively five. In Figure 2, the subject base studies are shown.

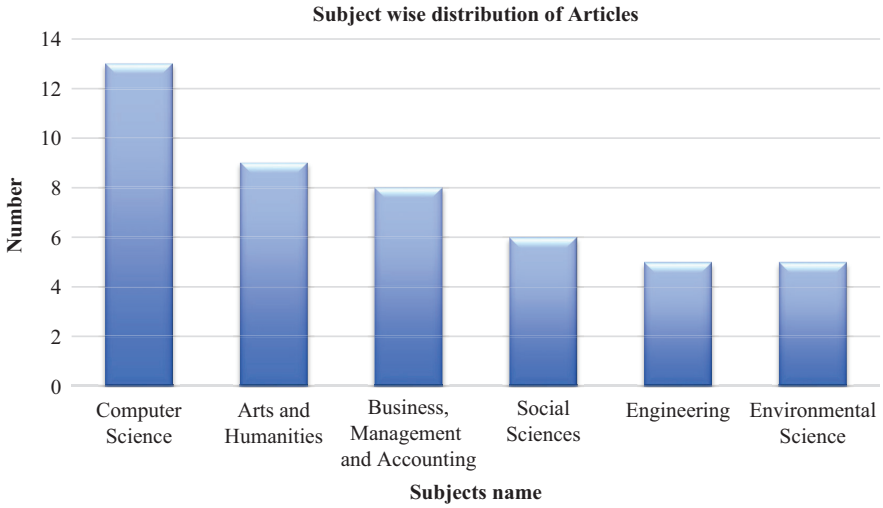

Fig. 2. Distribution of subjects on record chosen

In addition to this, the documents type is illustrated in Figure 3. The study's significant records are articles, a total of 21 articles are selected, and the percentage is 46% overall. The other significant contribution is conference articles with 39 percent of records. Finally, the nine percent of book chapters record a 6 percent is included from review articles.

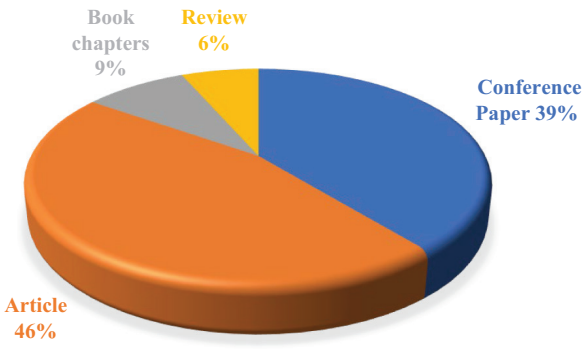

Fig. 3. Distributions of records from documents type selected

Moreover, the record's contribution from each year is explained in Figure 4. The documents are chosen from 2003–2021, and a significant rise has been recorded in recent years. The significant records are included from the year 2021, with a total number of 12. The recent rise in academicians' development and interest in digital technologies. The other significant contributors are 2020 and 2018, with six records from each year included in the study. The details are illustrated in Figure 4 of each year's articles selected below.

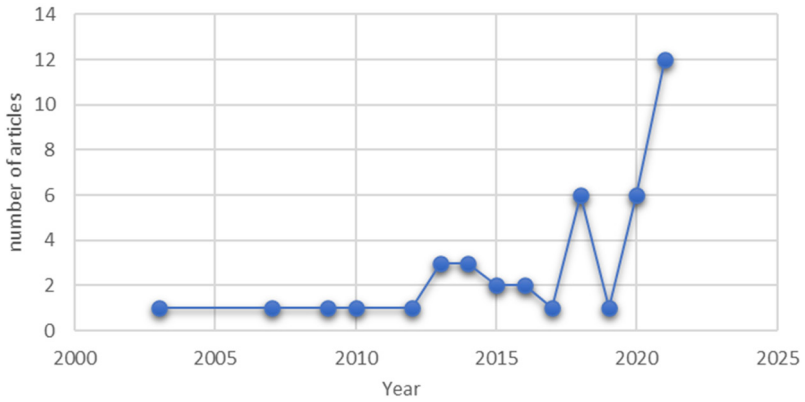

Fig. 4. Distributions of records from 2003–2021 selected

Furthermore, the number of articles included from sources is also analyzed. The Lecture Notes in Computer Science including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics is the journal with a significant number of 8 articles included in the current study. The other significant articles were selected from the ceur workshop proceedings with 6 records. In addition, the International Journal of The Inclusive Museum and Journal on Computing and Cultural Heritage contributed five articles to each journal. The other contribution of the articles is demonstrated in Figure 5 below.

