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The application and impact of digital technology in museum education--taking Shenzhen Museum's special exhibition "The Assemblage of Civilizations - Pingcheng and Yungang Grottoes in the Northern Wei Dynasty" as an example

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Abstract: The growing social interest in digital technology and museums is of great significance for the management, protection and development of cultural heritage and museums. This study explores the role of digital technology in museum education, taking the Yungang Grottoes exhibition "The Assemblage of Civilizations" at the Shenzhen Museum as an example. It evaluates the impact of digital technology on educational concepts, methods, resource integration and effectiveness, and proposes solutions to the challenges faced, in the hope of contributing to the development of museum education in China.

Key words: digital technology; museum education; Shenzhen Museum; Yungang Grottoes special exhibition; tourism management

1 Introduction

1.1 Background

China's focus on the cultural industry and education has led to government policies such as the "Opinions on Strengthening the Protection and Use of Cultural Relics" and the "Project for the Inheritance and Development of Traditional Chinese Cultures". These policies support museum education and relic preservation. Museums including the Shanghai Museum, the Shanxi Museum, and the Palace Museum are using digital technology to enhance educational programs and visitor experiences, driving the sustainable development of museums.

1.2 Purpose and significance of the study

The study of digital technology's application in museum education is crucial for enhancing educational quality and the dissemination of historical artifacts. It provides a theoretical basis for future research, advances museum education, satisfies public cultural and educational demands, fosters educational technology innovation, and enriches teaching methods. This, in turn, raises public cultural literacy and contributes to societal cultural prosperity and the effective use of digital technology in museums and historical preservation.

1.3 Literature review

Digital technology is acknowledged for its effectiveness in museum education, particularly in showcasing cultural

heritage and enhancing audience experiences [1]. It enables digital museums to overcome spatial and temporal limitations, expanding their educational roles [2], and improves tours, artifact visualizations, and interactive communication [3]. Despite existing research on digital museums, more is needed to meet diverse cultural and educational needs and to tackle challenges in digital museum education. The Shenzhen Museum's special exhibition exemplifies the universal application of digital technology in enriching the visitor experience and educational function.

1.4 Methodology

The research method section will introduce in detail the research tools and technical routes adopted by the topic, including field research method, case study method, qualitative analysis method and so on. Through these methods, the subject will quantitatively assess and qualitatively analyse the effect of the application of digital technology in museum education to ensure the scientificity and reliability of the research results.

2 Use of digital technologies in museum education

Digital technologies, including the Internet, IoT, Blockchain, AR and AI, are structured across service, content, network and device layers, enabling digital resource sharing and educational style diversity. These technologies, foundational for digital systems, have evolved through stages including the invention of the electronic computer, the PC and Internet era, and the modern IT phase with advances in cloud computing, big data, AI and IoT. This progression is marked by connected interactions and intelligent computing, with 5G, AI and robotics driving digitalization. Governments and businesses are prioritizing digital strategies to meet consumer demand and promote industrial integration [4].

In museum education, VR technology creates immersive 3D experiences, as seen in the Geological Museum of Chang'an University and the exhibits of Shandong Electric Institute [5]. AR enhances reality by overlaying virtual content, exemplified by The Palace Museum's 3D displays and exhibitions blending virtual content with reality [6]. 3D printing aids in restoration, education, and research, such as creating functional ancient musical instrument replicas . Online virtual museums and digital archives, like those of the Liaoning Museum of Palaeontology and the Anhui Museum, offer digital experiences, expanding the educational role of museums.

3 Case study of the Yungang Grottoes special exhibition "The Assemblage of Civilizations" at the Shenzhen Museum

3.1 Background

The Shenzhen Museum's exhibition "The Assemblage of Civilizations - Pingcheng and Yungang Grottoes in the Northern Wei Dynasty", from December 6, 2023, to May 24, 2024, presents 237 Yungang Grottoes-related artifacts. The highlights include Northern Wei treasures, a replica of Cave 12, and historical materials, showcasing ethnic integration and cultural exchange. Advanced digital and 3D printing technologies provide an immersive experience of the Cave 12. The exhibition underscores the historical significance of the 5th-century "Belt and Road" and the national integration of the Northern and Southern Dynasties, and promotes cultural identity and exchange in the Guangdong-Hong Kong-Macao.

3.2 Applications of digital technology in exhibitions

(1) Three-dimensional laser scanning technology: Three-dimensional laser scanning technology facilitates the collection of Yungang Grottoes data, establishing a digital archive for precise replication, crucial for off-site exhibitions like the Shenzhen Museum's Cave 12 replica, which achieves a hyper-realistic effect.

(2) 3D printing technology: 3D printing technology enables the creation of portable copies of caves by replicating them from high-precision data. This technology was used in the special exhibition to replicate Cave 12 of Yungang Grottoes in a 1:1 ratio, restoring its grandeur and diverse sculptures. The result is a tangible, immersive experience that captures the splendor of the Yungang Grottoes.

