Integrating Digital Techniques/Technologies in Developing Egyptian Museums

(Case Study: Alexandria Library Museums - Alexandria City)

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Abstract

Museums are one of the important means of attracting many visitors to them, and the more enjoyable the experience is, the greater the demand for them and their importance in conservation on their heritage pieces of cultural, artistic and historical value. This value gains increasing importance when integrated into the digital system. Research problem appears in lack of using digital technology to enhance museums, attracting visitors, and improving their experience, while conserving artistic and historical value, Also, methods of current display in old Egyptian museums are insufficient to effectively convey information and participate visitors. This research aims to explore new ways through digital technologies in developing museums, their interaction with their visitors to achieve sustainability, and enhance the user experience during visiting museums and make them more attractive and interactive knowledge exchange as well. The research follows the deductive analytical theoretical approach. It focuses on concept of digital museums, how using digital technologies in developing museum display in international experiences museums to benefit from them in Egyptian museums and using of digital technologies Alexandria Library (AL) Museums - Alexandria City as a case study. Finally, the research propose mechanism for using digital technologies in developing museums. The research ends with results and discussion then a presentation of the most important conclusions, which can be summarized in that possibility of benefiting from digital technologies developments in developing museums display. The study recommends by using of modern digital technologies in developing museums, especially heritage ones, and for their continuity for future generations.

1. INTRODUCTION

In the last twenty years of this century, there has been a leap in digital technologies that has affected the design and development of existing museums, Fig. 1. It is also useful for museums to rely on digital technologies in conditions of closure, such as what happened in the Corona pandemic, which was the only mean for the public to access them [1]. Therefore, using digital technology in museums can be divided into two parts:

1. Digitizing and documenting artifacts, artworks, and historical documents in museums for conservation on them by integrating into the digital world.
2. Using digital technologies in museum display by providing digital platforms for enhancing user experience and making them accessible to a global audience. However, challenges may arise regarding issues of security, protecting privacy, intellectual property rights, and maintaining authenticity when digitizing tangible objects or dealing with intangible items, Fig. 2.

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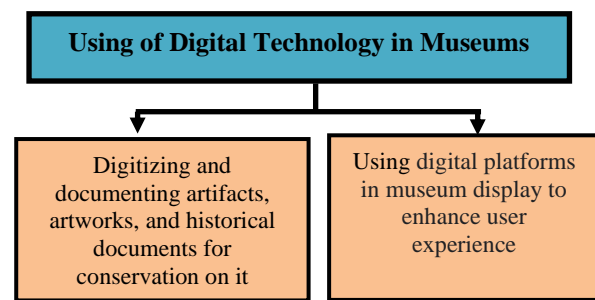Fig. 1. National Police Museum as a tradional museum, Citadel of Saladin, Cairo, Source: Researcher.

Fig. 2. Using of digital technology in museums, Source: Researcher.

1.1. Research problem

There is a lack of clarity about the extent to which digital technology means can be used to develop museums, and how to use it to attract visitors and increase the enjoyment of the visiting experience without compromising the artistic and historical value of the museum, both modern and heritage ones. Especially, the current method of display in Egyptian museums is not sufficient to convey information to visitors and attract them to it.

1.2. Research Aim

The research aims to develop proposals for the possibility of benefiting from digital technologies in finding fields of commonality between digital technology and the conservation on artifacts within museums, and integrating these technologies into various display methods to enhance user experiences, determine what to expect from digital technology while visiting museums, attract broader categories of the public, and increase understanding and interacting with the cultural and historical presented content, through a case study of the Library of Alexandria Museums - Alexandria City.

1.3. Research Hypothesis

The research assumes that using of digital techniques and technology in museums contributes to the possibility of developing and conserving museums, especially archaeological ones, for future generations. Which enhances user experience in visiting museums, increases accessibility, provides new opportunities for education and engagement, and provides an attractive environment that combines history and technology in an innovative and sustainable way.

1.4. Research Methodology

The research follows the deductive analytical theoretical approach. It is divided into five main parts, First: includes a theoretical background on the concept of the museum and digital technology, Second: deals with a study of the most important tools and means of digital technologies used in developing museum display, Third: the most important experiences and practices in using digital technologies in International and Egyptian museums, Fourth: using digital technologies in the Alexandria Library (AL) Museums - Alexandria City as a case study, Fifth: A proposed mechanism for using digital technologies in developing museums.

