

# Research on the application of digital media technology in museum exhibition design: a case study of the national museum of Singapore

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**Abstract.** There is a profound transformation in museum exhibition design. The ubiquitous digital media technology is driving the rapid evolution and development of museums. This trend is particularly evident in the need for diverse presentation methods to facilitate a high level of interaction and integration between audiences and exhibits. This research aims to explore the application of digital media technology in museum exhibition design, with the National Museum of Singapore as the research object. Through an in-depth examination of the digitalized exhibition projects in the National Museum of Singapore, insights can be acquired into how these technologies have changed the exhibition methods of museums and enriched the visitors' experience. This thesis will focus on the application, impact, and potential future development trends of digital media technology in museum exhibition design. The findings of this study can serve as valuable experiences and insights for other museums in the application of digital media technology.

## 1 Introduction

Museums have long served as a custodian of culture, history, and art and functioned as a unique portal into bygone eras. Museums can be traced back to the 18th and 19th centuries in Europe. At first, these institutions belonged to royalty and nobility for private collections and the display of artworks, curiosities, and scientific specimens. They were formal, static establishments that employed display cabinets and labels for their collection display.

Over time, museums became important places for public education and cultural dissemination. It was gradually recognized that their mission included not only preservation and display but also education and public inspiration. Early museums, in addition to regular exhibits, started to provide lectures, educational programs, and interpretive services to enhance audience comprehension and interaction.

Thanks to advancements in technology, traditional museums gradually introduced technological elements such as audio guides, slide presentations, and interactive exhibits to enhance the visitor experience. However, physical displays remained the mainstream.

In the early 21st century, the advent of digital media technology profoundly changed the operation of museums. The technology provided new tools and resources for museums to deliver richer, more interactive, and personalized experiences. Digital media technology was no longer a mere addition to museums but rather an integral component of overall exhibition strategies.

Traditional and digital displays merged together to offer audiences multisensory experiences.

The National Museum of Singapore has always been a proactive user of digital media technology and has created engaging visitor experiences through digital exhibition projects. The integration of digital media represents the opportunity for museums to better fulfil the expectations of modern audiences and disseminate culture and history to a broader territory.

## 2 Overview of digital media technology

### 2.1 Definition and classification

Digital media technology refers to a technological paradigm that employs modern computational and communication methods to comprehensively process forms of information, such as text, audio, graphics, and images, to render abstract information tangible, manageable, and interactive. [1] These technologies are applicable to various fields, including entertainment, education, culture, art, and commerce. Digital media technology covers various forms of media, such as text, images, audio, video, and interactive elements. Its primary classifications include VR, AR, multimedia displays, interactive screens and applications, digital audio and video, interactive simulations, digital publishing and e-books, and online media, among others. These different forms of digital media technology play crucial roles in many fields, as they enrich user experiences and provide new creative opportunities. The

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application and classification are undergoing evolution and expansion alongside technological advancements.

## 2.2 Development history of digital media technology in the field of museums

The application of digital media technology in cultural institutions has brought about major transformations, enhanced audience cultural experiences, and promoted cultural heritage preservation and sustainable development. Amidst this trend, cultural institutions will continue to be driven towards digitalization and

innovation. Museums, as vital cultural institutions to serve the public, disseminate culture and history, and fulfill civic education, have undergone several stages in the application of digital media technology, as illustrated in the table below.

In summary, digital media technology has significantly enriched museum exhibition design and visitor experiences, increased audience engagement and facilitated cultural heritage preservation and sustainable development to ensure the invaluable contributions of museums in the digital era.

