A Comparative Study of Intelligent Interactive Exhibitions in Chinese and Foreign Science and Technology Museums: Postprint

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Abstract

[Purpose / Significance] This study aims to promote science museums in fulfilling their social education and publicity functions through research on the sustainable development of intelligent interactive exhibitions, which holds important reference significance for libraries to enhance their comprehensive service functions. [Method / Process] First, the functional definitions and roles of intelligent interactive exhibitions are systematically reviewed, compared with other educational forms, and interaction methods are summarized; subsequently, the development status of intelligent interactive exhibitions both domestically and internationally is elaborated, with a comparative analysis conducted on the development history, theoretical research, functional effects, and innovative exhibition concepts of intelligent interactive exhibitions in Chinese and foreign science and technology museums, thereby identifying existing problems in the development of intelligent interactive exhibitions in China. [Result / Conclusion] After exploring the deep-seated reasons behind the low penetration rate of intelligent interactive exhibitions in science museums, it is recommended that managers of science and technology museums should consider the complete visitor experience scenario in science and technology museums; the informal education of science museums must be closely integrated with formal education to achieve shared resources and collaboration; by optimizing the current model of intelligent interactive exhibitions, maximizing enthusiasm for encouraging UGC (User-Generated Content), gradually improving the originality and universality of high-quality intelligent interactive exhibitions, thereby promoting the popularization of scientific knowledge and the enhancement of public scientific literacy.

Full Text

Preamble

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Abstract

[Purpose/Significance] This study aims to promote science museums in fulfilling their social education and publicity functions through research on the sustainable development of intelligent interactive exhibitions, offering important reference value for libraries seeking to enhance their comprehensive service capabilities. [Method/Process] The paper first clarifies the functional definitions and roles of intelligent interactive exhibitions, compares them with other educational forms, and summarizes interaction methods. It then elaborates on the current development status of intelligent interactive exhibitions at home and abroad, conducting comparative analysis of the development history, theoretical research, functional effects, and innovative exhibition concepts between Chinese and foreign science and technology museums to identify existing problems in China' s intelligent interactive exhibition development. [Results/Conclusions] After exploring the deep-seated reasons behind the low popularization rate of intelligent interactive exhibitions in science museums, it is recommended that science and technology museum managers consider the complete visitor journey in science and technology museums; that the informal education of science museums must be closely integrated with formal education to achieve linked resource sharing; and that by optimizing the current model of intelligent interactive exhibitions, the enthusiasm for user-generated content (UGC) should be maximally encouraged to gradually improve the originality and universality of high-quality intelligent interactive exhibitions, thereby promoting the popularization of scientific knowledge and enhancing public scientific literacy.

Keywords: science and technology museum; intelligent interactive exhibition; comparative research; Chinese and foreign comparison

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1 Introduction

In the digital development environment characterized by information exchange, human-computer interaction, and community sharing, libraries urgently need

to expand and transform their functions under the influence of learning society construction. Science and technology museums share high similarity with libraries in terms of functions and service content, practicing the tenet of "public access, participation, and sharing" through interactive displays, and their development history offers strong reference value for library development. Intelligent interactive exhibitions align with the stage changes of science museums in the converged media environment, innovating science communication methods, enhancing public appeal, and increasingly gaining mainstream attention from science museums. The "Pioneer Action, Forge Ahead" innovation achievements exhibition hosted by the History Museum of the Chinese Academy of Sciences comprehensively utilizes various advanced science popularization display methods and approaches to effectively disseminate cutting-edge scientific knowledge and scientific thinking to the public, enhancing the confidence and courage for innovation across the academy and even the national scientific and technological community, and stimulating innovation and entrepreneurship vitality throughout society [1]. "Intelligent interactive exhibitions" endow exhibits with unlimited regenerative potential, maximizing the utilization of science and technology museum exhibits and spaces, and promoting the popularization of scientific knowledge and the enhancement of public scientific literacy. However, alongside the vigorous development of intelligent interactive exhibitions, many disharmonious problems have become increasingly apparent, and discussions on the sustainable development of intelligent interactive exhibitions and related countermeasure research remain particularly insufficient. This paper first traces the development process of intelligent interactive exhibitions to identify their originally intended educational function origin, then comparatively analyzes the current development status and sustainability research achievements of intelligent interactive exhibitions in domestic and foreign science and technology museums, identifies the constraints affecting the development of China' s intelligent interactive exhibitions, and accordingly proposes feasible recommendations to fully maximize the science popularization effectiveness of intelligent interactive exhibitions, making them a beneficial supplement to science and technology museum exhibition education and providing good support for libraries to strengthen their comprehensive service functions, expand cultural service functions, and play their core values.

