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An Overview of Science Communication Methods and Practices in Museums in the New Media Era

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ABSTRACT

As an important social and cultural institution for the communication of science knowledge, museums carry the important mission of popularizing scientific knowledge, enhancing public scientific literacy and promoting social innovation. This study takes science communication in museums as the research content, systematically analyzes its communication status quo, methods and practice cases, deeply explores the existing problems and challenges, and puts forward optimization strategies. Through the study of communication content, channels, audience and other dimensions, combined with the exhibition, educational activities, new media communication and other specific practices, to reveal the internal rules and development path of science communication in museums. The study finds that museums need to make continuous efforts in strengthening talent training and team building, promoting communication efficiency upgrading, and enhancing public interaction and participation in order to adapt to the needs of the times, improve the efficiency of science communication and better serve the public.

INTRODUCTION

Currently, science and technology are experiencing constant development, and public demand for scientific knowledge continues to grow. Scientific literacy has become an important indicator of the comprehensive quality of individuals and the level of social development. As cultural venues integrating the functions of collection, research, display and education, museums have rich scientific collections and related resources, and they are the important foundation for science communication. Different from the educational platform provided by schools, museums provide the public with an irreplaceable learning platform for scientific and cultural knowledge with their unique exhibition space, diversified interactive forms and free learning atmosphere. Falk and Dierking have demonstrated that museum environments uniquely facilitate free-choice learning through immersive experiences that differ fundamentally from formal education settings (Falk & Dierking, 2013). However, with the changes in the social environment and the innovation of communication technology, the public has put forward higher requirements for the content and form of science communication. How museums can effectively utilize their own resources, innovate the methods of science communication and improve the communication effect is an important issue that needs to be solved urgently.

IMPORTANCE OF SCIENCE COMMUNICATION IN MUSEUMS

In the era of knowledge economy and information explosion, the public's demand for scientific knowledge

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is increasing rapidly, and scientific literacy has become the core competitiveness of individual and social development. This phenomenon aligns with Bucchi and Trench's observation that contemporary societies require new paradigms of science communication to bridge expert and public knowledge (Bucchi & Trench, 2021). As a natural scientific knowledge treasury, museums play an irreplaceable role in the field of science communication by virtue of their unique cultural attributes and resource advantages. An in-depth discussion on the importance of science communication in museums can not only clarify its value in science education, literacy cultivation and cultural inheritance, but also provide theoretical support for enhancing the effectiveness of science communication.

Popularize Scientific Knowledge

Museum is an important position for popularization of scientific knowledge, which can transform professional scientific knowledge into easy-to-accept content and deliver it to the public through well-designed exhibitions, vivid and imaginative explanations, and interesting and interactive experiences. The physical cars, books, images and models in the automobile museum show the changes and development of automobiles since the Industrial Revolution and their important influence on the public; the fossilized dinosaur bones in the nature museum vividly present the dinosaur's habits and evolution through restoration models and multimedia demonstrations. In science museums, the audience can visualize the charm of science and culture, thus stimulating a strong interest in scientific knowledge. This kind of popularization of science breaks through the limitations of one-way transmission of knowledge, allows the public to learn scientific knowledge in a relaxed and pleasant atmosphere, makes up for the limitations of school education in time and space, and also provides the public with good opportunities for lifelong learning.

Enhancing Scientific Literacy

Scientific literacy not only includes the mastery of scientific knowledge, but also the cultivation of scientific thinking, scientific method and scientific spirit. Museums provide a practical platform for the public to cultivate scientific literacy through a variety of activities and displays. In the hands-on experiment area of science and technology museums, visitors can personally participate in a variety of scientific experiments, such as mechanics experiments, optical experiments, car modeling and so on. During the experiments, the audience needs to observe the experimental phenomena, ask questions, make assumptions, design the experimental program and verify the results, a series of processes that can effectively exercise the participants' observation ability, logical thinking ability and practical operation ability, so that they can master the basic methods of scientific research. In addition, the museum organizes popular science lectures, scientific seminars and other activities, inviting experts and scholars to share scientific research results and scientific ways of thinking, which likewise help the public to broaden their scientific horizons, cultivate the spirit of science, and enhance their scientific literacy.

