Exhibition Design of the Thematic Science Popularization Space Based on Scientific Visualization

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***Abstract*—With the in-depth development of the concept of science communication, the thematic science popularization space has become a multi-dimensional place for the display and communication of popular science content. This paper combines the technical route of Scientific Visualization with the artistic strategy of exhibition design, and discusses the new method of science popularization space exhibition design from the perspectives of ontology, epistemology and methodology. Specifically, the guiding ideology of the current science exhibition design urgently needs to shift from Information Visualization to Scientific Visualization, so as to re-emphasize the relationship between people and other things, and establishes a modern concept for displaying scientific knowledge, scientific experience, and scientific communities.**

Keywords-component; scientific visualization; science popularization; exhibition design; new media art; multimedia technology

I. *THE CONNOTATION AND EXTENSION OF SCIENCE POPULARIZATION SPACE*

Popular science is an interpretation of science intended for a general audience. This concept came from the Popular Science Monthly, which was founded in May 1872 by Edward L. Youmans to disseminate scientific knowledge to the educated layman. After the concept was born, it presented different stages of development. From the mid-19th century to the early 20th century, the traditional stage focusing on "popularization of science", presented a one-way communication from scientists to the public. Since the mid-20th century, the modern stage concentrating on "the public understanding of science", changed the relationship between scientists and the public, and built up a two-way communication process.

Until now, the contemporary stage aiming at "science communication", introduces the third part besides scientists and the public, which including journalists, designers, government workers and so on. In terms of content of communication, the contemporary stage extends from the natural science to the social science and the humanities, and defines the connotation of science in a broad sense. In terms of mode of communication, science can be propagated to the public in many different ways. According to Karen Bultitude [1], a science communication lecturer at University College London, science communication can be broadly categorized into three groups: traditional journalism, live or face-to-face events, and online interaction. Among them, live or face-to-face events mainly include public lectures, science busking, popular science exhibits, science cafe and science festivals, which accelerates the spread of popular science knowledge in a certain space.

As the main form of dissemination of popular science knowledge in space, the thematic science popularization exhibitions can be traced back to the World Expo named "A Century of Progress" held in Chicago in 1933. Since then, the World Expo had set up themes to popularize scientific knowledge and promoted the scientific spirit. With the division of labor in society and the advancement of technology, the Thematic popular science museums (including the Natural Museum, Science Museum, and

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Technology Center) have been formed. People began to use the theme to distinguish complex exhibits and planned the display of popular science content.

However, with the intervention of Internet, the audience began to show a stratified trend, and the demand for popular science information also began to become diversified and differentiated. Thematic science popularization space was to be continuously refined. On the one hand, the science popularization museum has been planned a series of special exhibitions based on theme. On the other hand, some diminutive popular science content have also gone deep into the public space. Science popularization space has become a multi-dimensional place for popular science content.

II. *New Perspective: From Information Visualization to Scientific Visualization*

At present, the thematic science popularization space mainly pays much attention to visual effects and sensory experience with the support of digital multimedia technology. However, popular science content and scientific knowledge are often easily diluted by visually display. Especially for the thematic science space, the content value is greater than the form itself, and the visitors are still staying in the passive reception stage. The thematic science popularization space exhibition design deserves to be considered more.

The thematic science popularization space often carries certain humanistic value and scientific connotation. There is an urgent need to reconstruct them through Scientific Visualization. Card et al. [2] define the two forms of visualization as:

- Scientific Visualization: the use of interactive visual representations of scientific data, typically physically based, to amplify cognition.
- Information Visualization: the use of interactive visual representations of abstract, non-physically based data to amplify cognition.

While Scientific Visualization covers accurate visualizations of the real world, Information Visualization covers visualization of concepts that often are abstract in nature. The purpose of Information Visualization is to focus on exploration of the visual image in a static way, and the purpose of Scientific Visualization is to represent scientific knowledge and restore scientific scenes in a dynamic way.