2.1 Functional Definition of Intelligent Interactive Exhibition

The broad definition of interactive exhibition is "the interaction between learners' senses (vision, hearing, smell, taste, touch) and body and mind (intellectual, physical, emotional) with exhibitions (including environments), or the communication and exchange between visitors and exhibition service staff"[2]. K. McLean defines interactive exhibition as "in exhibitions where visitors can perform operations, collect evidence, select options, form conclusions, test skills, and visitors' operational behaviors can affect the exhibition process; visitors issue instructions or provide input, and exhibits will execute operations and provide feedback" [3].

"Intelligent interactive exhibition" refers to the collection of methods and approaches for public visit, appreciation, and exchange that utilize intelligent interactive devices (such as wearable smart devices, intelligent guidance systems, intelligent display devices, etc.) to enable the public' s senses and body and mind (intellectual, physical, emotional) to interact with exhibitions (including environments), or for visitors to communicate and exchange with exhibition service staff [4]. This "interaction" runs through the entire exhibition education process of science museums. By providing opportunities for hands-on experience and alternative learning methods—such as introducing Q&A, touch, and other feedback-based operational experiences during visitors' tours—intelligent interactive exhibitions can explore science popularization themes more deeply compared to traditional text and object exhibitions that showcase cramming-style education. They enhance interactive communication between visitors and exhibits, strengthen visitors' in-depth understanding of the scientific connotations behind exhibits, and achieve a closed loop of "stimulus - dissemination - feedback."

Internationally, "experience" serves as the functional origin of intelligent interactive exhibitions. In intelligent interactive exhibitions, visitors form "experiences" through interaction with exhibits and devices to enhance their cognition, thereby appreciating the scientific principles and scientific spirit behind them. Today, intelligent interactive exhibitions have become the mainstay of science museum exhibitions, representing an effective form of science education in science museums and the part that best embodies modern science museum educational philosophy [2]. The development of intelligent interactive exhibitions aligns with the stage changes of science museums in the converged media environment. By providing visitors with opportunities for personal experience and alternative learning methods, exhibits gain unlimited regenerative potential, maximizing the utilization of science and technology museum exhibits and spaces. This helps visitors fully understand the scientific and cultural connotations embodied in collections, enabling them to absorb the scientific knowledge, scientific methods, scientific thinking, and scientific spirit presented by intelligent interactive exhibitions and convert them into motivation and intellectual resources for future work and study, thereby promoting the popularization of scientific knowledge and enhancing public scientific literacy.

2.2 Role of Intelligent Interactive Exhibition

The New Media Consortium' s *Horizon Report* (Museum Edition) predicts that "new technologies such as micro-positioning technology, glasses-free 3D, holographic projection, augmented reality, virtual reality, and somatosensory interaction will be increasingly applied to museum display design, creating better learning contexts for visitors, bringing immersive new feelings and learning experiences, and further enhancing museum exhibition effects" [5].

(1) **Enhancing visitor learning in science museum exhibitions and achieving mastery through comprehension.** Dewey proposed em-

piricist educational philosophy, emphasizing the important contribution of "experience" in motivating and supporting learners' prior cognitive understanding [6]; Piaget proposed constructivist philosophy, emphasizing the interaction between learners and the physical world. He believed that through interaction, learners could adjust their understanding of prior cognition. This collision of thinking further encourages learners to internalize new knowledge into existing or forming cognitive structures and knowledge systems [7].

(2) **Enhancing exhibition appeal and evoking visitors' recall of exhibition content and connotations after the visit.** Foreign museums use refreshing approaches to break the stereotype that "museums are about history and tradition." The Natural History Museum in London launched a museum night program called Dino Snores for Kids customized for children aged 7-12, featuring an "Airbnb Base Camp" camping area [8] where children can sleep alongside the museum' s treasure—a 25-meter-long blue whale skeleton. This exhibition not only attracted large numbers of family visitors but also planted seeds of science and thinking in participants' minds. In an experience akin to "adventure," visitors learned about dinosaurs' living environments, threats, and challenges, gaining intuitive and in-depth understanding of dinosaurs' physical characteristics, living habits, and reproductive processes, which they could consolidate in future study and life.

2.3 Comparison of Science Museum Permanent Exhibition Science Education with Other Education Forms

The United States is the birthplace of the "modern science center," marked by the establishment of the San Francisco Exploratorium in 1969. American science and technology museums present several noteworthy development trends: close integration with American formal education (national formal education, science education); well-developed informal education systems in various venues, closely aligned with K-12 formal curricula, carrying out educational activities such as learning sheets, visits, hands-on courses, science and technology competitions, and field trips that correspond to state curriculum standards; close integration with U.S. science and technology strategic plans such as "Science, Technology, Engineering, and Mathematics (STEM)" and "Next Generation Science Standards," in which they "play an important role."

