Research and Design on Building Digital Immersive Exhibitions in Museums — Taking the "24 Solar Terms Exhibition at the China National Film Museum" as an Example

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Abstract: With the rapid development of technology, digital immersive exhibitions have become a new trend in museum exhibitions. This article explores the application of digital immersive technology in museum exhibitions, particularly its role in showcasing intangible cultural heritage. Taking the "24 Solar Terms Exhibition at the China National Film Museum" as a case study, this article analyzes the current situation, design, and technological implementation of immersive exhibitions, and discusses their value in enhancing audience experience, cultural education, and innovative development of museums. Through practical cases, this article demonstrates how to combine modern technology with traditional culture to create an exhibition experience that is both educational and engaging. The research results indicate that digital immersive exhibitions can effectively enhance cultural heritage and educational effectiveness, while also enhancing the brand image and social influence of museums.

Keywords: Digital immersive exhibition design; 24 solar terms culture; Interactive experience

1. Introduction

This study analyzed the literature published in the past 5 years using VOS software (**Figure 1**). At present, immersive exhibitions in museums are showing a trend of diversification, innovation, and technological development. Due to the development of technologies such as AR and VR in recent years, new forms of exhibition innovation have been promoted, and the experience of visitors visiting exhibitions has also been enhanced, making the presentation of museum exhibitions more vivid, intuitive, and with a stronger sense of participation from visitors. In terms of application cases, many museums have successfully applied these advanced technologies to exhibitions. For example, in

its exhibition plan for 2024, the Shanghai Museum will launch multiple special exhibitions, including the "Starry China — Sanxingdui Jinsha Ancient Shu Civilization Exhibition", which will fully utilize digital technology and immersive display methods to bring audiences a new viewing experience [1]. Dunhuang has also utilized relevant technologies, using immersive techniques to support the sustainable development of Dunhuang's cultural heritage [2].

Figure 1. Keyword relationship graph of immersive exhibition-related research

From the current published papers, it can be seen that around 2020, there was a significant amount of publications related to virtual reality technology and museums. However, there have been many problems in actual exhibition practice due to the high number of visitors to museums, VR and other devices are usually unable to meet the needs of all tourists and require long waiting times. Therefore, many museums have gradually begun to downplay the role of VR in exhibitions. However, tourists still need more innovative experiences. According to the research conducted by Thompson, the overwhelming majority of visitors exhibit a stronger preference for the space-surround environment [3]. Therefore, museums are constantly exploring, and the immersive experience surrounded by large screens undoubtedly has certain advantages in efficiency and cost (**Figure 2**). As described by Wickens, several characteristics of space-surround environments parallel the key features of "virtual reality" [4]. For instance, a museum can utilize dynamic displays, such as films and videos, which are capable of depicting scientific phenomena more accurately than static images [5]. In recent years, immersive art exhibitions set in museums have experienced vigorous development. The Frameless Museum in London immerses audiences in works by Monet, Van Gogh, and Cézanne through large-scale projections. Similarly, Milan Expo's Japan Pavilion "Harmony" uses digital technology to recreate rice fields' vitality. TeamLab further enhances immersive art with interactive spaces like "Yatagarasu", blending cultural storytelling and aesthetic innovation in transformative experiences.

technical means	advantage	disadvantage
Multi screen surround	1. Enhance spatial and immersive experience through multi angle visual display. 2. Display large-scale scenes and complex historical events. 3. Viewers can freely choose their viewing angles, improving their autonomy in visiting. 4. Suitable for showcasing dynamically changing content.	1. High equipment and space requirements, 2. with a large initial investment. Maintenance and updates are relatively complex 3. There are certain limitations on the spatial positioning and movement of the audience
Virtual Reality (VR)	1. Provide an immersive experience, allowing visitors to immerse themselves in historical or cultural scenes 2. Can reproduce scenes that cannot be visited in person 3. Enhance the fun of education and learning through simulation and interaction 4. Easy to update and modify content, keeping the exhibition fresh	1. High quality equipment and maintenance costs 2. May cause dizziness and discomfort for users. 3. Strong dependence on technology, once the device malfunctions, it may affect the overall experience. 4. There may be barriers to entry for visitors who are not familiar with urgent technology
Augmented Reality (AR)	1. Combining real and virtual information to provide a highly interactive visiting experience. 2. It can be accessed through mobile phones or tablets, making it easy to popularize and use 3. It can achieve real-time information updates and displays, improving the timeliness of exhibitions. 4. It helps attract young audiences and expand the audience of museums	1. The technical implementation is complex and requires precise positioning and image recognition 2. Information security issues, such as privacy breaches and data protection 3. The user interface and experience design requirements are high, and improper design may affect the visiting experience. 4. The dependence on devices is high, and there may be differences in experience between different devices

Figure 2. Analysis of the advantages and disadvantages of immersive exhibition technology

At present, there are still some shortcomings in the exhibition of intangible cultural heritage in museums. Many intangible cultural heritages exist in festivals and customs, and there are few specific actual items that can be displayed in exhibitions. Even if there are some exhibits related to festival customs, it is difficult for the audience to feel the cultural atmosphere.