Strengthening Cultural Inheritance and Innovation

Scientific knowledge is an important part of human civilization, which carries the wisdom of human beings to explore nature and transform the world. In the process of communication of scientific knowledge, museums also hold the important mission of inheriting scientific culture. By displaying ancient inventions and creations, such as the Four Great Inventions of ancient China, astronomical instruments, agricultural production tools, etc., science museums show the public the wisdom and creativity of ancient laboring people, and pass on the scientific and cultural traditions of the Chinese nation. Museums are also important promoters of scientific and cultural innovation, which stimulate the public's innovative thinking and sense of creativity by displaying the latest scientific research results and scientific innovation products. Some museums have organized exhibitions on future science and technology, showcasing recent technologies in such fields as artificial intelligence, virtual reality and biotechnology, so that the public can feel the infinite possibilities of science and technology, thus further promoting the innovative development of science and culture.

ANALYSIS OF THE CURRENT STATE OF SCIENCE COMMUNICATION IN MUSEUMS

With the development of technological innovation, the environment of museum science communication has undergone a great transformation. The integration of digital technologies has shifted museums from static repositories to dynamic participatory spaces, yet poses challenges in balancing technological innovation with epistemological authenticity (Huang, 2018). From the presentation of communication content, to the expansion of communication channels, to the diversification of audience needs, all put forward new challenges and opportunities for museum science communication. Analysing the current situation of science communication in museums can help identify the problems and point out the direction for subsequent optimization strategies.

Communication Content

At present, the content of science communication in museums covers natural science, technical science, humanities and other fields. However, in the actual communication process, there are some problems need to be solved. On the one hand, the exhibitions of some museums are oriented to academic research, and the

introduction of exhibits focuses too much on technical terms and theoretical knowledge, and the textual expressions are obscure and difficult to understand, making it difficult to attract the attention of general audiences. On the other hand, in some science exhibitions, the introduction of specialized knowledge such as species classification and evolution theory is also too in-depth and complex, lacking vivid stories and interesting elements, which leads to the audience feeling boring and tedious during the visit, making it difficult for them to properly understand and accept. In addition, there are differences in the demand for scientific knowledge among audiences of different ages, cultural backgrounds and knowledge levels, but museums often lack precise audience orientation in the design of communication content, failing to provide personalized scientific knowledge content according to audience needs. Therefore, museums need to make more comprehensive adjustments to communication content in the process of science communication.

Communication Channels

The traditional channels of science communication in museums mainly include exhibition display and educational activities. As the most classic communication method of museums, exhibition display conveys scientific knowledge and cultural information to the audience through well-designed exhibition space and exhibits combination. However, traditional exhibitions are limited in their coverage and influence by factors such as space and time, making it difficult to meet the public's demand for acquiring scientific knowledge anytime and anywhere. Educational activities such as science lectures, workshops and study tours can provide audiences with a more in-depth and interactive learning experience, but their dissemination effect is also subject to certain constraints due to the cost of organizing the activities and the limited number of participants. In the new media era, although museums have realized the importance of new media communication and have established new media platforms such as official websites, WeChat official account, Weibo, and Tiktok, there are still problems in the actual operation process. The official websites of some museums only briefly introduce exhibition information and collection resources, and lack interactive functions such as online exhibitions and virtual tours; the contents released by social media accounts are mostly static graphics and texts, which lack creativity and attractiveness, and are difficult to attract the attention and resonance of the audience. The lack of professional operation team and professional communication technology has led to the insufficient utilization of the communication power of museums in new media communication and other channels.

Communication Audiences

The audiences of museums are broad and diverse, covering people of different ages, occupations, cultural backgrounds and knowledge levels. There are significant differences in the demand and acceptance of scientific knowledge among different audiences. Young people are curious and more interested in interesting and interactive scientific contents, and they hope to learn scientific knowledge by participating in practical activities and game experiences; middle-aged and old people are more inclined to scientific contents with historical and cultural connotations, and they pay more attention to the practicability and cultural value of knowledge. However, in the process of science communication, museums often lack in-depth research and analysis of audience needs, fail to develop personalized communication strategies according to the characteristics and needs of different audiences, making it difficult to meet the needs of diversified audiences, which leads to the lack of interest of some audiences in the scientific communication activities of museums.