**Table 1.** The various stages of development and main trends in the application of digital media technology in museums

Age	Development Phase	Major Trend
Early 1990s	<b>Digital Collection and Archiving</b>	Digitized cultural treasures, including artifacts, artworks, and heritage items, enhanced preservation, management, and accessibility and laid the groundwork for future digital exhibitions and research.
Mid-1990s to 2000s	<b>Multimedia Presentation and Interactivity</b>	Utilized audio, video, and interactive screens to augment the appeal and educational value of exhibitions and provided audiences with greater opportunities for active engagement.
Mid-2000s Onward	<b>VR and AR</b>	Incorporated VR and AR technologies to create immersive exhibitions and interactive experiences and facilitated firsthand participation in historical scenes, cultural heritage, and scientific exploration to meet diverse audience preferences.
Late 2000s Onward	<b>Online Exhibitions and Virtual Museums</b>	Leveraged online platforms to extend collections to a global audience, delivered an experience similar to physical museum visits, and enhanced accessibility.
Mid-2010s Onward	<b>Mobile Applications and Smart Devices</b>	The popularity of mobile apps and smart devices prompted app development among museums for visitors to explore exhibits based on their individual interests and preferences.
Late 2010s Onward	<b>Data Analytics and Personalized Experiences</b>	Digital media technology offered opportunities for the collection and analysis of visitor data to gain a better understanding of audience interests and behaviors and, in turn, improved exhibit presentation and the provision of more personalized services.
Present	<b>Sustainability and Global Collaboration</b>	Digital media technology has rendered museums more environmentally sustainable, with less reliance on paper-based materials, and fostered the preservation and dissemination of digital cultural heritage. Museums can now share information and collaborate with global partners to promote cross-cultural knowledge exchange beyond geographical boundaries.

## 2.3 The Relationship between Digital Media Technology and Museum Exhibition Design

Museum exhibition design, as a complex process, aims for intrigue experiences for visitors to gain a deeper understanding of culture, history, and art. Elements of

museum exhibition design normally include the layout and arrangement of exhibits, labels and interpretive texts, display cases and shelves, ambient lighting, multimedia

presentations, decor and environmental design, thematic narrative frameworks, personalized experiences, interactive activities, and more, all usually combined to create an engaging, educational, and inspirational exhibition.

Museum exhibition design of today displays a developmental trend from static presentations to dynamic displays, from unidirectional communication to immersive interaction, and from traditional representations to diversity and innovations. [2] The integration of digital media technology into museum exhibition design enhances the appeal and education of museums as well as engagement among audiences, to further fulfill the social functions and value of museums. The integration of digital media technology into museum exhibition design enhances the appeal and education of museums as well as engagement among audiences, to further fulfill the social functions and value of museums. In the process, digital media technology continues its evolution and upgrading to refine its capabilities and diversify its forms. Together, these elements complement one another to drive the progress of the museum field.

### 3 Overview of the national museum of Singapore

#### 3.1 History and mission of the national museum of Singapore

Established in 1887 by the Singaporean government for the collection, preservation, and exhibition of artifacts related to Singapore's history, culture, and natural environment, the National Museum of Singapore stands out as one of the oldest museums in the country and boasts a long history with significant cultural and historical value. These days, it has become the largest museum in Singapore with the highest visitorship. [3] The museum's main building, a Baroque-style structure (refer to Figure 1), is listed as a national monument. It has undergone several restorations and renovations to maintain its original elements. Over its century-long history, the museum has seen many evolutions and expansions. Notable strides have been made in the improvement of its exhibition and display techniques.



**Fig. 1.** Main Building of the National Museum of Singapore

The museum is dedicated to the collection, preservation, and exhibition of artifacts related to

Singapore's history, culture and heritage, which contributes to a better understanding of their past and cultural traditions for both Singaporeans and people across the globe. The museum has hosted various themed exhibitions, events, and educational programs to enhance the understanding and appreciation of history and culture among the audience and encourage dialogue and understanding among different cultures and communities. The museum is also involved in digitalization and sustainability initiatives to safeguard cultural heritage and minimize its impact on the environment.

The museum plays an indispensable role in the preservation, dissemination, and exhibition of Singapore's history and culture. It is not only rich in historical and cultural significance but also serves as a cultural hub for the Singaporean community and international visitors.