Taking the 24 solar terms as an example, as an important intangible cultural heritage of China, how can exhibitors still make people feel the cultural atmosphere of intangible cultural heritage when they no longer need to cultivate in cities today? This is a topic that requires researchers to explore in-depth, and they need to combine the 24 solar terms with modern technology and innovate display methods.

2. Feasibility analysis of enhancing immersive exhibition experience

2.1. Technical support on software: Scene restoration technology

Use a FARO 3D laser scanner to scan the exhibition hall with multi-point control. A dedicated person selects suitable points and angles for accurate and complete spatial data (**Figure 3**). After the initial scan, post-process point cloud data in professional software (denoise, register, stitch). Finally, Use Twinmotion to simulate scenarios for virtual presentations, modeling, setting materials, and adding lighting and adjusting materials for video production visualization (**Figure 4**).
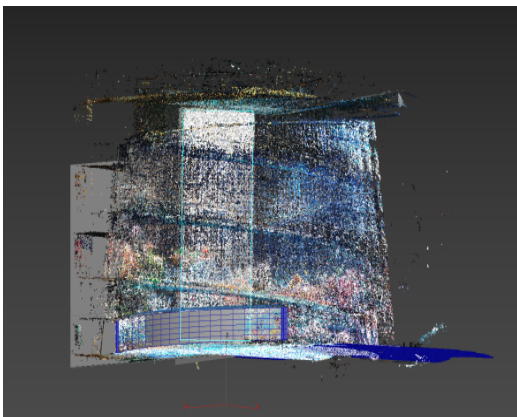

Figure 3. Point cloud generated by scanning with a FARO 3D laser scanner

Figure 4. Use Twinmotion simulation scenarios for virtual presentations

2.2. Animation production technology

Open AE settings parameters to create a 24 solar term engineering file. Hand-drawn materials for the 24 solar terms were imported into AE engineering files, and placed on different layers. Create animation effects by adding keyframes through attributes such as movement, rotation, and scaling, adding rich content such as special effects and sound effects, and finally rendering the output animation.

2.3. Collaboration between museums and universities

At present, the cooperation between museums and universities is showing a trend of deepening integration, resource sharing, and mutual benefit at the policy level. Museums can fully leverage their cultural resources and educational functions, while universities can utilize the advantages of talent cultivation to enhance their practical abilities, jointly promote the protection, inheritance, and innovation of intangible cultural heritage, and improve the professionalism of

high-level talent cultivation.

Both parties can jointly plan and implement museum-school cooperation projects, such as holding themed exhibitions, academic seminars, and other activities, which not only enrich campus cultural life but also enhance the social influence of the museum (**Figure 5**). In an open learning environment, students can be exposed to more new knowledge and ideas, stimulate their curiosity and creativity, put theory into practice, and lay a solid foundation for their future career development.
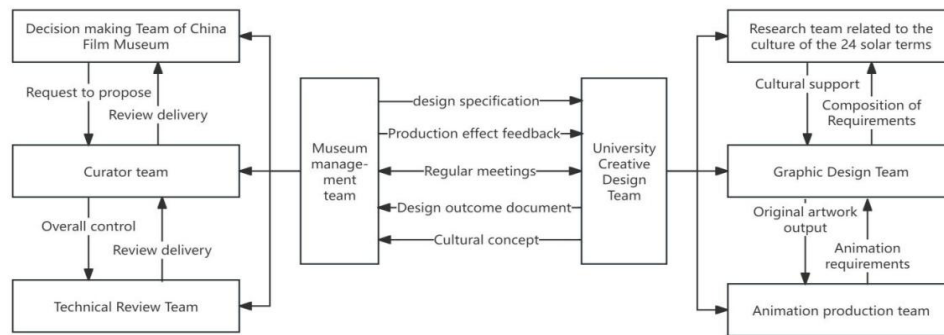

Figure 5. Flowchart of collaboration between museums and universities

3. Design practice of immersive exhibition

3.1. Immersive cultural experience

The Central Hall of the China Film Museum utilizes multiple sensory stimuli, including visual, auditory, tactile, etc., to create a comprehensive sensory environment that allows the audience to feel truly immersed in the environment presented by the exhibition. This atmosphere allows the audience to have a more intuitive understanding of the history and cultural background of the 24 solar terms, an intangible cultural heritage. At the same time, it provides them with a unique emotional experience. For example, during the Rain Festival, the audience feels like they are surrounded by lanterns on a small river at night, and during the Qingming Festival, they feel like they are in the cultural atmosphere of a small bridge flowing water in the Jiangnan region, truly experiencing the unique charm of traditional Chinese culture (**Figure 6**).