The change from Information Visualization to Scientific Visualization is an innovation in the exhibition design concept of the science popularization space. Scientific Visualization is originally for scientists to gain insight into data relationships, but in the process of transformation, a large number of visual forms with rich aesthetic value and communication value were generated. As shown in Table 1, artists have begun to work together with scientists to create more interdisciplinary effects, which satisfy scientific research, scientific education, and even the science popularization [3].Taking the project "Beautiful Chemistry" as an example, the "Reaction Section" makes full use of the latest 4K video cameras to capture the colorful and subtle details of a chemical reaction, and "Structure Section" makes full use of the 3D animation and interactive technology to show the magical structure and symmetry in chemistry. Research centers such as NASA, NOAA, JPL and NSERC have collaborated with artists on scientific visualizations [4].

TABLE I. 5W ELEMENTS OF SCIENTIFIC VISUALIZATION

5W elements of Scientific visualization		**Original connotation**	**Evolutionary connotation**
Who	Creator	Scientist	Scientists and Artists
Says What	Content	Scientific data and information	Scientific knowledge, Scientific thought and Scientific spirit
To Whom	Recipient	Scientist	Scientists and the public
In Which Channel	Circling channel	Professional field	Interdisciplinary field
With What Effect	Effect and Purpose	Promote scientific research	Scientific research, Science education and Science popularization

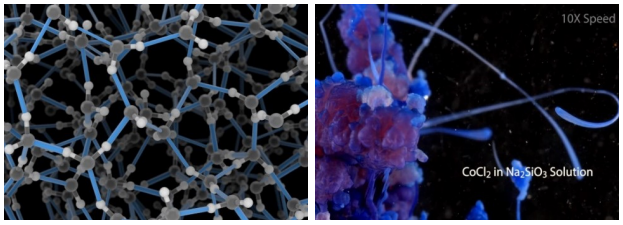

Figure 1. The project named Beautiful Chemistry, the left picture is "Structure Section", the right picture is "Reaction Section"

III. *Popular Science Communication Mode based on Scientific Visualization*

Information Visualization is only one-way dissemination of scientific knowledge, and Scientific Visualization is more suitable for the spread of scientific space, which returns to the human attribution of science dissemination. Specifically, the communication mode based on Scientific Visualization re-emphasizes the relationship between people and other things (Object, Society and Environment), and realizes the cross-propagation effect. It mainly includes three aspects: Scientific Knowledge Dissemination, Scientific Experience Dissemination and Scientific Community Dissemination.

A. Object-Society: Scientific Knowledge Dissemination

Dissemination of Scientific Knowledge is a spatial communication mode based on Object and Society. The science popularization space, as the exhibition place for explaining science, is the main space for visual display of scientific knowledge. The main characteristics include single-flow, small audience range and no feedback.

B. *People-Object-Environment: Scientific Experience Dissemination*

Dissemination of Scientific Experience is a spatial communication mode based on Object and Environment. As the exhibition place for experiencing science, the popular science space expands its one-way communication mode to two-way communication mode, which realizing the dissemination shift from the single scientific knowledge to scientific spirit, scientific method and scientific thought. The main characteristics include two-way communication, popularization and immediate feedback.

C. *People-Society-Environment: Scientific Community Dissemination*

Dissemination of Scientific Community is a spatial communication mode based on Society and Environment. As a spiritual place for spreading science, its communication process opens the communication channel of science and art. The main characteristics include interdisciplinarity, equality and the public participation.