METHODS OF SCIENCE COMMUNICATION IN MUSEUMS

In the presence of increasingly diversified public demand for scientific knowledge, museums are in urgent need of exploring effective integrated methods of science communication. Integrated communication frameworks must leverage three technological pillars: multimedia interfaces for object interaction, cloud-based dynamic databases for personalized content delivery, and algorithm-driven user profiling - all converging to dissolve physical-visitor dichotomies (Rovetta & Rovida, 2018). From traditional exhibitions and educational activities to emerging new media communication practice, different methods have their own advantages and applicable scenarios. Integrating these methods of science communication will enable museums to better fulfill their science communication functions and enhance their communication effects.

Exhibition Communication

Theme exhibition design

Theme exhibition is an important carrier of science communication in museums, and its quality directly affects the effect of communication. When designing thematic exhibitions, it is necessary to focus closely on the scientific theme, combine social issues and public interest points, and choose attractive and educational themes. For example, in the context of increasingly severe global climate change, the theme exhibition “Climate Change: Challenges and Responses” is planned to guide the public to pay attention to environmental issues and enhance environmental protection awareness by displaying the scientific principles of climate change, its impact on human society and the ecological environment, as well as response measures.

In terms of content design, it is important to emphasize systematicity and logic, and to develop explana-

tions from phenomenon to essence in a special perspective. A storytelling narrative can be used to integrate scientific knowledge into vivid stories, making it easier for the audience to understand and accept. At the same time, diversified display contents and forms should be designed according to the needs of different audiences, such as setting up interactive games and experience regions for young audiences, and providing professional audiences with in-depth academic research materials and thematic lectures, so as to meet the learning needs of audiences in different levels.

Exhibition design innovation

With the continuous development of science and technology, museum exhibition design should actively introduce new technologies and new methods to enhance the attractiveness and interactivity of the exhibition. In addition to the traditional physical display, model displays, multimedia displays, virtual reality (VR), augmented reality (AR), mixed reality (MR) and other diversified display forms can be increased. For example, in the dinosaur exhibition, the audience can wear VR or MR equipment, immersively experience dinosaurs' life in the Jurassic era; through the AR technology, the audience only need to scan the exhibits with a cell phone, thus can get rich text, pictures, videos and other information. The static exhibits can be “moved” by the design innovation.

The exhibition space design is also very important. Museums should pay attention to the space layout and atmosphere creation, be careful about reasonable exhibits display, lighting design, color matching and other means, to create an exhibition environment in line with the theme of the exhibition display. For example, in the astronomical exhibition, through the simulation of starry sky lighting effects and immersive display space, the audience seems to be in the vast universe, feel the charm of astronomy.

Communication of Educational Activities

Science lectures and workshops

Science lectures are one of the important ways for museums to communicate science knowledge. It invites well-known experts, scholars and researchers to hold science lectures, which focus on current popular science topics, such as artificial intelligence, new energy materials, environmental science and sustainable development, etc., and explains the principles, applications and development prospects of scientific knowledge in an in-depth manner in understandable language. Lectures can be combined online and offline to expand audience coverage. Offline lectures can be set up with interactive sessions to encourage audience questions and exchanges, and to enhance audience participation; online lectures can be conducted through live broadcasting platforms, which is convenient for those who can't make it to the site to watch and interact with each other through pop-ups and comments.

Workshops provide the audience with hands-on opportunities, and museums can design diversified workshop activities according to different scientific fields and audience needs. For example, in the “Little Scientist” workshop, children can learn simple chemical experiments and physics production; in the “Nature Exploration” workshop, participants can learn skills such as plant specimen production and insect observation. The workshops are usually conducted in small groups with professional instructors on site to ensure that each participant can fully participate and have a good learning experience.

Study tours and curriculum development

Study tour is an innovative form of combining museum education with school education, i.e., museums cooperate with schools and educational institutions to design personalized study tour courses according to the cognitive level and curriculum standards of students of different age groups. For elementary school students, museums can design interesting and experiential natural science study courses, such as “Exploring the Ocean World”, in which students learn about the diversity of marine life and the marine ecosystem by visiting marine specimens, watching popular science films and participating in interactive games. For secondary school students, museums can design courses with a certain depth and inquiry, such as “Ancient Scientific and Technological Achievements Exploration”, in which students study ancient scientific and technological artifacts, analyze their scientific principles and historical values, and cultivate scientific inquiry ability and cultural literacy.