American science and technology museums present excellent development momentum characterized by close integration with formal education, high socialization, high marketization, mutual learning and integration between science centers and traditional museums, and emphasis on new technology application [7]. Accordingly, the author compared the similarities and differences between science and technology museum permanent exhibition science education and other education forms in terms of nature, content, audience, methods, and effects, as shown in .

2.4 Summary of Interaction Styles in Science Museum Intelligent Interactive Exhibition

Science museum intelligent interactive exhibitions bring diversified experiences to users, specifically including sensory experience, emotional experience, thinking experience, associative experience, and action experience. Common interaction styles include: personal computer interaction, button interaction, touch interaction, sensor interaction, immersive virtual reality interaction, voice interaction, mobile terminal interaction, phantom imaging interaction, plain model sand table projection interaction, virtual reality enhancement interaction, 4D film interaction, knowledge quiz interaction, and through-screen touch interaction. In addition, there are innovative interaction methods such as dynamic scene restoration interaction, knob desktop interaction, 360-degree phantom interaction, virtual driving interaction, sliding rail demonstration interaction, virtual greeting interaction, and mobile phone on-demand interaction.

3 Current Status of Intelligent Interactive Exhibition at Home and Abroad

3.1.1 Function and Operation of Intelligent Interactive Exhibition in Chinese Science and Technology Museums

Intelligent interactive exhibitions in domestic science and technology museums have built a display media technology platform for museums facing visitors, which can be analyzed from multiple aspects including interaction forms, application scenarios, and interactive experiences. The current domestic situation is as follows:

(1) **Interaction forms.** Intelligent interactive exhibitions involve fresh and rich interaction forms, including images, film and television, audio, interactive experience design, touch screen information dissemination, sound effect environments, stage lighting effects, multifunctional theaters, wireless handheld interactive devices (PDA), interactive games, guidance systems, remote interactive education, and museum networks. These innovative and diversified exhibition interaction forms not only enhance exhibition appeal but also strengthen their social impact, promoting greater user participation in intelligent interactive exhibitions.

The large-scale multimedia interactive exhibition "World of Flowers" at the Beijing Botanical Garden [9] utilizes embedded multimedia demonstrators to comprehensively employ multiple media expression methods such as sound, light, and electricity, enhancing appeal to visitors and guiding them to independently participate in various interactive exhibition items. Through multimedia demonstrations, hands-on operations, and multimedia games, visitors can independently explore exhibition themes, comprehensively understanding the scientific knowledge involved in exhibition themes such as flower structure, function, types, evolutionary trajectories, and cultural connotations. This not

only expands ideas for science popularization display forms but also encourages experienced users to share with relatives and friends, triggering word-of-mouth effects.

(2) **Application scenarios.** Application scenarios are divided into three types: simulation demonstration exhibitions (such as ship driving and earthquake simulation); courseware performances; and building platforms for audience inquiry and discussion. However, science and technology museums in China that apply 3D technology mainly use it for viewing three-dimensional images of exhibits without deeply exploring the scientific connotations behind them.

The "Dream Theater" at the Shanghai Science and Technology Museum [10] is a large-scale multimedia theme theater that comprehensively utilizes multimedia means such as sound, electricity, and light. Its innovative devices and methods, including phantom imaging, interaction between real people and virtual actors, and reproduction of classic scientific scenes, allow visitors to experience the charm and immersion of modern media means in specific exhibition items, enhancing their understanding of scientific and technological fields and stimulating their enthusiasm and interest in science. However, this form of display only remains at the surface level of revealing scientific knowledge, lacking in-depth exploration of intrinsic scientific content.

(3) **Interactive experience.** During the process of operating intelligent devices, the equipment side occupies the actual initiative, while users only passively select options on the operation interface and wait for terminal responses, belonging to one-way information transmission. Many domestic museums remain at static exhibitions, with interactive equipment in an unmaintained state. During operation, users face problems such as unclear operation steps, insufficient understanding of the results presented by intelligent interactive devices, and inability to better grasp the scientific connotations and scientific spirit behind them.