#### 3.2 exhibition forms and characteristics of the national museum of Singapore

The permanent galleries of the National Museum of Singapore include the Singapore History Gallery on the first floor, the Singapore Living Galleries on the second floor, and some interspersed art installations. Various exhibition forms with distinctive characteristics are employed in these halls. "Firstly, since Singapore is characterized by its rich cultural diversity, the museum employs a narrative-driven and chronologically clear exhibition layout and display to highlight the historical and traditional aspects of Singapore's multiculturalism, as well as their customs and lifestyle. This method utilizes physical representations of historical settings to enhance the visitor experience with a strong sense of immersion. Secondly, the museum incorporates cutting-edge digital media technologies such as VR and AR to enable visitors to engage in simulated archaeological excavations or cultural festivities and form a deeper understanding of the culture and history. This approach fully exemplifies interactivity and immersion. Thirdly, the museum hosts various interactive workshops and educational programs for visitors to participate in and acquire knowledge related to crafts, traditional skills, and history. The objective is to provide visitors with an opportunity for in-depth comprehension of Singapore's history and culture and to consolidate the museum's educational aspect. Fourthly, the museum acts as a faithful practitioner of digitalization and sustainable development, as it is actively involved in the digitization of its collections and displays to offer online accessibility and lower risks concerning physical artifacts. These diverse forms of exhibition render the museum a fascinating cultural institution.

#### 3.3 Visitors to the national museum of Singapore

According to a survey conducted by the National Heritage Board (NHB) and the Singapore Tourism Board (STB) on visitor demographics and perceptions, 37 percent of museum-goers were from overseas, and 11 percent of overseas visitors were repeat museum-goers. National Museum of Singapore, as the paramount destination for tourists, attracts diverse visitor groups. They mainly comprise: (i) Local Visitors: National Museum of

Singapore, as one of Singapore's foremost cultural institutions, captures a substantial following of local visitors, including residents, students, families, and individuals; (ii) International Tourists: Located in the downtown of Singapore, the museum draws a multitude of international tourists that seek to gain insights into Singapore's history, culture, and heritage; (iii) Schools and Educational Institutions: Educational institutions frequently organize visits to the museum in order to enhance student's understanding of history and culture. Moreover, the museum offers educational and interactive activities to schools; (iv) Cultural and Community Groups: The museum collaborates with cultural and community groups to foster cultural dialogue and exchange. Members often visit the museum to gain a deeper understanding of their own traditional culture and history; (v) Families and Children: The museum provides parent-child activities and educational programs for a family-friendly cultural experience; (vi) Researchers and Scholars: The museum's collection of artifacts and documents is a magnet for researchers, scholars, and historians who come to study and come across the collections in the museum; and (vii) Culture Enthusiasts: The museum caters to culture enthusiasts with a keen interest in history, art, and culture, who visit to appreciate the exhibits and performances in the museum.

The National Museum of Singapore has always served as a pioneer in digital media technology, as it actively employs various technologies to enrich museum exhibitions and provide more interactive experiences for visitors. The following sections will delve into three specific integrations of digital media technology with exhibition design and its resulting effects.

## 4 Application of digital media technology in the exhibition design of the national museum of Singapore

### 4.1 Automated storytelling of exhibitions empowered by digital guided tour

Singapore History Gallery, located on the first floor of the National Museum of Singapore, exhibits the rich history of Singapore. With an extensive collection of artifacts and historical records, this exhibition area presents the entire historical development of Singapore from 700 years ago to the present day, covering Singapore's evolution from Lion City, British Crown Colony, and Syonan, to its present status as a global city.

A digital guided tour system is available in Singapore History Gallery. Through audio-visual guides, visitors are free to choose between two routes: the chronological order of historical events, primarily narrated by historians; or the biographical accounts of individuals who lived through those times. The design of the two different routes represents an outstanding idea that caters to the diverse needs of the visitors and enables them to be the masters of the museum with a sense of participation. Such a specialized exhibition design enhances the logic of the storytelling, whether concerning historical events or personal anecdotes.