2. A THEORETICAL BACKGROUND ON MUSEUM CONCEPTS AND DIGITAL TECHNOLOGIES

There are many basic concepts related to museums and digital technologies used in their development and conservation on their artifacts, including the following:

2.1. Definition of the museum

The International Council of Museums (ICOM) defines a museum as "a permanent, non-profit cultural institution in service and development of society, open to the public, that researches, collects, conserves, interprets, researches, transmits, and displays the tangible and intangible heritage of humanity, and communicates for the purposes of education and entertainment and promotes diversity, and sustainability, to meet the visitor's aspirations by adapting innovative technology, to communicate and encourage visits"[2], [3].

From this standpoint, importance of museums increased, their types multiplied, their spaces expanded, and their functional and technical requirements increased to include new, non-cultural roles. They now represented social, educational, recreational, tourism, and economic roles [4]. Since 2007, museums have begun to digitize their collection of artifacts for display and to conserve and integrate their exhibitions with digital content for

visitors. With the possibility of delivering, it to the public for education and entertainment [5], which enhances user experiences and provides easier and more usable systems [6].

2.2. Concept of technology/digital technologies

Digital technologies refer to tools, devices, and systems. Tools such as cameras and digital games, devices such as personal computers and tablets, systems such as software and applications, augmented, virtual reality, and intangible forms of technology such as the Internet. Which enables data to be created, stored, or processed to perform various functions, facilitate daily life, and improve work processes in various fields. It also provides technological solutions in the process of reconstruction and digital replicas of artifacts, which enables digital museums to focus on storage, conservation on museum records, retrieval, and interaction. Storage includes methods for recording images and data, and file formats [7], and replay audio recordings, music, video clips, etc. With it, some terms appeared, such as: Virtual Museum, Online Museum, Electronic Museum, Digital Museum, and Web Museum. Regardless of the different designations, it is a phrase A database available digitally over the Internet and fully linked to the museum's tools for making it accessible to a global audience [8].

2.3. Concept of Digital Museum (DM)

Digital Museum (DM) means images, descriptions, multimedia content, and other digital representations of physical objects found in traditional museums. It also refers to an online platform or website that displays collections of artifacts, artworks or cultural materials in digital format. So, users can explore the exhibits, learn about the items on display, and sometimes interact with the content. Below is Fig. 3. The relationship between museums and digital technologies.
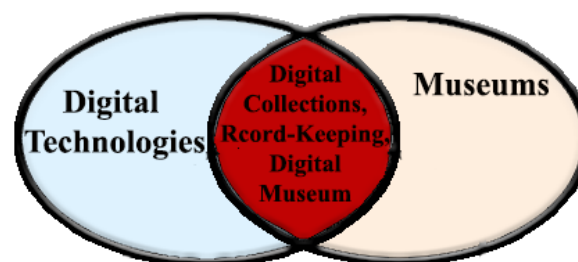

Fig. 3. Digital museums, Source: Researcher.

2.4. Concept of Virtual Museum (VM)

(VM) is a clear example of the application of digital technology in museums and a step forward for the digital museum by creating a simulated experience that resembles the physical museum environment. It represents a virtual entity for displaying museum holdings [4], through a set of digitally recorded images, audio files, text documents, and other data of historical, scientific, or cultural value that is accessed through electronic media, such as the Science Museum in London, and Paleontology Museum at California University, Berkeley [9]. Virtual museums also use technologies such as Augmented Reality (AR) or Virtual Reality (VR) to create an interactive and 3D experience.

2.5. Objectives of using digital technologies integrated in museums.

There are many objectives for using digital technologies in museums, including:
1. Digitization helps conserve valuable artifacts and historical records for use in extended reality applications, by using photogrammetry techniques, to create maps and generate data (GIS).
2. It works to enable museums to enhance their presentations by providing personal experiences that integrate technology with culture while conserving the exhibits and protecting them for future generations [10].
3. Improving experience of museum visitors, value of participation, and communication with the antiquities and exhibits, creating a more attractive and enjoyable experience, and encouraging them to explore the exhibits and learn more about them.
4. Conservation on importance of cultural museums, and accessibility for their exhibits to all visitors, including people with disabilities and virtual visitors, through online exhibitions, interactive simulations, audio descriptions and multilingual content, regardless of their linguistic abilities or proficiency.
5. Digital technologies facilitate provision of detailed information, interactive objects, and educational experiences that enhance visitors' understanding of the exhibits through interactive displays and multimedia presentations.

6. Digital technologies allow for dynamic and customizable exhibitions, where visitors can tailor their experience to their interests and preferences.
7. Collecting visitor data and analysis helps museums improvement their exhibits and make informed decisions for future improvements. By collecting data on visitor behavior and preferences, which helps improvement exhibition design and overall visitor experience.
8. Integrating traditional objects with digital technology through effective use of multimedia, (AR) and (VR) technologies to encourage interaction and active participation of visitors through interactive activities, workshops, and advanced technologies to transform the visit into a fun and interesting learning experience.