Museums can also cooperate with schools to develop school-based programs, combining the educational resources of museums with the school curriculum system. For example, museums provide professional interpretation resources and practice sites, and school teachers design teaching programs according to the curriculum needs to jointly create school-based courses with special characteristics, providing a useful supplement to school education.

New Media Communication

Website and social media application

The official website of the museum is an important online display platform and information dissemination area. In order to optimize the construction of the official website, it is necessary not only to provide comprehensive and accurate information about the exhibition and introduction of the collection resources, but also to increase the interactive functions and online educational resources settings. 3D modeling, panoramic display and other technologies can be used in the online exhibition section to digitize the physical exhibition, so that the audience can visit the exhibition without leaving home. At the same time, it is also possible to open a column of popular science articles and publish easy-to-understand scientific knowledge posts; provide virtual

tour services to help audiences better understand the content of the exhibition and so on.

Social media platforms are characterized by fast communication speed, wide coverage and strong interactivity, which are important channels for science communication in museums. Museums should develop personalized communication strategies according to the characteristics of different social media platforms and user groups. On WeChat official account, it can release in-depth science articles, exhibition previews and activity information; on Weibo, it can initiate discussions on popular topics and interact with users; on short-video platforms such as Tiktok, it can produce interesting short science videos to disseminate scientific knowledge in a vivid and imaginative way. For example, some museums have released a series of short videos on Tiktok called “Diary of Cultural Heritage Restoration”, which attracted a large number of fans by showing the process of cultural heritage restoration and effectively disseminated the knowledge of cultural heritage protection.

Digital exhibitions and online educational resources

Digital exhibition is an important form of innovation for museums to cope with the development of the new media era. Through digital technology, physical exhibitions are digitized and transformed to break through the limitations of time and space, so that more audiences can visit the exhibitions. Digital exhibitions can adopt various forms, such as 360°panoramic display, virtual roaming, interactive experience, etc., to provide the audience with an immersive visiting experience. In addition, museums can develop independent digital exhibition programs, combining advanced technology to create innovative and attractive digital exhibition content.

The development of online educational resources is also an important part of new media communication. Museums can produce high-quality popular science videos, e-teaching materials, online courses and other resources, which can be released and disseminated through official websites, social media platforms, online education platforms and other channels. These resources can be designed according to the needs and learning levels of different audiences, providing diversified learning methods and content options to meet the public's demand for independent learning. For example, some museums have launched “Science Classroom” online courses, which cover a wide range of scientific fields with interesting and lively content, and have been well received by the public.

CASE STUDIES OF SCIENCE COMMUNICATION PRACTICES IN MUSEUMS

With the background of the upgrading of public demand for science popularisation, Chinese museums are actively exploring diversified paths of science communication. Relying on characteristic exhibits and resources, Beijing Auto Museum activates the public's enthusiasm for exploring automobile science and technology with immersive study activities; Shanghai Science and Technology Museum builds a scientific knowledge dissemination matrix with short science videos by taking advantage of new media dissemination; and Shaanxi History Museum takes an alternative approach to create an interactive knowledge experience scenario through the ‘Dialogue with Yu Wenyong’ science and technology exhibition by integrating history and culture with advanced technology. These cases show the innovative wisdom and social responsibility of different types of museums in the practice of science communication, and provide a model for the development of the industry.

Beijing Auto Museum's “Interesting Cars” Theme Study Program

As a national-level museum, Beijing Auto Museum has been actively exploring and innovating in the field of science communication, and its “Interesting Cars” theme study program has achieved remarkable results and was honored as one of the “2024 National Innovative Cases of Museum Integration and Development”. Focusing on automobile science and technology, the study program makes full use of the museum's rich exhibit resources and perfect hardware facilities to build a platform for participants to learn more about automobile knowledge.