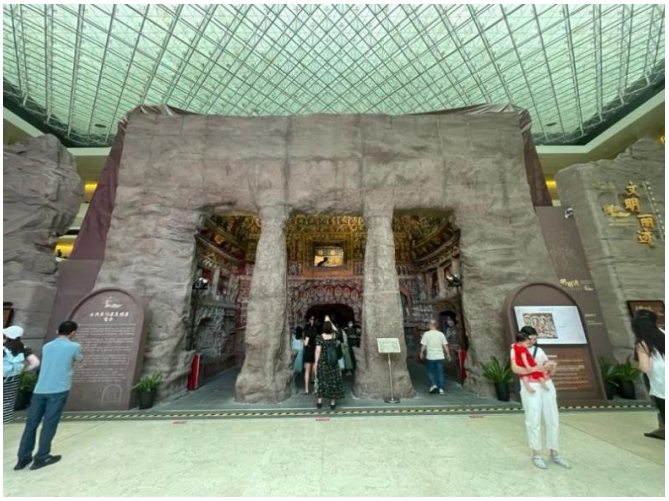

Fig. 1 Exterior of exhibition reproduction cave

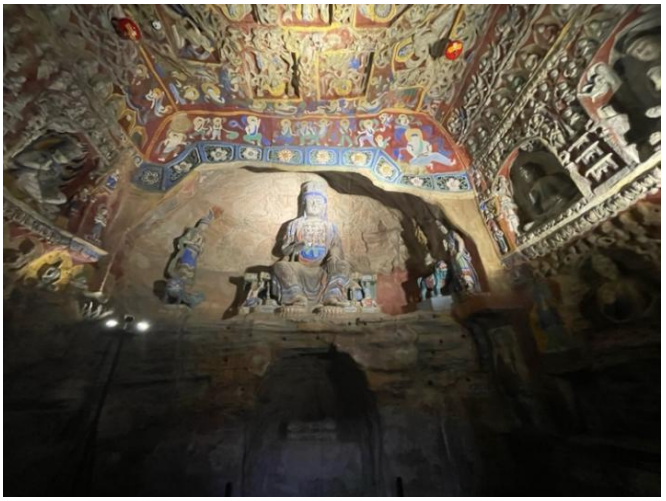

Fig. 2 Inside Cave 12 of Yungang Grottoes (replica)

(3) Online exhibition: The online exhibition leverages digital technology to enhance content distribution, allowing the art and information of Yungang Grottoes to transcend physical boundaries. This transformation from static to dynamic presentation rejuvenates the Grottoes' representation, enabling a broader audience to engage with its cultural significance. Interactive media devices within the exhibition facilitate virtual exploration and interaction, fostering deeper engagement with the Yungang Grottoes' heritage.

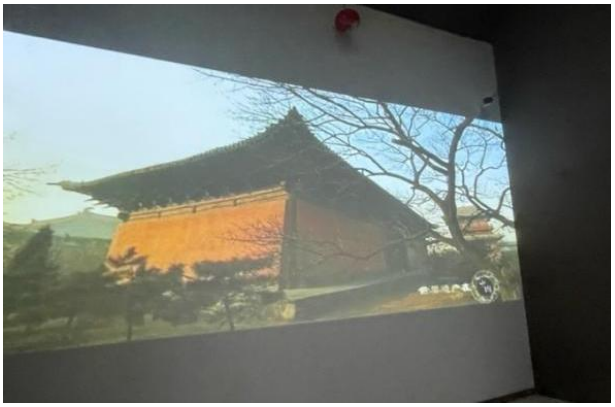

Fig. 3 Documentary film shown on site

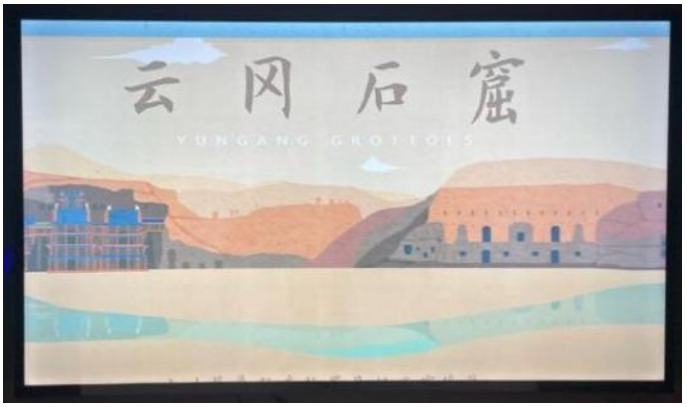

Fig. 4 Introduction video of Yungang Grottoes shown on site

(4) Virtual Reality (VR) and Augmented Reality (AR): The exhibition integrates VR and AR technologies to immerse visitors in a virtual Yungang Grottoes experience. Multimedia installations, including 720° panoramas and interactive games, enhance educational content. Physical exhibits with QR codes provide further historical context, promoting a comprehensive understanding of the grottoes' cultural importance. This hybrid of virtual and tangible elements enhances engagement with the cultural heritage.