This is how the digital guided tour system is employed within the chronological route. Initially, as visitors activate the electronic audio-visual guide, they are greeted with an opening introduction that summarizes the themes and significance of the Singapore History Gallery. Visitors are then guided into the ancient era to learn about the earliest settlements, civilizations, and trade activities in Singapore (refer to Figure 2). Historians explain the cultural and social characteristics of this period. The guided tour then leads visitors into Singapore's colonial era to delve into the history and development of the British Crown Colony. Visitors will hear accounts from historians about the challenges and hardships faced by Singapore during World War II, including the Japanese aggression and resistance from Singaporeans. Throughout this process, visitors can come across the exhibits, select specific items, view related videos and listen to audio guides. The videos normally include images of the exhibits or descriptive content, while the audio guides provide narration from historians or eyewitnesses (refer to Figure 3). The digital guided tour continues to interpret Singapore's journey to independence and nation-building, with an emphasis on major events and policies in the nation's development. Visitors can also utilize the search function on the device to locate specific exhibits or themes and delve deeper into content that they are interested in. Finally, historians discuss Singapore's transformation into a global city, modernization, cultural diversity, and international standing. Some exhibits incorporate interactive elements, such as interactive buttons on touch screens, by which visitors can get access to additional information or visual effects through these features (refer to Figure 4).

In summary, this digital guided tour system offers visitors an enriched historical cultural experience and a deeper understanding of the exhibits and content in the Singapore History Gallery. It contributes to greater engagement and comprehension among visitors, indicating that what truly touches visitors is a museum exhibition design rooted in lifestyles and indigenous cultural elements.



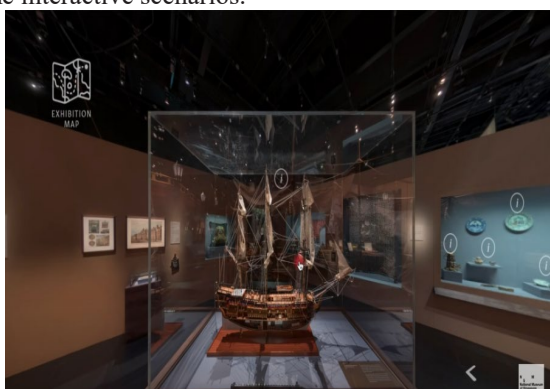
Fig. 2. Obtaining information through touchscreen devices



**Fig. 3.** The audience picks up the handset to listen to the narration of the experienter

#### 4.2 Expansion of immersive exhibition spaces through projection mapping technology

In the context of the National Museum of Singapore, projection mapping technology is employed in an exhibition area to recount the nation's growth and historical evolution. This technology incorporates digital techniques, computer graphics, projectors, and software to generate visual effects and map images or videos onto the surfaces of three-dimensional geometric objects to facilitate an immersive and interactive visual experience. The principle of projection mapping involves the creation, editing, and processing of digital images or video content to conform to the shape and surface of tangible objects. Computer graphics techniques are utilized to create and edit geometric models and perform image calibration and mapping for alignment with the object. Digital projectors are then utilized to project digital content onto the object, allowing for digital control over brightness, color, and viewing angle. Specific software tools and applications are applied to process digital content, execute mapping and calibration, and manage projection mapping in real-time interactive scenarios.