The “Interesting Cars” program was launched during the National Science Popularization Day 2024, and the theme study program was centered on the science and technology experience day, with rich and diverse contents. The program not only displayed Tesla's wonderful light show, which allowed the audience to feel the charm of the fusion of automotive technology and art, but also had a display area for future automotive technology, which covered a variety of projects, such as “Racing World”, 3D technology mystery, decoding of automotive engines and chassis, exploring new energy cars and auto-driving smart cars. Participants can experience the charm of automobile science and technology and understand the working principle, development history and future trend of automobiles in practice. In order to enhance the effect of the study, Beijing Auto Museum has well prepared automotive science manuals and study sheets, which are distributed to the public free of charge. With easy-to-understand language and vivid pictures, these materials introduce automobile-related knowledge in depth and provide participants with a systematic learning assistance. For this event, Beijing Auto Museum was also awarded the “Outstanding Science Popularization Day Activity” by Beijing Association for Science and Technology, demonstrating its outstanding contribution to science education.

The characteristic of this project lies in the integration of three aspects of science communication. The first is the unity of historicity and foresight. Through the display of "science fiction cars" to "flying cars", it not only traces the development process of industrial civilization, but also looks forward to the future transportation landscape. The second is the balance between professionalism and fun, transforming professional knowledge such as engine decryption and 3D technology exploration into immersive experiences such as interactive games and light shows. The third is the combination of educational and social aspects, which achieves systematic knowledge transmission through popular science manuals and study sheets, while cultivating young people's scientific thinking and social responsibility. This innovative practice vividly interprets the positioning of museums as the "center of technology and culture", using cars as carriers to build a science popularization bridge connecting historical wisdom and future innovation.

Shanghai Science and Technology Museum's "Nature in Your Pocket" Short Science Popularization Video Program

With the rapid development of new media technology, Shanghai Science and Technology Museum has kept pace with the new era and actively explored new paths of science communication, and the "Nature in your Pocket" short science popularization video program is the practice of its innovation. Short videos have become a powerful channel for the dissemination of scientific knowledge by virtue of their short, quick and low-threshold features. Shanghai Science and Technology Museum has taken full advantage of this medium to create short videos for popularizing science, so as to make scientific knowledge reach the public more conveniently.

Relying on the rich digital assets of Shanghai Science and Technology Museum, including documentaries, 4D movies, dome movies and other materials accumulated in the early stage, transformed scientific scripts, as well as professional talents and team mechanisms, the program creates a second creation of the "China's Rare Species" series to produce short science popularization video programs with unique styles. For example, the "My Animal Friends" video series focuses on Shanghai's native species, capturing animals around the public and revealing their "animal neighbors" such as raccoons, roe deer, elk, badgers and bead-necked turtledoves. The six episodes of short videos were launched on Bilibili and Tiktok's "Shanghai Science and Technology Museum Official Account" on World Wildlife Day, produced by Shanghai Science and Technology Museum and funded by the Pudong New Area Science and Economy Commission's Science and Technology Popularization Project.

This program is recognized for its content planning. In terms of content planning, the project creates a science popularization "combination state" with IP concept. Centering on the documentary brand of "China's Rare Species", the project has developed a diversified product system including monographs, picture books and extended cultural and creative products. Short videos, with their communication advantages, complement each other with documentaries, science popularization books, science popularization picture books, etc., achieving a positive cycle of short video "feedback" to other media, and other media filling the gap of short video fragmentation. This maximizes the coverage of different audience groups and enhances the influence and coverage of science communication.

Shaanxi History Museum's "Dialogue With Yuwen Yong - Exhibition of Scientific and Technological Archaeological Achievements of the Xiaoling Mausoleum of Emperor Wu of the Northern Zhou Dynasty"

As an important place carrying profound historical and cultural heritage, Shaanxi History Museum has been actively exploring innovative exhibition forms and science communication channels. The "Dialogue with Yuwen Yong - Exhibition of Scientific and Technological Archaeological Achievements of the Xiaoling Mausoleum of Emperor Wu of the Northern Zhou Dynasty" is a highly representative practice, which has attracted widespread attention in the field of archaeology and science popularization.