Figure 6. The main visual image of the immersive exhibition during twenty-four solar terms

People living in modern cities no longer need to cultivate, so how to protect and inherit the 24 solar terms culture, which is an intangible cultural heritage based on agricultural civilization, is a very challenging task. If it only shows

the characteristics of traditional agricultural culture, it may not arouse the interest of the audience and cannot meet the cultural needs of people today. However, through immersive experiential exhibitions, cultural heritage can be displayed more attractively, thereby expanding the breadth and depth of cultural inheritance. Viewers can gain a deeper understanding of the history and significance of cultural heritage, while also experiencing the charm and value of culture. This experiential approach not only helps to enhance public awareness and respect for cultural heritage but also stimulates their interest and sense of responsibility for cultural protection and inheritance.

3.2. User experience experiments before and after design

To verify the authenticity of the effect, the researchers took the form of a questionnaire survey to test the immersive effect. This research questionnaire was designed based on users' experiences before, during, and after the exhibition, comprising a total of 17 questions. The survey primarily focused on the differences in experience and sense of immersion among on-site audiences before, during, and after the exhibition. A total of 128 questionnaires were distributed. The survey results indicate the following.

The sensory experience at the China Film Museum received high recognition from the audience, with a significant improvement in immersion. As shown in **Table 1**, 44.43% of the audience rated the visual and animation effects as "excellent, highly impressive," while 35.15% considered them "quite impressive, with strong visual impact."
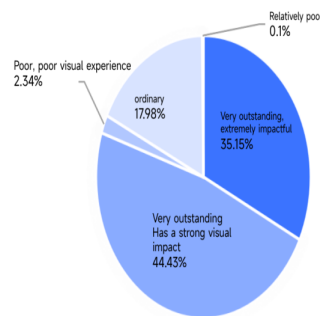

Table 1. Audience perception of visual effects

Additionally, by comparing the immersive experience of the "Twenty-Four Solar Terms" exhibition with other themed exhibitions in the museum, data on the differences in immersion before and after the experience were obtained. The results show that the audience's sense of immersion increased after the experience, as detailed in **Table 2**.
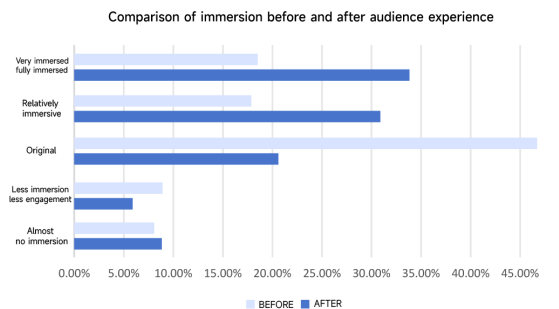

Table 2. Comparison of audience immersion before and after the experience

The communication of solar term culture was clear, leading to an enhanced cultural identity among the

audience. After the experience, the audience's understanding of solar term culture improved due to the clear information provided by the exhibition. Specifically, 28.9% of the audience found the displayed solar term information "very clear and easy to understand" (**Table 3**). Post-experience, the audience's awareness, and recognition of solar term culture also improved.
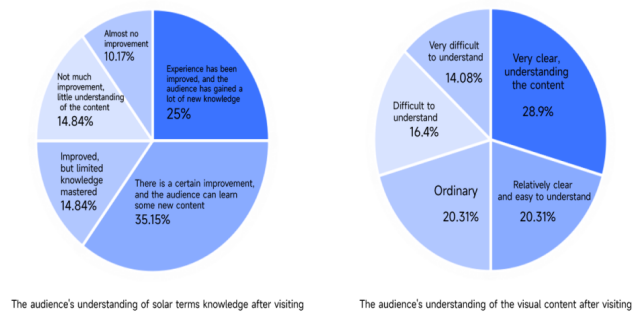

Table 3. Audience's understanding of solar term culture after the experience

The "Twenty-Four Solar Terms Immersive Exhibition" at the China Film Museum has achieved significant improvements in terms of immersion, visual experience, cultural dissemination, and audience identity.

4. Retrospect and prospect

This article explores the application of digital immersive exhibitions in museums and their positive impact on cultural heritage and education through in-depth research and design practice of the "24 Solar Terms Exhibition" at the China Film Museum. The researchers have found that by combining modern technology with traditional cultural connotations, not only can the audience's experience and participation be enhanced, but also the breadth and depth of cultural inheritance can be effectively expanded, the level of social education can be improved, and the innovative development of museums can be promoted.

In the future, museums should continue to explore how to better utilize digital technology to create more diverse and interactive exhibition forms, to meet the cultural needs of the public and enhance social educational value. At the same time, museums should also pay attention to the protection and innovative display of intangible cultural heritage, to revitalize traditional culture in modern society. Through these efforts, museums will be able to better fulfill their social functions, become cultural bridges connecting the past and future, tradition and modernity, and make greater contributions to promoting cultural diversity and the progress of human civilization.

In short, digital immersive exhibitions have opened up new paths for the future development of museums. The researchers look forward to seeing more innovative practices and breakthroughs, making museums a more vivid, open, and interactive cultural space, and allowing the brilliance of cultural heritage to shine on a broader future.

Disclosure statement

The authors declare no conflict of interest.

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