2.6. Digital tools and means used in developing the museum display.

There are many common digital technologies and media that can be used in developing museum displays to enhance the visitor experience. Museums are adopting to explore how to use them and make them more interactive, considering the nature of the exhibits, requirements of the artifacts, and the methods of display, including [10].

2.6.1. Three-dimensional models
It is one of the innovative ways to attract museum visitors and interact with the exhibits, which is used to create virtual and real replicas of damaged or lost artifacts. It is also used in computer models simulations, and high-resolution and 3D documentary photographs [5], which photos and video recordings provide multiple views of museums and World Heritage sites, with applications that give users the feeling of actually being there.

2.6.2. Digital photogrammetry
Detailed digital scanning or 3D laser scanning technology is used to prepare a digital reference document and databases with high definition and accuracy, given the formal information used in the form of animation, entertainment products such as digital movie, music playback or computer games [12], also include drawing maps and digitizing them in a multimedia way.

2.6.3. Interactive touch screens and technologies
Touch and multi-touch screens provide opportunities for visitors to interactively explore content via touch and obtain interactive information from exhibits based on data collected about artistic or historical objects, with the ability to display high-resolution videos and images. These screens also facilitate access to information for a larger number of people at one time [8], Fig. 4, Fig. 5. This provides opportunities for many users to interact with the application at the same time, especially with large screens.

2.6.4. Interactive lighting and sound technologies
Lighting and sound systems can be used creatively to create an appropriate atmosphere for exhibits and highlight important details. Interactive lighting systems can be used to highlight specific parts of exhibition or to achieve exciting visual effects. Sound can also be used to provide explanatory sounds or music to accompany presentations [13], [14], Fig. 6.

2.6.5. Sensor Technologies
Sensors, such as motion sensors, can be used to activate displays or digital content when a visitor approaches a specific display. Sensors can be used to determine the visitor's level of interaction with display, Fig. 7.

2.6.6. Human interface technologies
These technologies include facial, voice recognition, and interactive robots that can be used to communicate with visitors and respond to their inquiries.

2.6.7. Machine learning and artificial intelligence technologies
These technologies can be used to analyze visitors' behavior and provide accurate guidance for their visit.

2.6.8. Digital storytelling
Digital storytelling techniques combine multimedia objects, including text, images, audio, and video, to convey narratives about heritage. This approach enhances visitor engagement and allows for exploration of multiple interpretations for it.

2.6.9. Digital Information Network (Internet)
It helps introduce the most important museums, heritage and tourist sites, helps tourists get to know the area surrounding museums and existing services, and arranges their visit smoothly. It provides support for information generated by visitors through published photos and videos, and blogs [8], It also includes publications, websites, email, databases [5].

2.6.10. Holograms (Holographic display)

Holograms can be used to project a three-dimensional image of art or historical objects, creating a unique visual effect. They are produced using a laser and recorded on a flat photographic plate. When the plate is illuminated by a laser beam similar to the original beam used to create the image, the beam will pass through some parts and be absorbed to varying degrees in darker areas, eventually creating a combined wave. The end product of this process is the photographic recording and displayed holographic artwork [12], see Fig. 8. to Fig. 10.

2.6.11. Augmented Reality (AR)

(AR) can be used in mobile applications to explore a museum display through an adaptable user interface and apply to museum and historical environments. (AR) integrates digital content with real world to add 3D objects, additional information, or interactive objects to virtual versions of artifacts [10], [15]. Or virtual reconstructions of fixed exhibits for creating a distinctive user experience, providing access to multimedia content, and a better understanding of tangible and intangible heritage exhibits [6].

2.6.12. Virtual Reality (VR)

(VR) technologies create digital environments for three-dimensional, realistic interactive experiences that simulate heritage sites or historical events associated with the exhibits, taking visitors on virtual journeys to them. Users can explore these environments through headphones or other devices, using (VR) glasses to explore the museum, historical or artistic places in a completely realistic way.

2.6.13. Mixed Reality (MR) technologies

(MR) combines objects of (VR) and (AR) to provide a comprehensive experience that interacts with the real world while integrating virtual objects [2], Fig. 11. Among them are the following:

2.6.13.1. (Microsoft HoloLens): It is a mixed reality headset developed by Microsoft. It allows users to see and interact with holographic images placed in the real world. This can be applied in various educational and entertainment contexts, Fig. 12.

2.6.13.2. (Magic Leap): A company that produces mixed reality devices. Their glasses overlay digital images over the user's actual environment, creating a seamless integration between real world and virtual world, Fig. 13.

2.6.13.3. (Meta Quest)/(Oculus Quest): Although it is known as a virtual reality headset, it also has features that allow for (AR) experiences. Users can see the real world while wearing the glasses and interact with digital content, Fig. 14.