From a series of dimensions such as the origin of ethnic groups, face restoration, causes of death, dietary structure, the exhibition comprehensively displays the contents, methods, processes and results of scientific and technological archaeology of the Xiaoling Mausoleum of Emperor Wu of the Northern Zhou Dynasty, so that the public can have an in-depth understanding of scientific and technological archaeology as an advanced field. The exhibition design is ingenious, introducing the concept of "laboratory". Through spatial layout, color lighting, and exhibition design, the exhibition hall is transformed into a "laboratory", full of technology and modernity, making the audience feel as if they are in a real technological archaeological site. The exhibition hall is also equipped with AI interactive devices, allowing visitors to interact and converse with the reconstructed image of Yuwen Yong, gaining a deeper understanding of his mysterious identity and historical knowledge, and achieving a "dialogue" that transcends time and space. During the exhibition, a series of lectures and interviews were also arranged, inviting researchers from Shaanxi Provincial Institute of Archaeology, scientists involved in facial restoration, and other relevant experts and scholars to analyze the highlights of the exhibition online, explore how to interpret historical figures through DNA, share the unique experiences brought by the new exhibition, further deepen the audience's understanding and recognition of technological

archaeology, and greatly stimulate the public's enthusiasm for exploring historical science.

This exhibition is characterized by the use of advanced technology as a bridge to realize the deep integration of historical research and science communication. Through modern archaeological techniques, scientific research achievements such as the restoration of imperial appearance and the investigation of causes of death are transformed into visual exhibitions, combined with the creation of "laboratory" scenes and AI interactive devices, allowing the audience to immerse themselves in the charm of technological archaeology. The exhibition not only breaks down the disciplinary barriers between history and science, but also constructs a complete communication chain from knowledge display to public participation through expert lectures and online interactions, providing innovative examples that are both professional and interesting for historical museums to carry out science communication.

CHALLENGES AND PROBLEMS IN SCIENCE COMMUNICATION IN MUSEUMS

The above three cases have shown many highlights in the practice of science communication in museums, providing useful reference for the development of the industry. However, it is undeniable that there are limitations in the current field of science communication in museums, from the continuity of exhibition interaction to the depth of online communication, from the coverage of educational activities to the efficient use of resources, there is still room for improvement. At the same time, surveying the whole ecology of science communication in museums, problems such as the shortage of professional talents, insufficient communication effectiveness, and low public participation are gradually emerging, and these trendy deficiencies are restricting the further enhancement of the effectiveness of science communication in museums, which urgently need to be systematically analysed and solved.

Shortage of Professional Talents

Science communication is a highly specialized work that requires professionals with both solid scientific knowledge and familiarity with communication laws and methods. However, at present, the professional backgrounds of museum staff are mainly concentrated in the fields of history, archaeology and art, and there is a lack of professionals related to the history of science, communication and education, which leads to deficiencies in the planning of science communication content, exhibition design, organization of educational activities and operation of new media in museums. In terms of exhibition content design, due to the lack of professional communication talents, it is difficult to transform complex scientific knowledge into easy-to-understand and attractive display content; in terms of new media operation, due to the lack of professional technology and operation team, it is impossible to give full play to the communication advantages of new media and improve the communication effect. In addition, the training mechanism for the existing staff of museums is not perfect enough, and the lack of systematic professional training and learning and exchange opportunities makes it difficult to meet the needs of the continuous development of science communication.

Ineffective Communication

In the rapid development of digital technology, the science communication system of museums obviously has insufficient communication efficiency. First, many museums still rely on traditional static exhibition forms, multimedia interactive equipment is unable to fully show the dynamics and interest of scientific knowledge. The touch-screen guide system in some museums has problems such as slow response and untimely content update, and technologies such as 3D projection, virtual reality and augmented reality are only applied in a few museums on a pilot basis. Second, most museums have not yet established a perfect audience behavior analysis system, and it is difficult to obtain data such as the audience's visiting path, length of stay, and interest preferences, so it is impossible to optimize the exhibition design and activity planning based on the data. In addition, in terms of cross-platform technology integration, the online and offline communication channels of museums lack effective linkage, and online platforms are mostly based on simple graphic information release, failing to deeply integrate offline exhibitions with online science resources through technical means, resulting in the efficiency and coverage of science communication being limited, and it is difficult to satisfy the public's growing demand for digital learning.