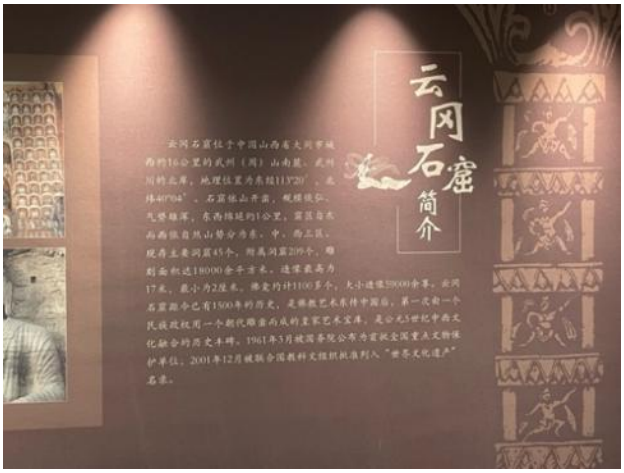

Fig. 5 Exhibition boards set up on site

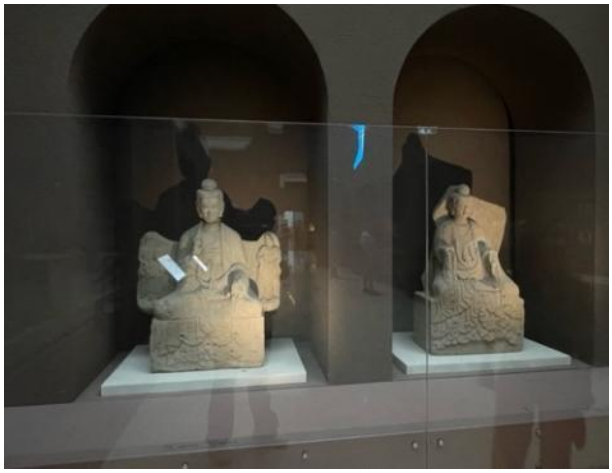

Fig. 6 Display of artefacts on site

3.3 Impact of digitising Yungang Grottoes on the audience

The Shenzhen Museum's exhibition employs digital technology to enhance interactivity and cultural understanding, showcasing the 1,500-year history of the Yungang Grottoes. Collaborating with institutions like the Palace Museum, the exhibit offers diverse perspectives and fosters engagement through symposia. Digital preservation initiatives and advanced technologies contribute to the preservation and transmission of cultural heritage, promoting deeper insights into the Grottoes' artistic and historical significance, while also enhancing the public's sense of responsibility in protecting cultural heritage.

4 Impact of digital technologies in cultural heritage education

4.1 Renewal of the concept of education

The application of digital technology in cultural heritage education has led to a fundamental shift in the concept of education. The traditional teaching model is teacher-centred and emphasizes the transmission of knowledge. Digital technology, on the other hand, puts students at the centre of the learning process and focuses on cultivating students' independent learning ability, creativity and critical thinking. This renewal of the concept of education helps to stimulate students' interest in learning and improve their learning results.

4.2 Optimisation of educational resources and methods

Digital technology has enabled the optimisation of cultural heritage education methods and the integration of resources. The special exhibition was held in the History and Folklore Hall (Civic Centre) of Shenzhen Museum, hosted by 8 entities.

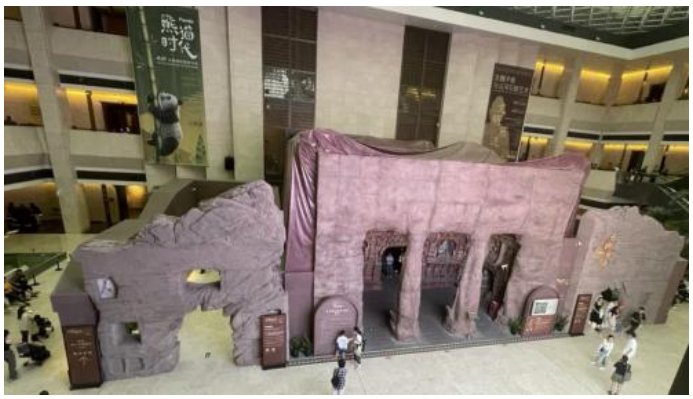

Fig. 7 Overhead view of Yungang Grottoes Cave 12 (replica)

The left half of the exhibition is dominated by digital panels. In addition to the basic knowledge of the caves, the pictures of overseas lost cultural relics in each cave and their current status are also explained in detail, and the significance of education is highlighted at this moment, which not only realises the significance of historical education across the space, but also conveys China's determination in the protection of cultural relics and the significance of public education for the future popularisation of the general public. This is unparalleled in other special exhibitions and is of great significance.