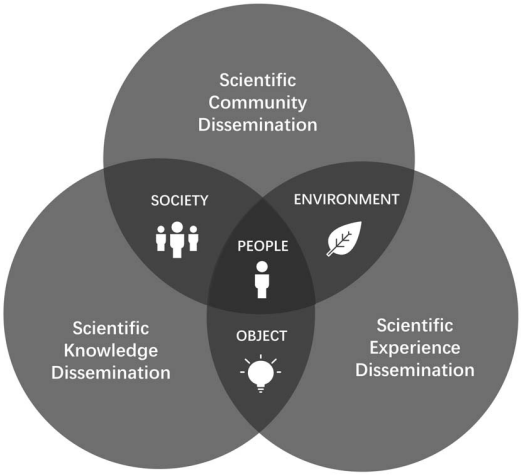

Figure 2. The communication mode based on Scientific Visualization

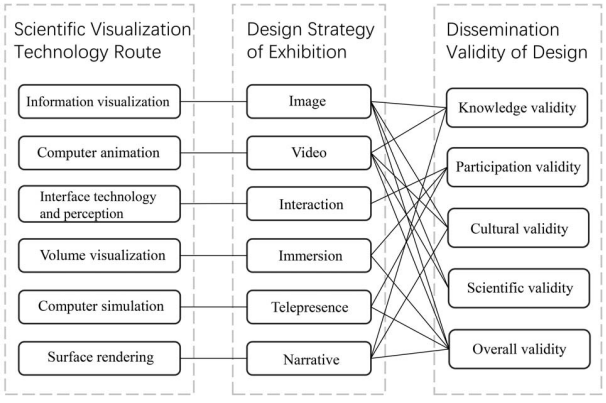

Figure 3. The exhibition design process based on Scientific Visualization

IV. *SCIENCE POPULARIZATION SPACE EXHIBITION DESIGN STRATEGY BASED ON SCIENTIFIC VISUALIZATION*

The process of exhibition design based on Scientific Visualization can be simply abstracted to designers' efforts to connect audiences to popular science communication through creating scene and space to achieve best audiovisual experience. Due to the application of Scientific Visualization, the whole process of exhibition design turns to be more complicated. When designing the exhibition space, designers should first consider the effect of the scene on the viewer's experience from the perspective of interaction, experience, immersion and so on. Then designers should combine the application strategies of Scientific Visualization in different levels of requirement to optimize the exhibition design.

As shown in figure 3, following the process of the exhibition design, Scientific Visualization technologies for science popularization space have been extended in three levels: scientific visualization technical route, design strategy of exhibition, dissemination validity of design. And they finally realize the construction of image, video, interaction, immersion, telepresence, narrative of exhibition design.

A. *Scientific visualization technology route*

Ed Ferguson et al. [5] define "Scientific Visualization" as a multidisciplinary approach, includes:

1) Information visualization: It focus on the creation of approaches for conveying abstract information in intuitive ways.

2) Computer animation: It is the art, technique, and science of creating moving images via the use of computers. Sometimes the target of the animation is the computer itself, but sometimes the target is another medium, such as film.

3) Interface technology and perception: It shows how new interfaces and a better understanding of underlying perceptual issues create opportunities for the scientific visualization community.

4) Volume visualization: It has become an essential technique for many sciences, portraying phenomena become an essential technique such as clouds, water flows, and molecular and biological structure.

5) Computer simulation: It is a computer program, or network of computers, that attempts to simulate an abstract model of a particular system.

6) Surface rendering: It is the process of generating an image from a model, by means of computer programs. The model is a description of three-dimensional objects in a strictly defined language or data structure. It would contain geometry, viewpoint, lighting, and shading information.

There are various types of thematic science popularization space, including the large-scale space represented by World Expo, the medium-scale space represented by science museum and the small-scale space represented by public science knowledge space. In this way, space of different scales is suitable for different Scientific Visualization techniques. Even if the same techniques are used, designers need to use artistic strategies to change ways of presenting. Take Computer Animation as an example, the small-scale space needs to be watched statically through TV,

computer, mobile phone and other display media, and large-scale space needs to place the animation in real space, where people can watch it in an immersive or interactive way.