**Fig. 4.** Obtaining a more visually intense introduction to exhibits through digital guided tour devices

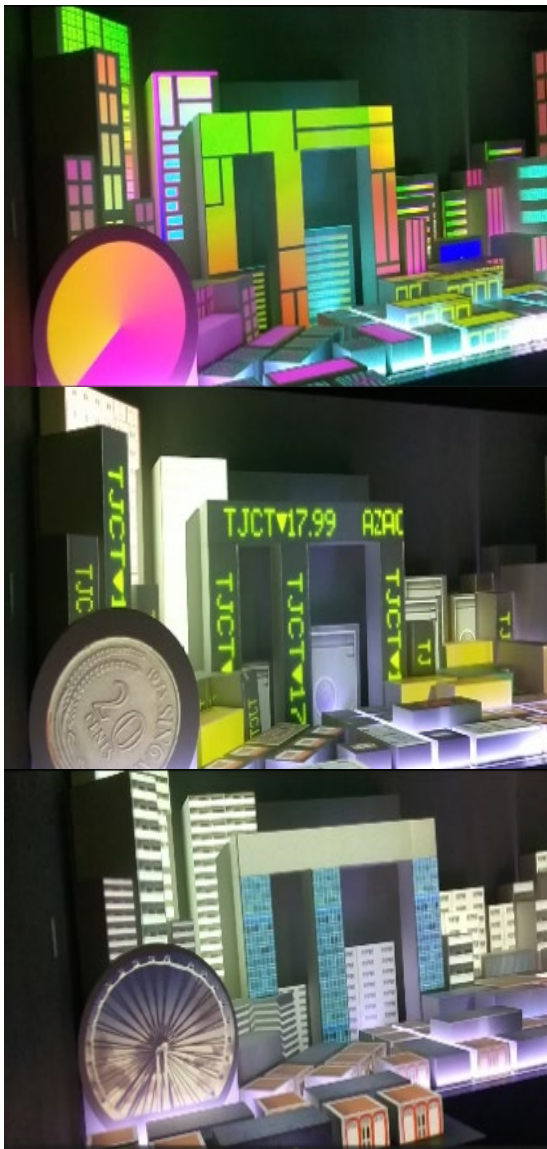
This digital media technology realizes the expansion of exhibition spaces into multiple dimensions and yields a myriad of spatial visual effects (refer to Figure 5). Within the exhibition area, geometric models made from uniformly painted wooden panels are employed. Their shapes and arrangement give rise to a multi-layered environment. The staggered placement of these models creates visual allure for visitors to appreciate the exhibits from various angles and heights. Embedded within these

models are LED light strips that change colors in response to variations in the projected imagery. Such a design enhances the atmospheric effect to establish an engaging environment. The overall design of the exhibition area is intended for a profound visual impact. As visitors find themselves surrounded by a variety of lights, colors, and shapes, a fascinating visual landscape comes into being. Visitors, in the meantime, experience auditory effects, visual stimuli, and electronic interactivity. Within this exhibition area, the combination of sound, light, electricity, and geometric models in the exhibition area presents visitors with an immersive experience to tangibly perceive the significance and charms of the presented content. This experience encourages them to delve deeper into the exhibition area and gain a richer understanding of the narratives and information contained therein.

#### 4.3 Dynamic imaging technology for an enhanced interactive exhibition experience

"Story of the Forest," a unique exhibition in the National Museum of Singapore, is produced by a collaborative effort between the museum and the Japanese digital art group, teamLab. It combines digital media technology with natural history and cultural heritage to immerse visitors in a breathtaking virtual forest with a distinctive experience. "Story of the Forest" draws inspiration from a collection housed in the Singapore National Museum, "Natural History Drawings", produced by William Farquhar, Singapore's first Resident, who, due to his keen interest in the region's flora and fauna, commissioned the creation of 477 watercolor paintings of 19th-century Malayan Peninsula flora and fauna to ultimately form the "Natural History Drawings." [4]

The exhibition sets a virtual forest as its backdrop, where visitors find themselves amidst a woodland. This virtual forest includes realistically rendered trees, plants, and natural sounds, which creates an authentic forest ambiance. The exhibition integrates advanced panoramic dynamic imaging technology that covers holographic projections, interactive screens, 3D audio, and virtual reality. Authentic natural history specimens, including insects, birds, plants, and animal specimens, are interspersed across this virtual forest. These exhibits demonstrate Singapore's rich biodiversity. Visitors can interact through touchscreen displays and explore different organisms and ecosystems in the virtual forest, gain insights into various plants and animals and engage with the virtual environment. The exhibition incorporates multimedia displays such as projection screens and touch-sensitive information points to offer information about Singapore's forest ecosystems, nature conservation, and urban development.