Insufficient Public Participation

Although museums have made a lot of efforts in science communication, there is still some possibility to improve public participation. On the one hand, some members of the public do not know enough about the science communication function of museums, and regard museums only as places for visiting and touring, and lack the awareness of actively acquiring scientific knowledge. In the process of visiting, the audience often just passively watch the exhibits without deeply understanding the scientific knowledge and cultural connotation. On the other hand, the content and form of science communication in museums fail to fully meet the individualized needs of the public. There are differences in the points of interest and ways of accepting scientific knowledge among the public of different ages, occupations and cultural backgrounds, but the content and form of communication and activities in museums are relatively fixed and lack of pertinence and flexibility, which makes it difficult to attract active participation

from different groups. In addition, the interaction mechanism between museums and the public is not yet perfect, and there is a lack of effective feedback channels and incentive measures. These phenomena require an improvement in the enthusiasm and initiative of the public to participate in science communication.

OPTIMIZATION STRATEGIES FOR SCIENCE COMMUNICATION IN MUSEUMS

In the face of the dilemma of museums in the process of science communication mentioned above, it is urgent to actively explore and implement effective optimisation strategies. The high-quality development of science communication in museums requires not only the intellectual support of professional talents, but also the continuous guarantee of diversified technologies, and even more interactive mechanisms that closely match the needs of the public. Only by focusing on the above core aspects and constructing systematic optimization plans can we break free from development constraints, fully unleash the social value of museum science communication, and truly achieve effective popularization of scientific knowledge and widespread inheritance of scientific culture.

Strengthen Talent Training and Team Building

Strengthening the training of science communication talents is the key to improve the level of science communication in museums. Museums should establish cooperative relationships with universities and scientific research institutions to jointly offer science communication-related professional courses or training programs, such as cooperating with universities in communication and science education to set up courses in the direction of science communication in museums, so as to cultivate composite talents who have both a solid foundation of scientific knowledge and a mastery of communication theories and practical skills.

For the current staff of the museum, a systematic training mechanism should be set up, internal training should be organized on a regular basis, and experts and scholars of the industry should be invited to carry out lectures and seminars to share the latest concepts, methods and techniques of science communication; staff members should be selected and sent to participate in domestic and international academic exchange activities and professional training courses to broaden their horizons and learn from the advanced experiences and practices. Museums can also promote exchanges through job training, case analysis and experience sharing to improve the staff's level.

In terms of team building, museums should set up interdisciplinary science communication teams, which include scientific researchers, exhibition designers, educators, new media operators, marketing personnel and other people with different professional backgrounds. Scientific researchers provide professional scientific knowledge and research results, exhibition designers transform scientific knowledge into visualized exhibition content, educators design diversified educational activities, new media operators are responsible for online communication and promotion, and marketing personnel carry out activity publicity and branding, so as to enhance the overall effect of science communication through the close cooperation of team members.

Promote the Upgrading of Communication Efficiency

Museums should follow the development trend of technology and actively introduce advanced technology to enhance the experience of science communication. On the one hand, increase the upgrading of multimedia interactive equipment, and widely use VR, AR, MR and other technologies to create immersive science popularization scenes. For example, the ecological environment of the dinosaur era is restored through VR, MR and other technologies, so that the audience can intuitively feel the survival of ancient creatures; AR technology is used to scan the exhibits, presenting a dynamic analysis of their internal structure and scientific principles. On the other hand, a digital management system should be built to integrate multi-dimensional information such as audience behavioral data and online browsing data, and accurately grasp the public demand through big data analysis, so as to provide a data basis for the customization of science communication content and activity planning, and realize the precision and personalization of science communication.

At the same time, it is necessary to break the communication barriers between online and offline, and realize the efficient integration and linkage of resources. In offline exhibitions, set up online interactive entrances so that visitors can participate in online knowledge quizzes, virtual exhibition roaming and other activities through code scanning to extend the visiting experience; on online platforms, launch offline exhibition reservations, science activities registration and other functions to attract the public to the museum for in-depth participation. Develop an integrated online and offline science popularization course, with the offline course supplemented by online pre-reading materials and the online course set up with offline practice tasks, to promote the complementary advantages of online and offline, form an all-round, multi-level science communication system, and expand the influence of science communication.