B. *Design strategy of exhibition*

From the technology route in the previous part to the design strategy, the translation of information expressed by scientific and technological convert to art is required. For example, "Interface technology and perception" in Scientific Visualization is linked to the "Interaction" in exhibition design. It is necessary in the first place to conduct pre-research on the concept of human-machine interface, interface perception technology, face recognition technology and so on, and then put forward the interactive mode of interaction means in language, touch, gesture, lever, remote control and other actions and behaviors.

Based on the Scientific visualization technology route, a one-to-one artistic expression method is proposed in exhibition design. The design strategy of exhibition includes six aspects: image, video, interaction, immersion, telepresence, narrative, providing a systematic scheme for the vitality regeneration of popular science content.

1) Image: It is used in the broader sense of any two-dimensional figure such as a map, a graph, a photography, a painting or other two-dimensional picture. The image is the main means of information visualization at the level of content expression and cultural inheritance, showing the information essence of the design strategy.

2) Video: Derived from image, the essence of video refers to a continuous sequence of images. It is an electronic medium for the recording, copying, playback, broadcasting, and display of moving visual media. In exhibition design, the video includes various media forms such as animation, film, etc., showing the dynamic essence of design strategy.

3) Interaction: It is a kind of action that occurs as two or more objects have an effect upon one another. The idea of a two-way effect is essential in the concept of interaction, as opposed to a one-way causal effect. In exhibition design, interaction includes two systems of trigger and feedback, which directly establishes the communication relationship between people and scientific systems.

4) Immersion: It is a perception of being physically present in a non-physical world. The perception is created by surrounding the user of the immersive system in images, sound or other stimuli that provide an engrossing total environment. According to Adams [6], immersion can be separated into three main categories: Tactical immersion, Strategic immersion, Narrative immersion. Different space is suitable for different immersion methods, but their identical purpose is to give the audience flow experience.

5) Telepresence: Different from the feeling of being present, telepresence allow a person to feel as if they were present at a place instead of their true location. Additionally, users may be given the ability to affect the remote location. In this case, the user's position, movements, actions, voice, etc. may be sensed, transmitted and duplicated in the remote location to bring about this effect. This methodology has been used extensively to develop skills in tele-intuition for audience participate in exhibition at any time and any place.

6) Narrative: It is a telling of some true or fictitious event or connected sequence of events, recounted by a narrator to a narratee. The narrative of exhibition design mainly refers to the spatial narrative characteristics of exhibition. Different from the linear narrative logic, the spatial narrative of the exhibition mainly focuses on three-dimensional spatial information including color, lighting, texture, multimedia, etc. The juxtaposition of information shows the theme of the exhibition as a whole and brings unlimited imagination to the audience.

C. *Dissemination validity of design*

After the introduction of the technology and art strategy, exhibition design needs to conduct a scientific evaluation of dissemination validity to form a closed-loop scientific research practice design. The validity study includes five elements: Knowledge validity, Participation validity, Cultural validity, Scientific validity, Overall validity. Image, video, and narrative are passive viewing methods, while interaction, immersion, and telepresence are active viewing methods, so the latter three factors are evaluative features of Participation validity.

Firstly, from the perspective of method, the five validity elements of exhibition design are relatively abstract concepts, which need to be evaluated through subjective evaluation, objective data analysis and other methods. In the design of the subjective evaluation scale, the measurement of participation involves a variety of factors such as the number of parameters of the audience, the quality of participation, and the means of participation, which need to be collected by controlling variables.