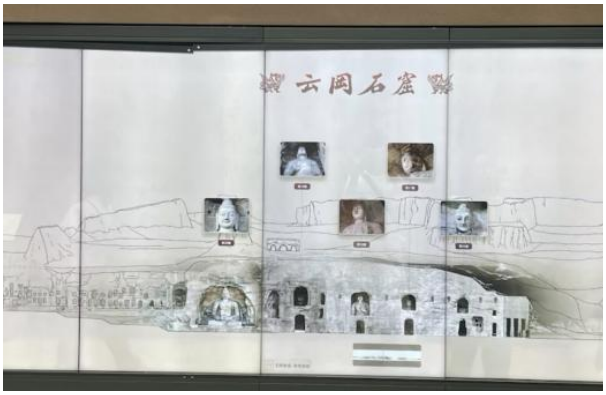

Fig. 8 Digital panels applied in the replica caves

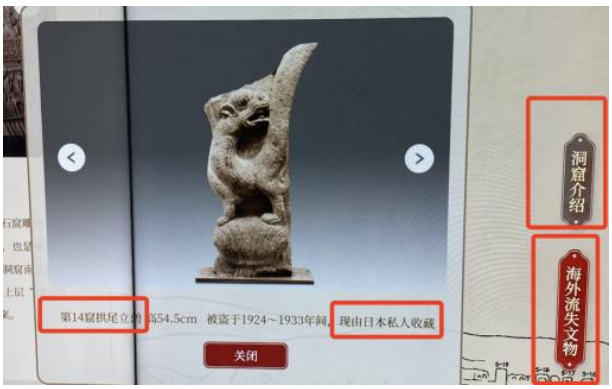

Fig. 9 Introduction to the panels on lost artefacts from Cave 14

Digital technology enriches cultural heritage education by expanding resources and content, innovating methods, and creating immersive learning experiences. This integration has made education more effective and engaging, boosting public interest in heritage preservation.

4.3 Enhancement of the effectiveness of education

The application of digital technology in cultural heritage education has greatly enhanced the effectiveness of education. Through virtual reality, augmented reality and other technologies, students can understand cultural heritage more intuitively and vividly, and deepen their understanding and memory of knowledge. In addition, digital technology can also achieve real-time feedback and adjustment of the education process, improve the relevance of education, and thus enhance the educational effect.

5 Challenges and strategies

5.1 Technical problems

The Shenzhen Museum's digital special exhibition, "The Assemblage of Civilizations - Pingcheng and Yungang Grottoes in the Northern Wei Dynasty" confronts challenges such as the need for frequent content updates due to rapid technological advancements, imposing significant costs and talent demands on public museums. The exhibition's success is equipment-dependent, and any technical issues can diminish the visitor experience. To address these concerns, the museum could emulate the Beijing Palace Museum's collaboration with tech giants like Tencent, Huawei, and Jingdong, establishing long-term technical partnerships and staff training programs to ensure the mastery of current digital technologies.

5.2 Education and dissemination of culture

Digital content may not be able to completely replace the educational value of physical cultural relics. Although digital technology provides rich visual and auditory experience, it may not be able to completely replace the value of physical cultural relics in terms of perception and emotional experience. At present, Shenzhen Museum and Shanghai Museum are more prominent in China, and in the future, it is still necessary to continuously increase the depth of research, expand the scope of research, and learn from the world's cutting-edge experience.

5.3 Policy support and guidance

Museums face financial and talent challenges in digitizing, with high costs for digital exhibits needing ongoing investment. The sector lacks professionals and resources, requiring policy support for growth. The Smithsonian's ASOA project, with initiatives like AR Butterfly and Science VR Treasure Hunt, shows the potential of digital engagement. Governments should boost funding, offer tax incentives, and encourage private sector involvement to create a robust support system for museum digitization.

5.4 Industrial synergies and development

Museums should expand collaboration beyond tech companies to include media, e-commerce, and educational institutions for digital education. For instance, the Tokyo National Museum's "Exhibition of Calligraphy and Art of Nishikawa Ning" at the Shanghai Museum not only promoted education and cultural understanding between China and Japan but also enhanced diplomatic relations.

6 Conclusion

This study examines how digital technology enhances museum education, using Shenzhen Museum's "The Assemblage of Civilizations" exhibition as a case. It found that digital technology improves learning experiences and access to cultural heritage, but also faces challenges like high costs and technology updates. Future efforts should focus on collaboration to overcome these challenges and create more engaging learning opportunities.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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