2.6.13.4. (Google Glass): Although they were originally designed as smart glasses, they allow users to experience (AR) by displaying digital information in the user's field of vision.

2.6.13.5. (Samsung Odyssey): A mixed reality headset from Samsung present a mix of (VR) and (AR) experiences, which allow users to see and interact with their surroundings, Fig. 15.

Fig. 4. Muli-touch screens in Museum [16]

Fig. 5. Interactive touch screens in Museum of the Future, Dubai[17]

Fig. 6. Colour scene, visitors in the La Halle space at Atelier des Lumières, Paris Supports digital lighting technologies[18].

Fig. 7. Sensing technologies[17].

Fig. 8. A projection mapping installation created as part of A Night At The Mansion. Award-winning visitor attraction set up throughout the rooms of Harewood House, West Yorkshire, England[19].

Fig. 9. Holographic Experience at the Whaling Museum, Nantucket, Massachusetts, Cape Cod[20].

Fig. 10. A three-dimensional display of King Tutankhamun's mask inside the hall designated for its display at Egyptian Museum in Tahrir, using "hologram" technology to simulate the display with the original pieces, which is what the Heritage Documentation Center used to simulate the original mask during its restoration period[21].

Fig. 11. Mixed Reality[22]

Fig. 12. Microsoft HoloLens[23]
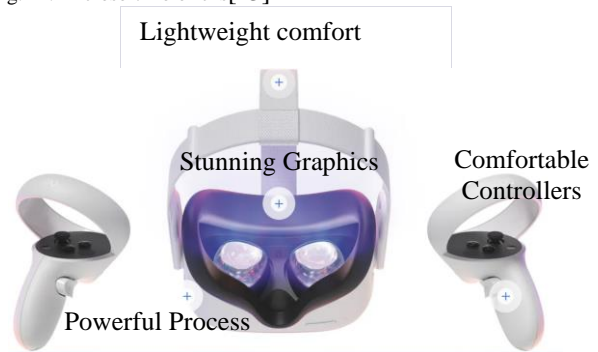

Fig. 13. Magic Leap[24].

Lightweight comfort

Stunning Graphics

Comfortable Controllers

Powerful Process

Fig. 14. Oculus Quest[25].

Fig. 15.Samsung Odyssey[26]

Fig. 1. Interactive touch screens at the Art Museum. (Cleveland Museum of Art) - Ohio - America[27]

2.6.14. Smartphone applications

Apps for smartphones provide additional information about exhibits and their accessibility by having visitors take their mobile and tablet devices with them, provide audio guides and display multimedia content (text, video, audio, animation, images) of 3D digital replicas, participate in interactive experiences and provide personalized experiences, and enable visitors to interact with the content, especially those with disabilities. Sight is also used

as a tour guide to help the visitor while touring inside the museum to identify things of interest to the visitors, which enhances user experience and increases the visitor's ability to learn inside the museum [6], [28]. It is also used as a virtual museum. This application uses image recognition and Q) technology to read the visitor's code to retrieve information about the selected objects.

Finally, provides access to a large number of artifacts without any risks to them, and is available over a long period of time, allowing the content to be saved and reused for their own purposes [8], [29].

2.6.15. *Social media using digital media in all its different forms*

Using social media and sharing information via social media platforms (such as Facebook, Twitter, Instagram, and Pinterest) [8], helps establish a new model for museum's relationship with its visitor and sharing digital heritage with different communities through a group of social media applications that encourage the exchange of ideas by creating user communities. Online via various networks, such as (RSS), (Flickr) and (YouTube), all of which offer new possibilities for interacting with their visitors [29].

2.6.16. *Interactive games in digital heritage*

They are often called games designed with educational objectives for different ages and levels and are often placed on their websites to encourage users to visit and interact with them, mobile applications designed for individual use, and online games.

In general, different types of applications can be beneficial to visitors if used in the right place and time, and in line with the right needs of museums strategy. Focusing on how to leverage the right technology tools that best support their mission as technology has become an important component of enhancing the museum experience [29], [30].

These are some examples of digital technologies that can be included in the development of museum displays to improve interaction and increasing its attractiveness [31].

3. THE MOST IMPORTANT EXPERIENCES AND PRACTICES IN FIELD OF USING DIGITAL APPLICATIONS IN INTERNATIONAL MUSEUMS

Below are some examples of international experiences in using digital applications in heritage and new museums.