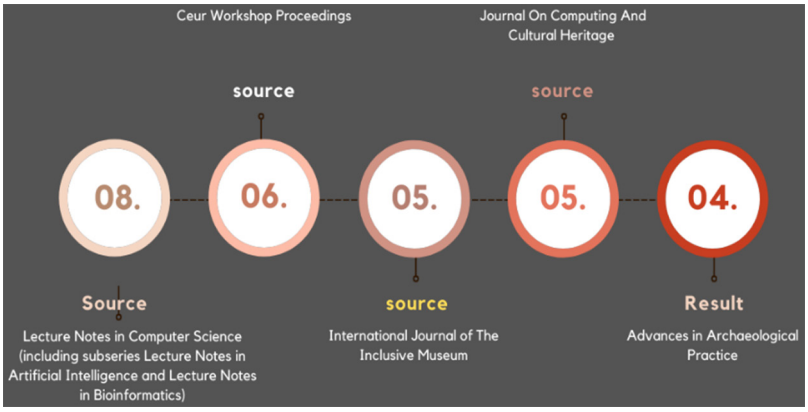

Fig. 5. Distribution of articles from sources

Finally, the study also included the states that contributed more research on the digital technologies for the visitors' museums experience. A significant number of articles are contributed Netherland and United Kingdom with six records, and Italy and Japan contributed 5,5 articles for the current study. The details of other countries are illustrated in Figure 6.

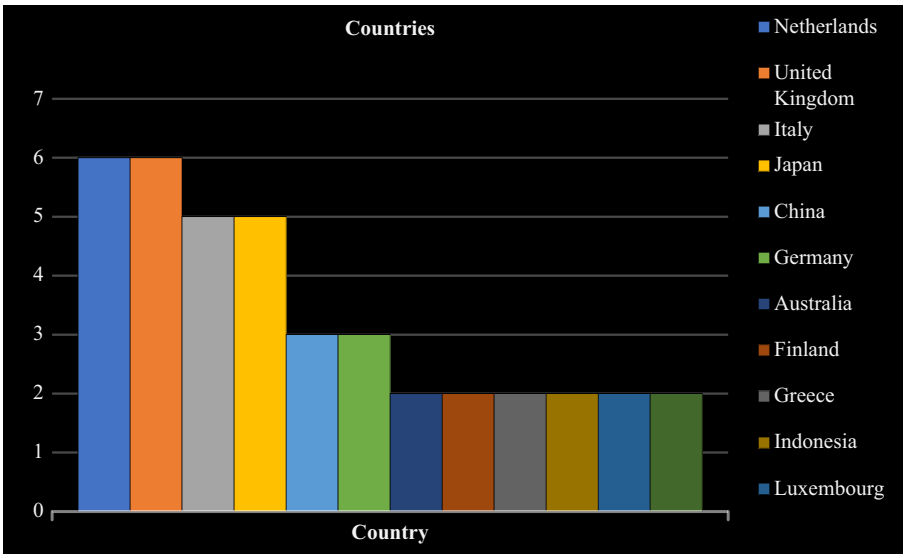

Fig. 6. Distribution of records selected from countries

Researchers have seen an insatiable curiosity in technical advancements and visitors' experiences in digital museums. Museums employ various digital technologies to enhance visitors' exposure to the digital era. Furthermore, the author extracted the occurrences of critical terms from VOS viewer software and found the classification, average of each classification, digital technologies average key terms significantly higher by 40 % compared with the digital museums and visitors' experience. In addition, the relevance score and average relevance score of critical terms are also illustrated in Table 1.

