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Case study

The development and evaluation of Chinese digital science and technology museum

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ABSTRACT

There has been a considerable increase in the needs for implementation of multimedia representation technology into the museum field to develop online exhibitions and enhance museum educational functions. China Digital Science and Technology Museum (CDSTM) is such an emerging effort in this field. The purpose of CDSTM is to provide solutions to issues of unbalanced museum distribution, exhibition space limitation in China and seeking more ways to offer diverse and multimedia-rich exhibitions. This paper addresses the application of incorporating innovative and rapid digital technology in digital science and technology oriented museum development in China. Three modes of online exhibitions have been developed to emphasize user experiences through extensive application of animation and virtual reality technologies. CDSTM's e-learning functionality in promotion of scientific literacy in the public and enhancement of formal school science curriculum is also discussed. In addition, evaluation on users' expectation and satisfaction is conducted to identify perception based on questionnaire and web logs. The feedbacks indicate that CDSTM has positive impacts on mitigating traditional science and technology museum challenges, and has the potential to promote science education and science literacy in public as well.

1. Introduction

As an important part of the public service system and national culture and educational infrastructures, science and technology oriented museums, including subject-specific science museums (e.g., the air and space museum), natural science museums (e.g., the natural history museum), science and technology museums (e.g., the science museum or science center), take responsibilities to increase the public's general understanding of science and technology and promote the public's engagement with science and technology. However, such museums in China are under great pressures and could not fully perform their social roles because of some critical problems.

The first problem remains that the quantity of science and technology oriented museums are too small comparing to the huge amount of population in China. Statistics in 2008 [1,2] show that China has around 700 science and technology oriented museums. Among them, 40% are natural science museums (also called as the natural history museum); 39% are science and technology museums (also called as the science center); 21% are specific subject based technology museums [1,2]. The ratio between the number of such museums and population in China is only 1/4 that of United States and 1/8 of Japan [1,2]. In addition, the geographic distribution of these museums in China is obviously imbalanced. Most museums are located in comparatively developed areas in the south and east. To be more precise, around 48% are built in east China, 32% in central China, while only 20% in the west [1,2], which inevitably hinders people living in more remote areas to visit.

The second problem is that exhibition space is rather small. Most of such museums only provide 36% of their museum space for exhibit presentation in average, which is much lower than China's criterion – no less than 50% [3]. This confined space hinders exhibition designers to present innovative exhibits and therefore reluctant to update their exhibits. Unchanged or less changed settings make revisiting unnecessary. Statistics show that only 16.4% people visited science and technology oriented museums per year in China for this reason [4].

Thirdly, most of visitors expect museums to generally improve their knowledge and expand their learning horizons, which require

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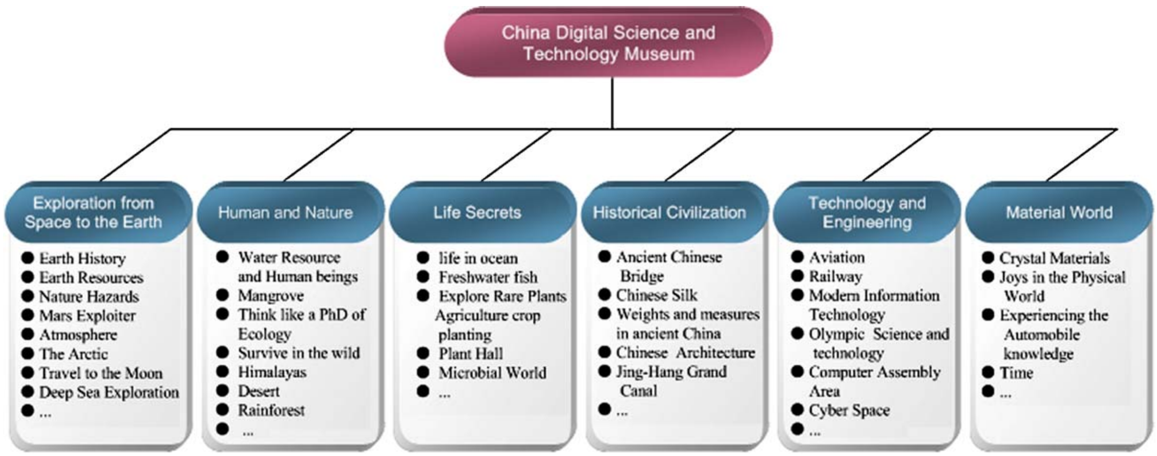

Fig. 1. Themes and sessions of online exhibitions in CDSTM.

designers to represent exhibitions involving varying degrees of depth of information, options that facilitate visitors' flexibility and choices in an interesting, informative and easy-to-understand way [5]. However, many science and technology oriented museums in China organize their exhibitions mainly with static objects or artifact models involving little interactions. Usually, these exhibits are labeled with some professional terminologies, which is not easy to understand and can hardly meet public's general expectation and requirements [2].

In general, the above-mentioned reasons make great barriers for science and technology oriented museums in China to meet their social roles and reach their purposes. To tackle the problems discussed above and with the purpose of stimulating the public's interests in science and promoting their scientific literacy, China government embarked a national founded, non-profit project, China Digital Science and Technology Museum (CDSTM) in 2006.

CDSTM is a collaborative project supported by China Association for Science and Technology, Chinese Academy of Sciences and Ministry of Education. The aims of CDSTM are to take the best use of advanced information technologies to (1) exhibit achievements and advances in science and technology and how science and technology impact on social life in the past, present and future; (2) be a connection between latest science and the public.