In addition, it is necessary to establish an in-depth cooperation mechanism between museums, science and technology enterprises and scientific research institutions to jointly carry out the research and development of science communication technology. Museums provide application scenarios and demand orientation, science and technology enterprises provide technical

support, scientific research institutions provide theoretical guidance, and the three parties work together to develop exclusive technologies and applications suitable for science communication in museums. For example, jointly developing an intelligent navigation system based on artificial intelligence to achieve personalized explanations and real-time interaction; jointly explore the application of metaverse in science communication and build a virtual museum space. Through multi-party cooperation and innovation, we continuously enhance the technological content and innovation of museum science communication, bringing the public a richer science communication experience.

Enhance Public Interaction and Participation

In-depth understanding of public demand is a prerequisite for enhancing public interaction and participation. Museums can widely collect public opinions and suggestions on the content, forms and activities of science communication through questionnaires, interviews and online messages, etc., to understand the interests and needs of different groups. For youth groups, online and offline interest surveys can be carried out to understand their favorite scientific fields and the forms of activities they are interested in; for adult audiences, interviews can be conducted to understand their learning needs and expectations for scientific knowledge. Based on the results of the survey, personalized science communication strategies will be formulated, and communication contents and activities will be designed to meet the needs of the public.

In the design of exhibitions and planning of activities, it is necessary to increase interactive links to enhance public participation. For example, interactive experience areas should be set up in exhibitions to allow visitors to participate in the exhibitions by touching, operating and playing games, so as to enhance the visitors' experience and learning effect. In educational activities, group cooperation and project-based learning are used to encourage audiences to actively participate in discussion, practice and innovation. At the same time, new media platforms are utilized to carry out online interactive activities, such as online science popularization contests, science quizzes, topic discussions, voting and selection, etc., to attract the public's participation and increase their attention and enthusiasm for participation.

In addition, it is also essential to establish a perfect public feedback mechanism. Museums should set up specialized feedback channels, such as suggestion boxes, online customer service, private messages on social media, etc., to collect feedback from the public in a timely manner, analyze and process the feedback from the public carefully, and improve the shortcomings in their work in a timely manner. For the public who actively participate in science communication activities and put forward valuable suggestions, appropriate rewards and commendations should be given, such as awarding honorary certificates, giving museum souvenirs, providing free visiting opportunities, etc., so as to motivate more public to participate in the science communication work of museums.

CONCLUSION

As an important social and cultural institution of science communication, museums play an irreplaceable role in popularizing scientific knowledge, enhancing public scientific literacy, and inheriting and innovating scientific culture, etc. Through various methods and approaches such as exhibitions and displays, educational activities, and new media communication, museums have made certain achievements in the practice of science communication, but they are also facing problems and challenges such as shortage of talents, ineffective communication, insufficient public participation, etc. In order to further improve the effect of science communication in museums, it is necessary to adopt optimization strategies in terms of strengthening talent training and team building, promoting the upgrading of communication efficiency, and enhancing public interaction and participation. It is important to strengthen cooperation with colleges and universities and scientific research institutions, cultivate professional science communication talents, establish a systematic training mechanism, and improve the level of the staff; follow the development trend of technology, actively introduce advanced science and technology, break the barriers of online and offline communication, and establish an in-depth cooperation mechanism between museums and science and technology enterprises and scientific research institutions; deeply understand the needs of the public, increase the interactive sessions, and set up a perfect feedback mechanism to improve public participation and satisfaction.

With the continuous progress of science and technology and the sustained development of society, the public's demand for scientific knowledge will continue to grow. Museums should keep pace with the times, continue to explore and innovate the methods and modes of science communication, give full play to their own advantages, integrate the resources of all parties, and make greater contributions to promoting the development of scientific and cultural activities in society. As demonstrated by Hein's constructivist museum theory, effective science communication must progressively shift from passive knowledge transmission to active meaning construction, where visitors' prior experiences and personalized learning pathways become central to exhibition design(Hein, 1998) . In the future, museum science communication will develop in the direction of more specialization, diversification and personalization, and become an important platform for the public to acquire scientific knowledge and cultivate scientific spirit.

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