Table 1. Keyword occurrences, classification, average relevance score, and relevance score

Term	Classification	Average	Occurrences	Relevance Score	Average Relevance Score
article	digital museum	30%	9	0.339	0.114
author			4	0.7435	1.000
dimension			5	0.5741	1.250
example			3	2.8156	0.750
exhibit			7	0.9031	1.750
exploration			4	0.6886	0.571
light			4	1.1235	1.333
number			4	1.3224	0.800
practice			5	0.5879	1.667
presence			3	1.686	0.750
process			4	0.6401	0.667
reality			4	1.0388	0.667
role			10	0.5567	3.333
service			4	1.0168	0.500
tool			5	0.8299	1.667
traditional museum			4	0.8653	1.333
Total			79		
transformation	digital technologies	40%	4	0.6765	0.038
addition			4	0.4684	0.571
augmented reality			4	1.5335	0.500
building			4	0.8558	1.333
collection			7	0.76	1.000
construction			3	2.2899	1.000
data			5	1.1446	1.667
digitalization			3	0.6586	0.600
future			4	0.799	1.000
goal			6	0.7874	2.000
impact			6	0.9889	1.500
internet			3	1.5702	0.750
museum experience			8	0.3004	1.333
museum professional			3	1.6914	1.000
new technology			3	1.3901	1.000
prototype			5	0.4542	0.833
recent year			4	3.2284	0.667
response			4	0.6747	0.800
term			4	0.7244	0.050

(Continued)

Table 1. Keyword occurrences, classification, average relevance score, and relevance score *(Contiuned)*

Term	Classification	Average	Occurrences	Relevance Score	Average Relevance Score
time			8	0.5457	0.075
value			6	0.3586	0.857
virtual museum			5	1.1358	0.625
virtual reality			3	3.2786	1.000
Total			106		
world	Visitor's experience	30%	7	0.3778	0.088
analysis			8	0.4129	0.100
attention			3	1.321	0.038
content			7	0.5171	0.088
implementation			3	1.0927	0.038
importance			3	1.1014	0.038
mechanism			5	0.905	0.063
opportunity			4	0.4403	0.050
order			3	0.9755	0.038
part			4	0.4406	0.050
perception			4	0.5927	0.050
person			6	0.3503	0.075
satisfaction			3	0.904	0.038
series			3	0.9505	0.038
understanding			6	0.5644	0.075
user experience			6	1.3431	0.075
visitors experience			5	1.4484	0.063
Total			80		
Grand Total			265		

A vigilant assortment of sixty most frequent keywords from 46 records was approved to classify the literature orderings. The keywords' occurrence and relevance scores were calculated by exploitation text network using VOS Viewer software and explained in Table 1. Based on co-occurrence and keyword analysis, we discovered three significant literature clusters on digital technology, digital museums, and visitor experience. The VOS viewer yielded the same findings for the categorization of literature. Figure 7 depicts the VOS viewer categorization of literature.