TABLE 1. THREE EXAMPLES FOR USING DIGITAL APPLICATIONS IN INTERNATIONAL MUSEUMS

Name of the Museum	Descriptive of practices of using digital applications in the Museum	The most important digital tools in the Museum	Figure of the digital tools in the Museum
3.1. London Museum-United Kingdom (1753)	It is an early adopter of (AR) capabilities and the Street Museum app, which uses historical photo collections to allow users to use their smartphones to view a memorial or any scene of their choice on the street they walk around to see the same scene from the past. The museum also uses digital display technology and LCD screen to display various film and photographic contents to combine many faces of fictional character of Sherlock Holmes, as well as appropriate digital media to give visitors a complete experience. Fig. 16[32].	(AR), LCD screen, Digital media, Mobile application audio, Digitization of artifacts	Fig. 16. Display screens in London Museum - UK
3.2. Louvre Museum-Paris, France (1793)	The museum uses digital technologies to make it possible to take a virtual interactive tour through each floor of the museum through tools available through its website, online exhibitions and multimedia guides where maps of the museum, including the museum rooms, can be downloaded with 360° images that can be manipulated. , (3D) exploration, access to microsites of specific artworks, quick documentaries films, access to a huge database of works, with ability to schedule visits to researcher-only areas. Which leads to improving the visit time to the museum, and enhancing the visitor experience[8]. (AR) applications also used for some of the exhibits, Fig. 17.	360° images, (3D) exploration, (AR) applications, Digitization of artifacts	Fig. 17. (AR) applications in Louvre Museum, Paris - France

3.3.National Museum of Emerging Science and Innovation, also known as (Miraikan) - Tokyo, Japan (2001)	This high-tech museum features a large number of interactive displays. Visitors can explore space by entering a model of International Space Station. The museum also includes science workshops for children, where children particularly enjoy with screens by touching many of them, climbing on them, and playing with them. Visitors can learn and do a huge amount of things[31]. In addition, one of the prominent pieces in the museum is the famous LED globe, which displays a display of the Earth as it is visualized through geographic data. visitors can also interact with artificial intelligence reboots [33], [34], Fig. 19.	Model of International Space Station, LED globe, artificial intelligence reboots	Fig. 18. Famous LED Earth - National Museum of Emerging Science and Innovation, (Miraikan) – Japan.

4. CASE STUDY: USING OF DIGITAL TECHNOLOGIES IN ALEXANDRIA LIBRARY MUSEUMS - ALEXANDRIA CITY

There are many museums inside the Library of Alexandria in the basement, and they consist of the Antiquities Museum, which deals with the different eras in Egypt from the Pharaonic era to the Islamic era, as well as some special wings such as sunken antiquities and Windson Island, Manuscript Museum for the rarest books on various subjects such as mathematics, astronomy, astrology, novels, and jurisprudence, a museum for the most important official figures such as President Mohamed Anwar Sadat, public figures such as Mohamed Hassanein Heikal, artistic figures, painters and caricature artists. Unlike the cultural panorama that tells the history of Egypt

There are touch screens that tell the history of different figures, such as Alexander the Great, and screens showing documentaries about some artifacts and what was discovered during excavations to establish the Library of Alexandria, which was the reason for the opening of the Antiquities Museum in the library.

4.1. History of establishment of the Alexandria Library Museums and the reason for their establishment

The New Library of Alexandria and its associated museums were opened in 2002 AD as a main library and cultural center in the city for reviving and conserving the cultural and historical heritage of the Old Library of Alexandria since ancient times in the third century BC, which included countless manuscripts and texts and a center for education and scholarship until it was established. Gradually destroyed over the centuries.

It houses millions of books, manuscripts, and multimedia resources, and serves as a center for research, education and culture.

The Library of Alexandria contains four museums: the Antiquities Museum, the Manuscript Museum, the Sadat Museum, the History of Science Museum [35], and others. It also includes research centers, conference centers, art galleries, and a planetarium. It hosts many cultural events, exhibitions, and conferences throughout the year.

4.2. Main considerations in designing the Alexandria Library's museums in digital form:

1. The Library of Alexandria was designed in a symbolic circular shape like the disk of the sun, and equipped with the latest technologies and facilities for conserving books, manuscripts, and digital resources.
2. Objects of ancient Egyptian, Greek, Roman and Islamic architectural styles were combined with modernism.
3. Access to the library and museums is open to everyone regardless of background, nationality or language.
4. Lecture halls, conference rooms, planetarium and exhibition spaces are included to support a wide range of educational and cultural activities.

4.3. The most important digital technologies used in the Alexandria Library Museums

The research focuses on the Antiquities and Science Museums from (AL) Museums which used digital technologies to develop the museum display.