Case 1: Artificial guide intelligent robots tailored for museums have emerged as a new force. The Guangzhou Thirteen Hongs Museum introduced an intelligent commentator—the Pangolin greeting robot Alice; the Dalian Natural History Museum launched an intelligent service robot commentator Amy; the Nanjing Six Dynasties Ancient Capital Museum introduced the intelligent robot "Xiao Liu" ···When conducting artificial guidance, these intelligent robots not only provide traditional voice explanations but also use facial touch screens to interact with visitors through pictures, videos, and interactive games, allowing visitors to deeply understand the cultural connotations and scientific spirit behind exhibits. The intelligent robots also use cameras on their chests and heads to identify visitors' gender and age, adjusting their explanation style accordingly and using dialects to communicate instantly with visitors from all over.

Case 2: China' s first national-level navigation-themed museum, the "Shanghai China Maritime Museum" [11], has established over 70 interactive exhibi-

tion items, using diversified media technologies for environmental simulation to vividly reproduce the development course of China' s maritime history and creatively disseminate maritime scientific knowledge. For example, container loading and unloading operation simulators are displayed in the form of scenario-based platforms; the submarine area restores the main submarine cross-section scene, allowing observation of periscopes and providing visitors with focusing simulation, distance measurement, and combat simulation experiences.

Both cases above have practical problems such as long visitor queuing times, unclear operation steps, insufficient understanding of the results presented by intelligent interactive devices, inability to better grasp the scientific connotations and scientific spirit behind exhibition items, as well as issues like long feedback times for intelligent interactive equipment, untimely responses, misunderstanding of input information, overly long feedback times, singular results, and high economic and time costs for later maintenance.

3.1.2 Innovative Concepts of Intelligent Interactive Exhibition in Chinese Science and Technology Museums

The innovative exhibition concepts of new-style intelligent interactive exhibitions enable the development of intelligent interactive exhibitions to achieve multi-dimensional development in coordination with society.

(1) **Stimulating visitors' curiosity and fostering interest in the scientific fields behind exhibitions.** Xin Ge, design director of the Shanghai Planetarium Engineering Construction Headquarters and a designer who has been engaged in science popularization exhibition design for 18 years, stated: "The Shanghai Planetarium takes stimulating visitors' curiosity and interest in astronomy as its core goal, rather than merely disseminating astronomical knowledge to visitors. Our design philosophy is to create an experience, not to compile a textbook [12]." While focusing on creating a good exhibition atmosphere, the Shanghai Planetarium makes visiting and experiencing science museums an impressive memory for visitors, thereby fostering their strong interest in the scientific fields where exhibition items are located.

(2) **Integrating the spirit of collaboration into interactive multimedia display forms.** In intelligent interactive exhibitions, by allowing multiple visitors to participate together in collaborative or competitive relationships, multi-person interaction with exhibition items and interpersonal interaction are realized. This allows visitors to enhance their collaborative abilities and cultivate a sense of unity and cooperation while learning scientific and cultural knowledge, creating a positive and harmonious atmosphere.

(3) **Evoking visitors' "continued participation" after the visit.** Museum visitors are not confined to the physical space of science museums. When they leave, if they can still recall what they saw and heard in the science

museum, their willingness to visit again will be further enhanced.

3.2 Current Status of Foreign Science and Technology Museum Intelligent Interactive Exhibition

3.2.1 Functional Effects of Existing Display Methods

(1) **Enriching visitor experience and enhancing cognition of exhibits.** Science museums are constantly developing and changing, with distinct stage characteristics and era features at each phase. Since the late 1960s, science museums have entered the second stage of their development [13], actively creating conditions to encourage visitors to conduct hands-on operations or experiments and learn scientific and cultural knowledge through practice, appreciating the scientific connotations and scientific spirit behind them. They no longer simply collect exhibits but independently research and develop exhibits based on the needs of scientific development stages and science communication, achieving true openness of science museums to visitors.

At the British Museum, visitors can select exhibit sites or follow thematic guided tours during their visit. These thematic guided tours highlight the connections between exhibits, and audio guides record the exhibits that visitors have seen and create an electronic souvenir belonging to the visitor' s visit [16]. Visitors leave the science and technology museum with this special electronic gift. After the exhibition ends, they can still recall the exhibits they saw and the scientific principles and scientific thinking contained within them. Each review is like a new exploration, leading to a deeper understanding of scientific discoveries while enhancing curiosity about related scientific fields.

The Louvre Museum in France [14] introduced the Nintendo 3DS handheld video game control tour system with real-time positioning function in May 2015, allowing visitors to know their specific location information at any time and navigate directly to the specific location of exhibits they want to see according to their own needs. The Louvre also provides over 700 audio commentaries and sign language videos about artworks; the "Winged Victory of Samothrace" presented using 3D simulation technology can be viewed by visitors with the naked eye. Whether 3D simulation imaging, self-guided tour systems, or multimedia interactive displays, all allow visitors to appreciate the charm and cultural essence of the Louvre' s rare exhibits through interaction, leading to deeper cognition and understanding of the scientific knowledge and scientific thinking behind them.