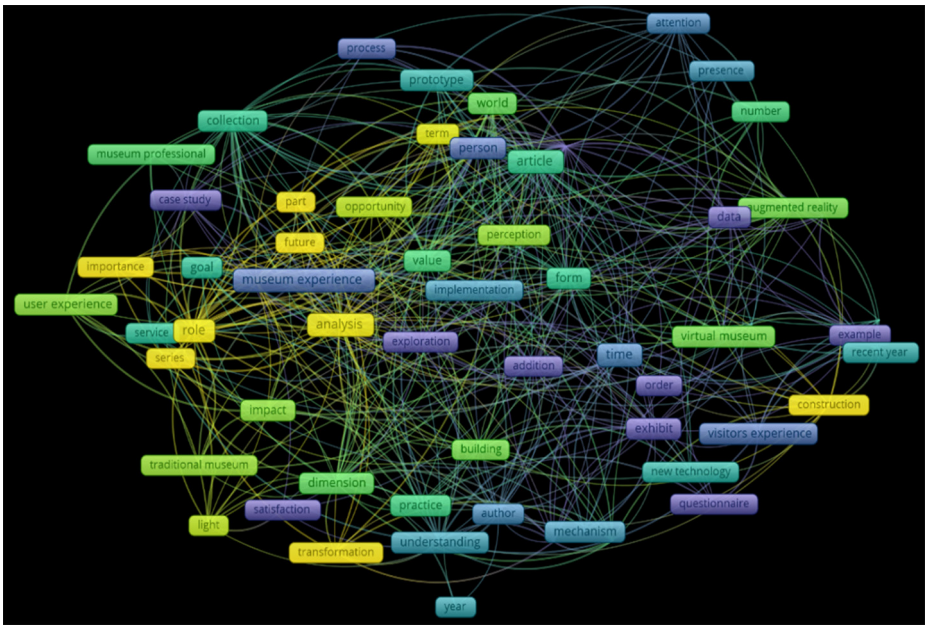

Fig. 7. Classification of literature using VOS viewer

3 Classification

3.1 Digital museums

Advanced human-computer communication technologies and conventional interaction techniques are being created, and digital technology is becoming a tool of artistic expression. Culture is impacted by technology, and the interplay between the two is more important than ever in this setting [17]. Despite its current popularity, digital museum experience design is not an entirely new notion in museology. Several scholars had undertaken museum ethnographies since the 1930s, when seminal work on visitor psychology was published [18]. On the other hand, the study [19] stated that digital museums might serve various functions, including cultural heritage interpretation, but are also the ideal approach to drawing the audience to art. Digital technology opens forth new possibilities for museums regarding communication and information distribution. The utilization of digital collections and communicating and interacting with the public, particularly with a youthful audience. Furthermore, digital museums are the most compliant in offering relevant content and digitalization features such as interactive digital signage, augmented reality, interactive video mapping, automated display slider, interactive kiosk, and interactive light show [20].

Table 2. Distribution of author, year, citations, settings, and context from the systmatic literature review findings

Authors	Cited by	Settings	Context
Kamariotou et al., 2021b	1	cultural heritage	digital museums
Morse et al., 2021		digital cultural collections	future of digital interactivity
Novakovic, 2021		cultural heritage	COVID-19
Wiastuti et al., 2020	2	accessible information perception	digitalization facilities
Mason, 2020	4	digital dimensions	digital experience
Longo et al., 2018	5	cultural heritage	smart learning experience
Lin & Lin, 2017	5	cultural tourism	visitors' museum experiences.
Narumi et al., 2016	2	digital exhibitions, digital public art, and digital signage	crowded situations

Digital technologies are being "humanized" in the recent digital era due to an interweaving of the digital world and physical space and integrated media and mixed reality [21]. The availability of digital resources creates the cultural heritage site experience; visitors may have a user-driven, interactive, and relevant learning experience through digital resources [22]. Besides this, [23] indicate that employing technology to enhance visitor experiences is an inevitable trend in cultural tourism. It allows travelers to create tailored tours based on their interests and time constraints, making their trips to digital museums more educational and flexible. The digital exhibition and artwork using interactive media at the digital museum is an essential aspect connected to digital technology. In addition to interactive digital art and digital exhibition methods in museums, interactive art and entertainment in public areas are becoming more popular. The popularity of digital public art, which blends public art with digital art, is progressively growing [24]. Overall, the digital museum is drastically altering the museum visiting experience, and numerous new technologies are continually increasing the quality.

3.2 Visitor experience

Digital museums, made possible by various developing technologies, provide visitors with a multidimensional experience through physical engagement and interaction. For example, impression of immersion in the distant world influences the level to which users are persuaded by what they see, hear, and feel. It also gives users with an improved sense of realism and a higher sense of presence when compared to non-3D surroundings [25]. As a result, digital museums provide a potentially unique sort of immersive experience as compared to traditional museums, which are dominated by static displays and exhibitions [26]. In addition, deliver this remarkable experience for tourists, museums have shifted their focus and adopted a more "visitor-oriented" strategy. The digital museum approach determines how museums employ technology to foster innovative network expansion, competitive advantage, and economic efficiency [27]. According to [28], digitizing museums is one way to improve their long-term viability and operational efficiency, resulting in a better user experience. Users' options for digital

museums are no longer restricted to actual visits and travel; they may now explore cultural and heritage sites throughout the world utilizing mobile applications [29]. As a result, this tendency is expanding the usage of standard technology; also, social media has forced museums to adapt to changing lifestyles to better engage their guests throughout their stay [30].