4.3.1. The Antiquities Museum:
It is one of the few museums in the world that displays art pieces that were discovered in the same place they were displayed. The museum contains 1,133 displayed pieces that reflect the history of Egypt across the Pharaonic, Greek, Roman, Coptic and Islamic cultures, with a focus on Alexandria and the Hellenistic period, most notably the following two collections:
A. Art pieces discovered during excavation work at the library site (1993-1995).
B. Antiquities raised from the bottom of the Mediterranean Sea near the eastern port and in the Abu Qir Bay area.
The museum was designed in a modern style using the latest interior design techniques. Such as modern optical lighting systems that are suitable for exhibitions, and fire and anti-theft systems, Fig. 19, Fig. 20. Sensors to

measure temperature, humidity, and movement inside the place, especially after the museum is closed, Fig. 21 and Fig. 22. The Antiquities Museum's website also includes a database containing nearly a thousand artifacts, the first of its kind in Egypt. In terms of displaying most of his holdings to the public on the Internet in different languages. Through the website, user can enter any of the museum's sections and read a historical and artistic introduction about the era to which the displayed pieces belong. Visitors to the site can also take an imaginary tour inside the museum halls.

4.3.2. The Museum of the History of Science:

It includes the historical aspect of science in Egypt through three important historical eras: Pharaonic Egypt, Hellenistic Alexandria, and the Arab-Islamic civilization in the Middle Ages. The Museum of the History of Science is not a traditional museum. It offers several activities targeting the general public, especially school students, in addition to organizing several traditional museum tours.

(AL) Museums also provide interactive screens with detailed information and pictures about the books, manuscripts, and artifacts on display, and visitors can interact with these screens to obtain additional information, Fig. 23. to Fig. 26. To provide an enjoyable and interactive visiting experience for visitors.

• (VR) and (AR) presentations are being prepared in cooperation with the Center for Documentation of Cultural and Natural Heritage.
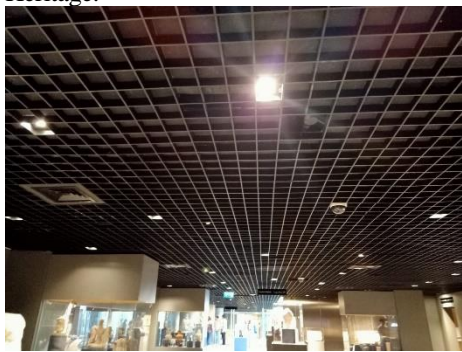

Fig. 19. A lighting, ventilation, air conditioning and sound network in the museum's ceiling to support its lighting and sound technologies, Source: Researcher.

Fig.20. Thermometers for post-visit snooping around the museum, Source: Researcher.

Fig. 21. Humidity and temperature measuring devices throughout the museum, Source: Researcher.

Fig. 22. Museum doors operate with sensors, Source: Researcher.
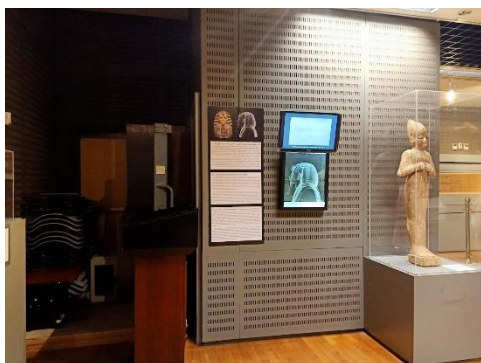

Fig. 23. Many interactive displays in the cultural panorama, Source: Researcher.

Fig. 24. Panorama screens show documentaries in Alexandria Library Museums, Source: Researcher.
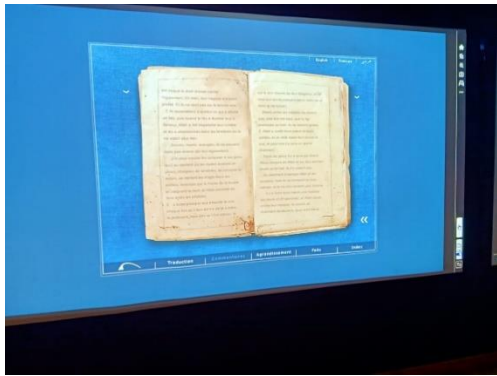
Fig. 25. An interactive touch screen to display manuscripts and archaeological books at the Manuscript Museum, Source: Researcher.

Fig. 26. An interactive touch screen to display events and photographs of journalist Mohamed Hassanein Heikal in his museum, Source: Researcher.

Through studying the previous theory and studying the case of the (AL) Museums, the research proposes the following mechanism for integrating digital technologies in museums, as follows:

5. A PROPOSED MECHANISM FOR USING DIGITAL TECHNOLOGIES IN DEVELOPING MUSEUMS

The following is a proposed mechanism for the effective use of digital technologies in museums, providing visitors with rich, enhanced experiences, Fig. 27.