(2) **Demonstrating the process of scientific discovery and technological invention.** Intelligent interactive exhibitions in science museums can vividly explain abstract scientific concepts by combining them with daily life events, integrating the history of scientific discovery into diversified science popularization styles of intelligent interactive exhibitions to enhance science popularization effects.

Discovery Point, Dundee' s intelligent interactive exhibition demonstrates how cargo and ballast achieve balance; the Hunter Museum has a rotating model replica to simulate the process of grinding grain [2]. Through the multi-sensory experience provided by intelligent interactive exhibitions, a rich immersive and appealing science and technology museum atmosphere is created for visitors, restoring classic scenes that allow visitors to travel through time and "see" the daily life of ancient Egyptians, understanding the evolution of scientific germination.

3.2.2 Innovative Concepts of Foreign Science and Technology Museum Intelligent Interactive Exhibition

(1) **Encouraging everyone to personally contact or even touch objects to learn the scientific principles behind exhibitions.** A major characteristic of science museums is "interactivity." Through visitors' personal experience and operation of exhibits, they can deeply understand the exploration process, scientific principles, and scientific development prospects behind exhibition items, further appreciating the charm of science and remembering scientific knowledge more accurately and comprehensively.

The Deutsches Museum in Munich, established in 1853, was the first to allow visitors to personally conduct various simulation tests to strengthen their understanding of science and technology. The museum has over 4,000 exhibits that can be operated with buttons, earning it the nickname "Button Museum."It also features an airborne laboratory for students to conduct scientific experiments [17].

The National Air and Space Museum in Washington displays many lifelike wax figures of wartime ace pilots, and there are no "Do Not Touch" signs in the exhibition halls. Visitors can operate exhibits themselves, including directly touching rocks brought back from the moon, and journalists can also photograph exhibits at will [18]. Through personal contact, visitors' senses such as touch and hearing are greatly mobilized. Exhibits are no longer static and historical but experiential, interactive, interest-stimulating, and thought-provoking.

(2) **Humanistic care for visually impaired individuals.** Science and technology museums are open to all members of the public, and the audience for science popularization education in science museums naturally includes visitors with physical disabilities. Due to their physical disabilities, these visitors cannot view exhibitions like normal visitors. In such cases, science museums can use intelligent interactive exhibitions to create barrier-free environments for these special visitors, helping them "see" exhibitions using hearing, touch, and other senses, further achieving ideological and cultural accessibility.

The British Heritage Museum [19] provides free special services such as voice guides for visually impaired individuals and allows them to directly touch most

three-dimensional cultural relics. The application of intelligent interactive exhibitions breaks through the limitations brought by visual impairment, allowing them to experience the progress brought by scientific and technological development like visitors with normal vision, demonstrating full humanistic care.

(3) **Allowing visitors to understand the practical applications and social significance of scientific achievements.** Scientific research does not occur in a vacuum. For scientific achievements to be effective, they must be applied to real-world contexts to exert their social benefits and have a positive impact on society. When visitors participate in intelligent interactive exhibitions in science and technology museums, they should not only see the rapidly changing landscape of science and technology as research levels continuously improve but also see the tangible changes and real benefits brought by scientific and technological progress.

The U.S. government' s science advisor—the National Academy of Sciences and the American Association for the Advancement of Science—jointly participated in the National Science Education Program and conducted a series of beneficial attempts. For example, the Marian Koshland Science Museum [20], officially opened in April 2004, uses the most advanced equipment and technology to display the complexity of science, making it easy for ordinary visitors to understand and participate. These exhibitions include unique dynamic displays, charts, videos, and science programs. The museum' s exhibitions adopt a "thematic development" display method, combining hot topics and focusing on key areas representing 21st-century scientific development directions and affecting sustainable development [21].

Under the exhibition theme of "global warming," dynamic displays allow visitors to experience floods in Chesapeake Bay, verify the predicted gradual rise of sea levels worldwide, and feel the impact of global warming through a copper globe that mimics the greenhouse effect. Through intelligent interactive exhibitions, the process of scientific discovery is integrated into diversified science popularization styles, enhancing science popularization effectiveness.