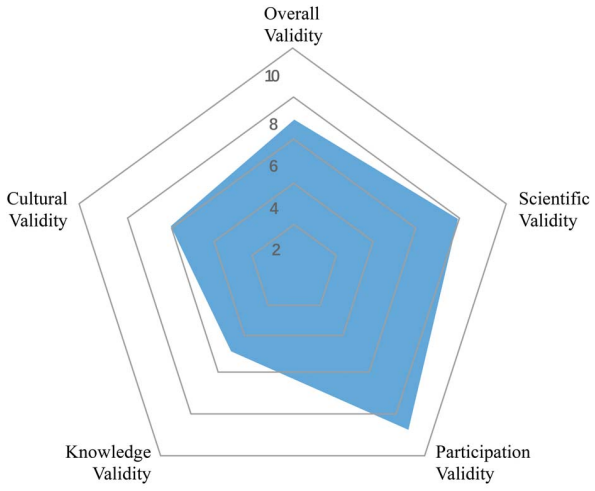

Figure 4. The efficiency measurement table

Secondly, from the perspective of process, the evaluation criteria and evaluation items of dissemination validity may also change according to the development of the research on the presupposition. Finally, from the result point of view, it is necessary to establish the efficiency measurement table shown in Figure 4 to complete the visual analysis of design propagation validity, which is convenient for horizontal and vertical comparison.

D. *Case study: Micropia Museum in Amsterdam*

According to research, microbes are everywhere, and everyone carries more than two kilograms of bacteria. Although they are usually associated with diseases, humans also need to rely on microbes to survive. Micropia Museum is located in Amsterdam, which aims to declare through such a contradiction that microbes are neither signs of contamination nor the cause of disease, but an important basis for our understanding of the internal and external worlds. As a whole, Micropia is not just a museum, but also functions as a platform, a link between people and science. Seeing and experiencing is kept central, with the focus on the (mostly positive) relationship between microbes and visitors.

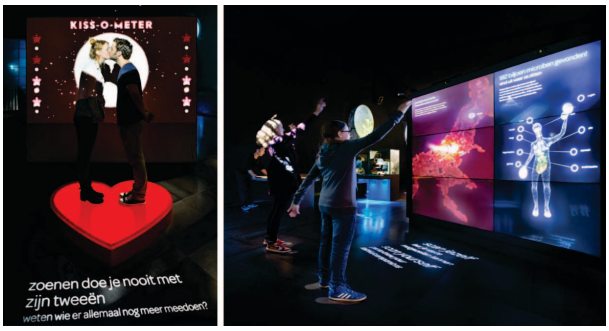

Figure 5. The design strategy of exhibition based on Interaction

Figure 6. From the first floor to the second floor: an science popularization space exhibition design based on Knowledge validity

Firstly, Micropia introduces a large number of technical strategies related to Scientific Visualization, such as human body scanners, microscopes, interactive devices, and computer animation. Here, visitors can see, explore, and experience all aspects of microbes, and even make themselves part of the exhibition to achieve the purpose of balancing interactive experience and knowledge learning.

Secondly, the museum makes comprehensive use of the above mentioned six aspects of exhibition design strategy, and emphasizes points of Interaction and Narrative. For Interaction, you can discover how many bacteria you exchange with a French kiss. On a life-size screen you can see how many microbes "live" with you. For Narrative, the only light in Micropia comes from the exhibited objects. It is an inverse laboratory: not white and sterile but dark and mysterious. All eyes are automatically on the microbes.

Thirdly, the museum does not neglect the dissemination validity of scientific knowledge because of its emphasis on Interaction and Narrative. The first step is to take the elevator to the second floor after purchasing the tickets. As the elevator rises, the computer animation zooms in on faces, closer and closer, smoothly transitioning from actual video to animations of eyelash mites and skin cells, then bacteria, and eventually viruses. In the second step, in addition to the various experience devices mentioned in the previous section, a real laboratory is set up on the second floor, where the audience can observe technicians cultivating microbes and preparing exhibits. The third step is to walk back up the spiral staircase to the first floor to operate the various microbial learning devices. From dark to bright, we can learn almost everything about microbes.

V. SUMMARY

Our work provides a new design path for the Thematic Science Popularization Space. Design strategy and dissemination validity shown here are not all inclusive or definitive. While they are representative of basic theories, they do not account for the full complexity that emerges from Scientific Visualization. Future work includes testing this system in practice to show more possibilities of science communication. Guided by Scientific Visualization, the exhibition design furtherly combines human cognition and emotion with multimedia technology, and establishes a specific scene connection between human and science.

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