1. Assess needs and set clear objectives:
- Clear needs and objectives must be identified for integrating digital technologies into the museum, such as enhancing visitor engagement, increasing accessibility, improving educational communication, or conserving artifacts.
- Conduct a comprehensive analysis of the current state of the museum's technological infrastructure and its digital capabilities.

2. Define the target audience for digital improvements and engage stakeholders:

The needs and preferences of different visitor groups, including age, interests and technological proficiency, must be taken into account so that exhibitions tailored to visitors' interests can be prepared accordingly.

3. Develop a comprehensive digital strategy consistent with the museum's mission and goals:

This strategy should define the types of digital technologies that will be used and how they will be integrated into the museum experience in accordance with development goals.
- This may include exhibitions, interactive displays, virtual tours such as (AR), (VR), (AI), and multimedia presentations. Evaluating digital technologies and tools and their compatibility with the museum's objectives and existing infrastructure.
- Prioritize technologies that are compatible with the museum's budget and resources.

4. Creating mobile applications for the museum:
- By preparing an application on a mobile phone, people can view artifacts from different angles (360 °) that cannot be seen in the museum itself, such as mummies, which enriches the enjoyable experiences of visitors. This provides visitors with access to digital content and interactive features. This application can serve as a guide providing information about exhibits, artifacts, historical events or about historical figures.

5. Implementing augmented reality (AR) experiences:
- (AR) can provide a deeper understanding of archaeological and historical objects. It contributes to improving the vision of exhibits and artifacts in three dimensions by overlaying digital information, animation, or three-dimensional models on physical objects, and additional information about it when using smartphone applications.
- Lighting and sound technologies: Modern lighting and sound technologies are used to highlight books, manuscripts and artifacts on display and provide an enjoyable and interactive experience for visitors.
- Artificial Intelligence techniques: Artificial intelligence techniques are used to improve the library search experience and provide quick answers to questions related to the content in the library.

6. Providing virtual tours:
- Providing virtual tours that allow remote visitors to explore museum exhibits and collections online and learn about their features and contents through a computer or smartphone. These tours can also be interactive and include multimedia objects.

7. Enhance accessibility:
- Ensure that digital technologies are accessible to all visitors, including people with disabilities by implementing features such as text-to-audio, voiceovers, translations, touch screens, and designing digital

interfaces and assistive technologies for diverse audiences, and interfaces that help them explore, deal with, and respond to artifacts[5].

8. Combine games:
- Use games techniques to make learning and exploration more engaging. By creating digital games and challenges that encourage visitors to interact with the exhibits and compete or cooperate with others.
- Create interactive experiences that encourage visitor participation and exploration. Using games, touch screens and interactive displays can enhance engagement.

9. Collect and analyze visitor data:
- Collect and analyze data about visitors' interactions with digital technologies to understand their expectations, preferences, and usage patterns. This information can be used to improve the digital experience over time [36].
- Implement data collection mechanisms to collect information about visitors' interactions with digital exhibits.

10. Strengthening cooperation of experts and training of workers:
- Digital and archaeological experts collaborate to explore new possibilities to enhance the museum experience.
- Training museum staff on how to use and maintain digital technologies, so that they are prepared to assist visitors with any technical questions or problems. Which requires their involvement in the planning process.

11. Monitoring, evaluating and improving the museum's digital technologies:
- Continuous monitoring of the effectiveness of digital technologies in achieving the goals of integrating them into the museum. Collect feedback from visitors and make adjustments based on their input.
- Periodically evaluate the impact of digital technologies in achieving the museum's goals and objectives.
- Measuring visitor satisfaction, participation levels, and educational results.
- Continuously update and improve digital content and interfaces based on visitor feedback and regularly analyze data to keep the museum experience relevant and engaging.
- Keeping pace with emerging digital technologies and trends in the field of museums.

12. Budget, Sustainability and Maintenance:
- Allocate the necessary resources to integrate, maintain and sustain digital technologies, by ensuring that there is a long-term plan to finance and modernize digital components.
- Develop a long-term plan to maintain, modernize and sustain digital technologies.
- Allocate resources for ongoing technical support and content updating.

By following this proposed mechanism, museums can systematically integrate digital technologies to enhance the visitor experience, achieve their goals, and effectively conserve and display heritage.

Fig. 27. A proposed mechanism for the effective use of digital technologies in museums, Source: Researcher.

6. RESULTS AND DISCUSSION

With the advent of digital technologies in integrating museums into what is called a digital museum or virtual museum, visitors can enhance their site visit experience by directly discovering and interacting with what they

see, enhancing education and accessibility, conserving heritage and the possibility of personalizing the museum visiting experience according to visitors' interests, adapting with their evolving needs and expectations. It also provides an opportunity to engage a wider audience of different ages.