4 Comparative Study on Chinese and Foreign Science and Technology Museum Intelligent Interactive Exhibition Development

4.1 Development History Comparison

Foreign science museums entered the second stage of museum development in the 1960s, actively applying intelligent interactive exhibitions to eliminate barriers between visitors and exhibits, encouraging visitors to conduct hands-on operations or experiments to explore exhibits, understand important scientific principles behind demonstrations, and create an infectious and influential science and technology museum atmosphere through immersive practical experiences, extending visitors' stay in venues and deepening their memory and

impression of science museums. Due to earlier practice regarding intelligent interactive exhibitions in foreign science museums and more mature theoretical development compared to domestic development, they possess certain reference value for domestic research on developing science museum intelligent interactive exhibitions.

Domestic science museums start from life practice, focusing on social hotspots and important issues. Through visitors' personal experience and interaction, they provide reasonable explanations for major scientific events and social hotspots and establish their own cognitive thinking, thereby better absorbing and digesting scientific knowledge acquired from science museums.

4.2 Functional Effects Comparison

The interaction forms and application scenarios of domestic science and technology museum intelligent interactive exhibitions are rich and diverse, offering visitors a wide range of choices. However, the following problems remain: limited exploration of new functions beyond three-dimensional imaging and multi-sensory experiences; visitors' insufficient understanding of the scientific knowledge, scientific methods, scientific thinking, and scientific spirit behind the multi-sensory experiences presented by intelligent interactive exhibitions; and science museums' need to bear the enormous financial consumption and technical support pressure required for later maintenance and updating of interactive exhibition equipment.

Foreign science and technology museum intelligent interactive exhibitions focus on enriching visitor experience, helping visitors establish "experience" to enhance cognition of exhibits. By connecting intelligent interactive exhibition items with real life, science museums vividly and intuitively explain scientific principles. After the visit, they can still evoke visitors' "continued participation," providing visitors with opportunities for sustainable exploration, challenge, and experimentation, stimulating visitors' creativity.

4.4 Innovative Exhibition Concepts Comparison

Domestic science and technology museum intelligent interactive exhibitions can, on the one hand, stimulate visitors' curiosity and foster interest in the scientific fields behind exhibitions; on the other hand, by allowing multiple visitors to participate together in collaborative or competitive relationships, they realize multi-person interaction with exhibition items and interpersonal interaction, allowing visitors to enhance collaborative abilities and cultivate a sense of unity and cooperation while learning scientific and cultural knowledge, creating a positive and harmonious atmosphere.

Foreign science and technology museum intelligent interactive exhibitions have the following innovative exhibition concepts: encouraging science museum users to personally contact intelligent interactive exhibitions or participate in interactive projects; providing humanized services that allow visitors with

physical disabilities to also "view" exhibitions through intelligent interactive exhibitions; adding exhibition content about the application and social benefits of scientific and technological achievements, allowing visitors to understand how scientific achievements are implemented and tangibly improve our lives.

5 Analysis of Problems in Chinese Science and Technology Museum Intelligent Interactive Exhibition

Domestic development in the field of intelligent interactive exhibitions started relatively late, lacking norms and direction, resulting in some confusion. However, crisis is also opportunity, coupled with rapid economic development, which brings many new ideas for the development of intelligent interactive exhibitions. For example, most exhibit description pages are attached with QR codes that visitors can simply scan to obtain exhibit information and AR displays, enabling online and offline interaction. Many museums also design and develop WeChat mini-programs for exhibitions to achieve online-offline linkage, solving problems such as low participation due to space limitations. The "Pioneer Action, Forge Ahead" innovation achievements exhibition hosted by the History Museum of the Chinese Academy of Sciences has a QR code for each exhibition item. Scanning with a mobile phone opens the exhibition item introduction page containing audio files and complete commentary scripts, facilitating visitors' in-depth understanding of China' s independently developed new technologies, new equipment, and new materials, and allowing them to feel the scientific thinking and scientific literacy behind the innovative practices and achievements of "reaching the heavens, entering the earth and sea, connecting macro and micro, and integrating top and bottom" from numerous Chinese Academy of Sciences research institutes and great scientists, converting them into motivation and intellectual resources for future work and study.

In contrast, foreign intelligent interactive exhibitions already have mature systems and precedents, with a high average level. However, the direction of effort remains increasing the richness of exhibits.

5.1 Lag of Practical Results Behind Theoretical Innovation

In the mid-to-late 20th century, international museums completed the conceptual transformation from "exhibit/collection-centered"to "people-centered."Since the 1980s, a major change from "object to event" has occurred, that is, using a theme and storyline to connect "lonely and fragmentary objects" into "meaningful narratives" [22], giving birth to "thematic exhibitions" in cultural and historical museums. However, many science centers still adhere to the "exhibit-centered" concept, long emphasizing that "(participatory experience-type, dynamic display-type) exhibits are the soul of science centers," and have been committed to improving exhibit richness without achieving overall linkage between exhibition items. The resulting structural problems are not conducive to smooth information transmission and reception in science museums and can-

not generate the power to stimulate the public to love, understand, and apply science [18].