**Fig. 5.** Exhibition Design with Projection Mapping Technology



**Fig. 6.** A Corner of "Story of the Forest"

Moreover, this unique exhibition approach provides visitors with a multisensory experience: (i) a visual experience. Visitors are firstly introduced to a virtual forest environment that features lifelike trees, plants, and flora and fauna specimens. They can wander through this realistic virtual forest to appreciate the details of leaves, observe insect activities, and watch animal behaviors. Visual effects are presented through projection and screen technology to create an engaging forest landscape; (ii) an

auditory experience. The exhibition offers authentic sound effects that simulate various sounds of the forest, including bird calls, rustling leaves, flowing water, and animal calls to enhance the realism of the environment and deliver visitors with a feeling that they are in a thriving forest; (iii) a tactile experience. Touchscreens and interactive devices enable visitors to interact with the virtual environment. They can, through touchscreens, explore different plant and animal specimens to trigger interactive effects and acquire more information, increasing their engagement; (iv) olfactory experience. Scent technology may be employed in the exhibition environment to simulate the natural scents of the forest. Viewers can smell the aromas of trees, plants, and soil to further reinforce their sense of being in a real forest; and (v) emotional experience. The exhibition aims to arouse emotions and curiosity among visitors, who can interact with the flora and fauna in the virtual environment to understand the importance of nature conservation and the relationship between urbanization and nature. This emotional connection encourages visitors to engage in deeper reflection upon the natural world and cultural heritage.

The multisensory, immersive experience offered by "Story of the Forest" allows visitors to engage in a unique exploration of Singapore's natural environment. This exhibition encourages visitors to gain a deeper understanding of the beauty and fragility of nature, as well as the importance of sustainable development. It represents the remarkable application of digital media technology in museum exhibition design and yields an unforgettable cultural experience for visitors.

## 5 Advantages and impacts

The application of digital media technology in museum exhibitions has introduced multiple advantages and positive impacts. For instance, it creates immersive exhibition experiences for visitors to fully immerse themselves in the exhibition. This greater sense of immersion enhances visitor engagement and contributes to a deeper understanding of the exhibit. The sustained innovation in digital media technology combines visual, auditory, tactile, and olfactory stimuli through various technical means. Visitors can obtain more sensory stimulation through visual observation, auditory experiences, touchscreen interaction, or the use of VR devices to enhance the vividness of the exhibition; Digital media technology provides opportunities for interaction with exhibits. Visitors can touch screens, press buttons, use mobile applications, or don virtual reality headsets to access additional information or interact with the exhibits. Digital exhibition design allows for museums' easy content without extensive adjustments, which helps maintain the freshness and charm of the exhibit and adapt the museum to the diverse needs of visitors. Museums can employ digital media technology to track visitor interests and interactions, so as to offer personalized content recommendations and create unique experiences for each visitor; Digital exhibitions offer not only information, but also education and inspiration. They assist visitors in a better understanding of history, culture, and science and

stimulate curiosity and a desire to learn. Moreover, as digital exhibitions reduce the demand for paper materials and physical exhibits, they contribute to reduced resource waste and energy consumption and the sustainability of museums; with digital media technology, the exhibits of museums become accessible online on a global scale. This approach expands the visitor base as it includes those unable to pay physical visits to the museum; Digital exhibitions add vivid color to museums to attract a broader visitor base, especially the younger generation and technology enthusiasts.

In summary, the application of digital media technology has brought about a profound transformation in museum exhibitions. The technology enriches the visitor experience, enhances the charm of museums, and provides cultural institutions with more opportunities to convey knowledge about culture, history, and science.

## 6 Analysis of challenges and trends

There exist challenges to the application of digital media technology. Among them were costs, technical maintenance, digital privacy, and security issues. Museums must allocate large resources to the development of and maintenance of these technologies, and, in the meantime, address digital security and privacy concerns. Additionally, museums must ensure the accuracy and authority of digital displays to maintain their professionalism and credibility, and strike a balance between traditional and modern, physical and digital demands. It is also crucial to manage the relationship between digitization and traditional exhibition methods to preserve their uniqueness and value.