Table 3. Distribution of author, year, citations, settings, and context from the systmatic literature findings

Authors	Cited by	Settings	Context
Guo et al., 2021	2	emerging technologies	digital museum experiences
Kamariotou et al., 2021c		virtual museum	"Visitor-oriented" approach
Ahmed et al., 2020b	2	technologies	COVID-19
Hanussek, 2020	1	smartphone	museums and archaeological exhibitions
Traboulsi et al., 2018	5	digital transformation	senior visitors
Sookhanaphibarn et al., 2015	3	social media	Facebook fan page
Wu et al., 2021	0	mobile Internet	experiential environment

Visitors nowadays expect to utilize integrated products to assist them in accessing essential information before, during, and after their journey and sharing and documenting their experience during and after their stay. Thanks to new websites, mobile applications, and social media, museums may now readily reach out to their audiences via digital technologies and options [31]. ewers can choose from various alternatives and sources to enjoy the tours and experiences via the use of digital technologies. According to [32], a paradigm change in museum objectives has occurred due to the growth of communication and information technology and the introduction of technical advances (mobile and portable devices, multitouch displays, interactive 3D, augmented reality, and virtual reality). As a result of this transformation, researchers are looking into the interaction between new technologies, museum interpretation, and visitor experiences. Building on the concept of the visitor-centered museum, a contemporary trend is to make museum collections broadly accessible via digitizing cultural heritage collections for the Internet. Finally, interactive technologies allow consumers to visit digital museums and get valuable experiences with technology.

3.3 Digital technologies

The digital museum is a collection of objects, specimens, and documents that have been digitized and saved using high-resolution scanning, photography, 3D modeling, and other technologies and will be fully displayed by the physical museum in terms of exhibition, collecting, learning, and research [33]. According to [34], on-site and online museum visits have been made more enjoyable thanks to digital technologies. People may visit digital museums and obtain information, services, and learning materials at any time using intelligent mobile devices. Museums may utilize augmented reality and virtual reality technology to bring collections to life and shift spectators' viewpoints. In addition, virtual museums have gained much traction during the pandemic as "cloud exhibitions," and they have a lot of business potential [35]. The use of digital

technology is not restricted to AR and VR; many other digital advancements are also enhancing the visitor experience. The IoTs, Gesture Technology/Non-touch Interactives, Mobile Technologies, Artificial Intelligence, LED/Laser Projection Technologies, Virtual Touring, and Flexible Technology Exhibit Platforms in recent times [36–38].

Table 4. Distribution of author, year, citations, settings, and context from the systmatic literature findings

Author	Citations	Settings	Context
Huang & Lv, 2021		Virtual Reality (VR) technology and Augmented Reality (AR)	exhibition technology
W. Li & Xiao, 2021		Augmented reality technologies	virtual tours
Gong & Xiao, 2021		cloud exhibition	Positive media comment
Markopoulos et al., 2020	3	Virtual reality, avatar technologies, virtual worlds, holograms, gaming and gamification	financial crisis
R. Y. C. Li & Liew, 2015	13	Digital curation	user interface (UI)
Varvin et al., 2014	4	future museum exhibit	virtual body of a visitor
Kristianto et al., 2021	12	3D visual effect	augment the visitor's museum
Maciej Serda, 2013	44	Semantic Web technologies	digital museum collections
Petridis et al., 2013	5	Augmented Reality (AR)	Internet of Things (IoT) and Social Computing

However, the current pandemic significantly hit the museum business, and Museums' operating costs rise over time as exhibit upkeep, and acquisition prices rise. This expense is inversely related to the amount of money that can be made. Virtual reality, avatar technologies, virtual worlds, holograms, gaming, and gamification may provide low-cost or no-cost creative engagement and unique experiences to worldwide visitors and create new revenue sources [39]. In addition, mobile and wearable computing devices, such as widescreen smartphones, Google glasses, and smartwatches, are rapidly being created as interfaces for numerous applications because of the rapid rise in users [40]. Digital technologies are significantly transforming the visitor experience, and frequent integration of these technologies is beneficial to the visitor experience at museums [41]. Finally, Digital relics or cultural artifacts may be shown in a virtual museum and examined in various ways, giving the viewer many options. Using essential picture imaging and photogrammetry, educational institutions and notable museums have digitized their collections with reasonable ease [42].