5.2 Space Issues

The content construction of science museums faces the contradiction between limited display space and numerous display contents. Science museums at home and abroad are gradually moving toward thematization or specialization of publicity and education content, with each theme expressed through knowledge chains and storylines. This requires science museum content construction to consider both physical exhibit design and scenario-based design co-created by visitors. Comprehensive science museums no longer adopt a discipline-classified structure, resulting in key issues such as non-prominent themes and arbitrary content selection. To do well in content construction for science museum intelligent interactive exhibitions in the converged media environment, exhibition themes must be clearly selected, and the structure for presentation must be clearly defined, ensuring both content connectivity and integrity and originality.

5.3 Educational Issues

Both domestic and foreign intelligent interactive exhibitions have considerable room for improvement. Through comparative research on Chinese and foreign science museum intelligent interactive exhibitions, the following deficiencies are identified and analyzed:

Intelligent interactive exhibitions have developed for many years but still cannot break away from the traditional model that primarily displays text and image information supplemented by other multi-sensory experience exhibition methods. The vivid informal education of science museums remains influenced by traditional cramming-style formal education, lacking demonstration of the discovery process of scientific and technological achievements and display and publicity of scientific principle deduction and proof.

5.4 Social Harmony Issues

The construction of science museums must never include decadent, backward, or negative content. However, while popularizing scientific achievements, it should also allow visitors to see the difficulties and challenges faced by scientific and technological development, cultivating a sense of crisis and awareness of potential dangers. This comprehensively fulfills the educational function of science museums, imperceptibly allowing the public to fully recognize that "science and technology are a double-edged sword," correctly grasping the balance between "abuse" and "use" in the pursuit of scientific and technological achievements, and building harmony between people and between people and nature. This is something we always need to emphasize and is also a major topic.

6 Suggestions for Application Planning of Intelligent Interactive Exhibition in Science and Technology Museums

The era of information exchange, human-computer interaction, and community sharing has arrived. Science museum intelligent interactive exhibitions align with the stage changes of science museums in the converged media environment, which is beneficial for the preservation and memory of scientific and technological achievements. Their vigorous development helps science museums enhance their informal education functions and also has certain reference significance for libraries to strengthen their comprehensive service functions. In response to some problems existing in the development process of China' s intelligent interactive exhibitions, we make the following suggestions for science and technology museum exhibition design and planning:

6.1 Attractiveness

This requires exhibition themes to be vivid and interesting, with appealing appearances, sufficient fun, and profound scientific and cultural connotations that attract visitors to stop, watch, and interact.

Direction of effort: Science museums are important drivers of social civilization development. They must shoulder the task of knowledge dissemination and also emphasize answering major topics and hot discussions in the process of social civilization development from a scientific perspective, promoting the integration of science and technology with humanities. Enhance the fun of the exhibition participation process, work hard on exhibition content, expression forms, material matching, and environmental arrangement, capture the public' s interest points, and arouse in-depth thinking from the public. Do well in content construction, focus on drawing nutrients from the exploration process of major scientific and technological achievements, and integrate them into exhibition item design.

6.2 Navigation or Operation Instructions Should Be Easy to Understand

The intelligent navigation robots or human-machine interface design in intelligent interactive exhibitions must fully consider visitors' exhibition needs. Interface design should conform to exhibition themes and exhibition item characteristics, the language used should be accurate, popular, and concise, the content included should be clear and organized, and multiple science popularization styles should be used to give visitors comprehensive and profound cognition of exhibition items and themes.

Direction of effort: Use multimedia means such as images, text, and sound to enable visitors to clearly and explicitly understand the operation steps and interaction forms of intelligent interactive devices; conduct instant responses according to visitors' dynamic needs; conduct multiple rounds of formative testing and make adjustments based on results.

6.3 Encourage Exploration

Learning often occurs when visitors are allowed to conduct independent inquiry. Science museums should encourage visitors to conduct open-ended exploration of possible conclusions.

Direction of effort: The design and development of exhibition items should emphasize both the display of scientific and cultural knowledge and the demonstration of their invention processes. Through the enhancement of intelligent interactive exhibitions, visitors can be inspired in innovative thinking while mastering scientific and cultural knowledge, integrate them with previously acquired knowledge, and contribute to the development of an innovative society.