Through an exploration of the application of digital media technology in exhibition design of the National Museum of Singapore, the author contends that these experiences and practices offer valuable insights for other museums and cultural institutions. With the rapid development of digital media technology, the future of museum exhibition design is bound to evolve in the following three directions:

(1) Digital media technology provides museums with improved opportunities to realize vivid and fascinating presentations of exhibits and engage audiences through storytelling. This approach fosters a deeper understanding of history, culture, and art and adds luster to museum exhibitions. With the stories of exhibits presented through digital media technology, visitors can form emotional connections to resonate with the displayed content with ease and increase their engagement. For museums that focus on local culture, digital media technology can help display the rootedness of local culture. It can enhance interactivity in exhibitions as visitors can participate in the interaction and become part of the story to form a deeper understanding of local culture and history. Furthermore, with digital media technology, exhibits become accessible on a global scale, which contributes to the promotion of local culture, attracts a greater number of international audiences, and strengthens cultural heritage.

(2) New media communication in museums should prioritize a "people-centric" approach and attach importance to culturally-driven promotion and an

"audience-oriented" concept of public service. The directions of media communication methods and the selection and arrangement of content should be indeed determined by the public's needs, to ensure the public actively discover, comprehends, and interprets exhibits and their associated culture, and the subjectivity and initiative come into full play in the cognitive process. Through the integration of the "people-centric" and "audience-oriented" principles into the application of digital media technology, museums can create more appealing and meaningful cultural experiences. This helps establish deeper cultural connections, stimulate learning and curiosity and achieve more effective cultural promotion.

(3) It is of great importance to ensure the objectivity and authenticity of digital media technology in museum construction. Digital media technology should not be merely considered a trend; it is essential to align with the specific circumstances of each museum and promote the effective delivery of exhibits. It is crucial to recognize that "new media technology can only come into effect in the right time and place," which requires that digital media technology correspond to the theme and content of the exhibition. It can be employed to emphasize and enrich exhibit content rather than being subject to unrelated or conflicting purposes. The information presented through digital media technology should be objective and accurate. Museums should ensure that digitally displayed content undergoes thorough research and validation to prevent erroneous information. Museums should be aware of the needs and expectations of their visitor to determine when and how to use digital media technology. It should be of educational value, employed to explain and expand upon exhibits and enable visitors to gain a deeper understanding of the subject matter. Digital media technology should be user-friendly for visitors to engage in effective interaction with it. Museums should offer guidance and support to ensure full utilization of the technology among visitors. Regular maintenance and updates are necessary for digital media technology to ensure its objectivity and effectiveness. Museums should evaluate the effectiveness of digital media technology to ascertain whether it achieves the intended objectives, which contribute to the sustained improvement and optimization of the application of the technology.

## 7 Conclusion

There are some limitations to the traditional methods of museum exhibition. Typically, artefacts are placed in display cases, with a physical distance and barrier between the visitors and the exhibits, which makes it difficult for them to gain a deeper understanding of the historical, cultural, and narrative aspects of the artifacts. However, digital media technology has brought about a revolutionary transformation in museums, as it infuses exhibits with greater interactivity and charms and overcomes certain limitations to traditional exhibition methods.

The application of digital media technology has presented the National Museum of Singapore with abundant opportunities to create more fascinating and

educational cultural experiences. It enhances the appeal of exhibitions, contributes to cultural heritage preservation, promotes sustainability, and provides visitors with more interactive and personalized experiences, which positions digital media technology as an indispensable component of museum exhibitions.

The prospects for the application of digital media technology in museums are highly promising. It will play an essential role in enhanced immersive experiences, personalized interactions, intelligent guidance, global connectivity, augmented cultural heritage, and innovative exhibition design. These technologies will continue to undergo evolution and innovation to create greater opportunities for museums to capture the attention of visitors, convey cultural and educational information, and, in the process, drive the future development of digital media technology.

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