4 Conclusion and future agenda

Integrating digital technology to visit and explore museums will undoubtedly improve visitors' museum experiences. Utilizing digitization, visitors may immerse themselves in the experience and learn more about the artifacts [17]. The study aims to look at how digital technologies are used in digital museums to improve the visitor experience. Furthermore, this study will look at how digital technologies impact visitors' experiences in high-tech digital museums that conserve cultural heritage,

provide educational opportunities, and enable interactive visualization. The PRISMA statement 2020 was utilized to include and exclude records for the research. The final 46 papers came from two well-known databases, Scopus, and Web of Science. In addition, for classification, we use the VOS viewer programme and key keyword occurrence analysis. For the discussion, three key issues were examined: digital museums, visitor experiences, and digital technology. Figure 8 illustrates the digital technology used in digital museums from the literature.

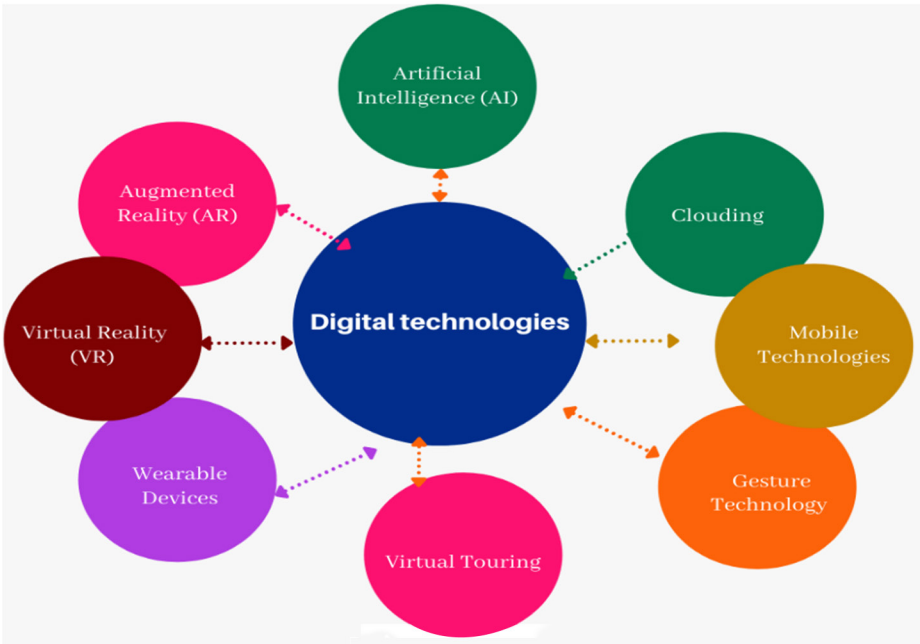

Fig. 8. The outcomes of the digital technologies used in digital museums

In recent years, technological innovations have grown increasingly important to visitor experiences and museum operations worldwide. Technology has a wide range of uses in the museum ecosystem, from delivering immersive digital engagements to curating the visitor trip, enhancing navigation, and optimizing operations [43]. Findings of the current study indicate that significantly advanced technologies in recent years have enabled the evolution of a wide range of solutions and creations targeted at aiding digital museums. The extensive studies emphasized the application of AR and VR in museums to boost cultural heritage exhibitions. In addition, many new inclusions of digital technologies like Personalization/Wearable Devices, Gesture Technology/Non-touch Interactives, Mobile Technologies, Indoor GPS tracking systems, Artificial Intelligence, Flexible Technology Exhibit Platforms, Virtual Touring, and clouding are also enhancing the visitor's experience in museums.

Finally, the future of digital technologies is heavily reliant on museums' progress in developing interactive technology. The COVID-19-induced digital acceleration allows researchers and practitioners to examine how governments and organizations

have adopted technology briefly, delivering crucial lessons for the future. Future researchers must focus on working on the extension of technologies in digital museums prospective that are useable for the conservation of cultural heritage with a broader visitor's experience.

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6 Authors

Ahdab Najib Hijazi, Institute of IR4.0, Universiti Kebangsaan Malaysia, Selangor, Malaysia. E-mail: p94049@siswa.ukm.edu.my

Hanif Baharin, Institute of IR4.0, Universiti Kebangsaan Malaysia, Selangor, Malaysia.

Article submitted 2022-04-19. Resubmitted 2022-06-17. Final acceptance 2022-06-17. Final version published as submitted by the authors.