6.4 Encourage Interaction Among Visitors

A wall in the Washington Children' s Museum in the United States bears this motto: "I hear and I forget; I see and I remember; I do and I understand." This motto has become an important guiding principle for many science and technology museums and science centers to develop exhibition items [20]. Intelligent interactive exhibitions encourage family members or peers to participate in intelligent exhibition items in collaborative or competitive relationships, providing visitors with opportunities for interpersonal communication and exchange. Through cooperation, they think about and cognize scientific issues, better understand the scientific principles and scientific spirit behind them, improve visitors' initiative and enthusiasm for participation, and cultivate their awareness of collaboration.

Direction of effort: Design and develop experience- and inquiry-centered exhibition items, science popularization performance dramas, etc.

6.5 Content Accuracy

To achieve content accuracy, exhibitions should simplify themes and refine concepts when presenting grand topics.

Direction of effort: Focus on the fit between the scientific connotations embodied by devices and exhibition themes, carefully consider under the guidance of themes what structure should be used to establish a content system that conforms to themes, what forms should be used to present rich scientific connotations and encourage visitor participation and interaction, and what narrative methods should be used to integrate resources for better science popularization publicity.

6.6 Support Initial Participation and Continued Participation

This means that intelligent interactive exhibitions should help visitors determine how to approach exhibitions and how to begin interacting with intelligent interactive devices. During the participation process, exhibitions should provide

visitors with opportunities for sustainable active exploration, challenge, and experimentation. They should help visitors leave science museums with questions to think about, facilitating visitors' connection between exhibition content and their own life reality or past experiences. Through reviewing scientific knowledge and scientific connotations, they form their own thinking and cultivate innovative talents.

Direction of effort: When developing and designing intelligent interactive exhibitions, the counter-intuitive principle can be applied to trigger strong cognitive conflicts during visitors' exhibition experiences, helping visitors remember and cognize correct scientific concepts.

6.7 Closely Integrate with Formal Education to Achieve Linkage Resource Sharing

Su Donghai believes: "Museums and schools have different approaches but the same goal in conducting science education for the public. Scientific knowledge is the extension of the knowledge system and the cultivation of interest." The best science museums are not about building scale and the number of exhibits but reflect the functions of science museums and have local characteristics, being welcomed by the public [23]. As an important component of informal education, sustainable museums should actively combine with formal education to form a joint force and promote the progress and development of China' s science popularization cause.

Direction of effort: Schools and out-of-school educational institutions should maintain a complementary and closely linked relationship, working in coordination. Strengthen exchanges and cooperation between domestic and foreign science and technology museums and science centers, closely integrate informal education with formal education, accelerate the construction of the science and technology museum system; strengthen the collection of scientific and industrial collections, enhance the operational capabilities of science museums, continuously expand the real and virtual exhibition and education platforms of science museums, and achieve leapfrog development of China' s science museum cause.

6.8 Maximize Encouragement of User-Generated Content Through Current Models

UGC (User-Generated Content) helps the public fully release their enthusiasm and creativity. Through personal participation in platform architecture building processes, behaviors such as public rating, browsing, commenting, collecting, and subscribing to exhibition items not only help other visitors select content, process and organize information, and ultimately transform information into their own use but also objectively promote science museums to optimize their intelligent interactive exhibition presentation methods.

Direction of effort: Exhibition content construction should determine exhibition themes based on extensive surveys of the public and listening to opinions,

integrate UGC throughout the entire exhibition process, maximize the function of UGC; establish a material reward mechanism for high-quality content to achieve external drive; grasp users' psychological and emotional factors, stimulate users' creativity through spiritual and emotional incentives to achieve internal drive.

7 Conclusion

In the new media environment, the intelligent interactive exhibition, an innovative exhibition method in science museums, is beneficial for the preservation and memory of scientific and technological achievements. Its vigorous development helps science museums enhance their informal education functions and also has certain reference significance for libraries to strengthen their comprehensive service functions. However, China' s intelligent interactive exhibitions have some problems in their development process. The popularization rate of sustainable museum intelligent interactive exhibitions is still not high, and the popularization degree is not high. Science museums should allow the public to better understand and recognize intelligent interactive exhibitions in science museums to enhance their science popularization effectiveness. To this end, the author recommends that science and technology museum managers should consider the complete scene of visitors touring science and technology museums; that the informal education of science museums must be closely integrated with formal education to achieve linked resource sharing; and that by optimizing the current model of intelligent interactive exhibitions, the enthusiasm for UGC should be maximally encouraged to gradually improve the originality and universality of high-quality intelligent interactive exhibitions, making them a beneficial supplement to science and technology museum exhibition education and providing good support for libraries to strengthen their comprehensive service functions, expand cultural service functions, and play their core values.

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Note: Figure translations are in progress. See original paper for figures.