Although it is more enjoyable for visitors, it is likely that a virtual museum will not be a complete substitute for physical museums.

Through the experience of integrating digital technologies into the (AL) Museums, a change was observed in the way visitors interact with heritage and educational content. Which helps with accessibility, quality of content, visitor engagement, museums' continuity in enriching the visitor experience, and effective conservation of heritage, and increase their understanding of the exhibits and cultural content, Also Through personal interviews with staff of the (AL) Museums show:

1- They were trained to deal with added digital technologies in order to be able to help visitors deal with them.
2- many other Egyptian museums that use this experience to apply it to them.
3- The museum seeks to add other new technologies to it in an effort to continue developing and modernizing it.

It becomes necessary to develop a comprehensive mechanism that helps these technologies improve the library visitation experience, attract visitors, provide a better understanding of Egyptian and global history and culture, and address the challenges of digital survival of heritage.

7. CONCLUSIONS AND RECOMMENDATIONS

Conclusions reached regarding the mechanisms of digital technologies, their integration into museums, and the development of museum display will be presented below, with an explanation of the most important recommendations of the research.

7.1. Conclusions

The research reached a number of conclusions, the most important of which are:

- The three international experiments demonstrated the suitability of digital technologies according to the nature of these museums, especially historical ones, in addition to recording and digitizing artifacts in a way that conserves their value in light of the museum's budget.
- Many digital technologies have been used in the museum display of the (AL) museums, such as: (VR) and (AR) presentations, Thermometers for post-visit snooping around the museum, A lighting, ventilation, air conditioning and sound network, Humidity and temperature measuring devices, which enhances visitors' experience of the museum.
- Digitizing artifacts and historical records contribute to their conservation and protection, facilitate their integration with digital technologies, and conservation on heritage for future generations.
- Using of digital technology and development of digital tools helps visitors enhance their museum experience and participation, in addition to exploring information about artifacts, and understand their expectations of how best-designed digital technology applications can be developed.
- Digital technologies help ensure accessibility to attract more visitors, including people with disabilities and foreigners through mobile sites and communicate in new ways.
- Digital technologies make museum exhibits more attractive, interactive and informative, attracting visitors and holding their attention for longer periods.
- Museums have expanded their reach to a global audience through online exhibitions and virtual experiences, expanding their influence and relevance by using (AR), (VR), and (Holographic display).
- Digital technologies enrich educational opportunities within museums, providing visitors with in-depth information, interactive experiences, various educational resources, and gaining a deeper understanding of the museum's artifacts.
- Collecting and analyzing visitor data through Machine learning and artificial intelligence technologies enables museums to make data-driven decisions and improve exhibition design, planning and visitor engagement strategies.

7.2. Recommendations

- Traditional museums must think about how to develop the museum display of exhibits and artifacts in a way that increases chances of competing with all available means of entertainment and technological developments to attract the visitor's attention and encourage his visit to these places.
- Necessity of museums to continue exploring and adopting advanced digital technologies such as (AR), (VR), and (AI) to remain at the forefront of cultural institutions.
- Necessity of enhance visitor interaction and participation through using of interactive technologies such as (AR) and (VR) to provide educational and entertainment experiences.

- Prioritize accessibility by ensuring that exhibitions and digital resources are designed to accommodate visitors with different abilities and implementing features such as text-to-speech, sign language interpretation and touch displays.
- Conservation on a high level of digital content quality, ensuring accuracy and relevance. Through cooperation with technology experts, architects, specialists, and conservationists to organize information digitally, and to ensure compatibility and integration of technological technology implementation processes without harming the integrity of museums, especially heritage ones, and their historical and cultural value.
- Adherence to local laws and legislation and international conventions related to conservation when integrating digital technologies into museums and heritage buildings.
- Develop comprehensive educational resources, such as online courses, virtual tours, and educational games, to extend the learning experience beyond a physical museum visit.
- Ensuring that strong security measures are taken to protect visitors' data and privacy, as well as for artifacts and exhibits.
- Ensuring to collect visitors' comments to continuously improve exhibitions, and digital services. Implement mechanisms for visitors to provide comments and suggestions.
- Necessity of technical training for employees to operate and maintain digital technologies and interact with visitors.
- Necessity of continuous monitoring and evaluation of the impact of these digital technologies on museum buildings and heritage buildings, along with maintenance and modernization, in order to conserve their continuity and keep pace with the latest technical developments and employ them effectively.
- Establish collaborative partnerships between museums and commercial organizations such as museum companies, film production companies, the media industry, or online communities to enhance the user experience.
- Necessity of developing the way of existing museums are presented, and integrating digital technologies into them in a way that is compatible with their nature and keeping pace with the times in order to satisfy all age groups that visit these museums.

Acknowledgements

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