This paper represents the ongoing endeavors in the development of CDSTM and discusses its applicability to support formal and informal science education. The rest of this paper is structured as follows. Section 2 gives details about the design and representation of CDSTM's online exhibitions. Section 3 concerns CDSTM's e-learning applications. Assessment and evaluations to CDSTM are presented in Section 4. Future development and improvements of CDSTM from previous experiences and users' feedbacks are discussed in Section 5.

2. Exhibition representations

CDSTM aims to emphasize user experiences through extensive use of animation and virtual reality technologies so that the general public would easily understand essential knowledge in science and technology, and increase the engagement with science. CDSTM would like to combine leisure and learning through its design and development because this is a most valuable asset that museums can offer [6].

Six themes are selected and developed in CDSTM for help and service to work for science popularization. The themes cover topics ranging from Earth science, biology science, physics science, technology and engineering, environment and sustainable development. Each theme consists of several subject-specific sessions (Fig. 1). Ninety sessions in total have been developed and released on CDSTM web site (http://www.cdstm.cn). They are designed in three modes: the 'virtual museum' mode, 'interactive experiment zone' mode, and 'resource bank' mode.

The virtual museum transfers the front edge of the development of science and technology and deeply dissects the scientific connotation behind the events of science and technology and their major impacts on people's life in order to advocate ideas of science and expand public's science perspectives.

The interactive experiment zone integrates and improves various hands/minds-on resources so as to build a virtual environment or platform for users to understand how to think like a scientist and experience the procedure of science inquiry across the hurdles of time and space, which will trigger creativity, a more serious science attitude and a stronger capability of solving scientific problems.

The main task of the resource bank is to build a high quality database of popular science resources and to provide source materials for educators to conduct science education.

2.1. Virtual museum

One of the key characteristics of the 'virtual museum' mode is to integrate and link various multimedia representations to create highly interactive and visualized online exhibitions. Every format of multimedia plays a specific role in exhibit interpretation and enhances the effect when combined into one interface [7–10].

An example from this mode is *Science and Technology of Ancient China* session (http://amuseum.cdstm.cn/AMuseum/ancitech/). Science and technology of ancient China, which had generally stood in the forefront of the world during a very long period before 16th century, is an important part of Chinese ancestors to witness the glories in history. In this session, animations and simulations are widely used to show how ancient Chinese developed technologies to improve their life in four essential requirements of people: food, clothing, housing and transportation.

Taking textile technique as an example, China is known as a country with rich heritage of making textiles. Ancient Chinese textile had developed to an advanced and improved stage in terms of growing cotton, flax plant, mulberry tree and silkworms, using minerals and plants as dyes, and developing textile equipments[5].

[5] Chinese Brocade, http://en.cnaca.net.cn/knowledge.asp?id=155.

Fig. 2. Snapshot of an ancient Chinese handloom—*Yaoji*.

Yaoji (one kind of the oldest ancient handloom and widely used in ancient China) was a representative case of those weaving equipments. In this section, texts and illustrations are used to depict the basic structure and principle of *Yaoji*. A flash animation has been developed to redisplay how *Yaoji* works to produce textile. The illustration constructs a scenario that an ancient Chinese young lady is sitting on a mat in a sunshine afternoon. *Yaoji* is laying on her legs and fixed by her feet through an axe on one side while another side of *Yaoji* is fixed around her waist by a waistband. Press the “Play” button on the right bottom of the illustration, the flash demonstration with narrations would be loaded and run to show you clearly how *Yaoji* produces patterned cloth step by step (Fig. 2).

2.2. 2.2 Interactive experiment zone

Interactive hands-on science could make a major contribution to science education even though its effect would not be immediately and directly [11]. Previous researches show that increasing, innovative variations help to capture more effectively the diversity in visitors’ ideas and mental processes [12]. So we invite online visitors to not only read the online contents from a distance, but also involve in the virtual interactive experiment zone by controlling variables and observing the consequence.

Taking *Giant Panda online observation* section as an example, Giant Panda lives in a few mountain ranges in central China, mainly in Sichuan, and also in Shaanxi and Gansu provinces. In “*Giant Panda*” session, developers set a remote operable WebCam in ‘Wolong Giant Panda Nature Reserve’, which is located in Sichuan province. Users with a registered account have the privilege to control the WebCam and observe the Giant Panda in Wolong online through the WebCam (only one user one time), which provides a good opportunity for people who love Giant Panda but could not go to the zoo to closely watch them in person. Users are allowed to record their observations in online forms and submit to the server. They can also shoot short videos of Giant Panda online and save the video as a souvenir keeping for themselves or sharing with other users. These records and shooting videos are listed by submitted time and shared with all web visitors (Fig. 3). This online interactive observing experience helps to enhance people’s interests in panda by involving them in panda’s daily life in a nature environment rather than in a zoo.

Meanwhile, a simulation is developed for online visitors to get familiar with a series of variables that scientists set for raising a baby Giant Panda. In this simulation environment

Fig. 3. Observation reports submitted by registered users.

(http://b1museum.cdstm.cn/giantpanda/virtualgame/partone_2_box.html), users can change the volume of input parameters (such as the room temperature, humidity rate, milk volume and daily frequency of feeding a baby Giant Panda) and observe how these changes might affect its growing under an artificial breeding mode.

2.3. Resource bank

Multimedia representations developed by the above two modes, as well as posters, cartoons and audiovisual works, reports, research materials digitized from physical science museums and other institutes are all stored in a relational database and catalogued by their themes. This database will assist to effectively solve the rising problems of shortage of popular science resources and materials, as formal and informal science education are carried out. All digital representations are described in metadata sets so that they can be extracted dynamically and sorted by subject, media type or updated time, which naturally constitute an online resource bank for targeted users. Besides that, metadata description and URL of each single resource can be extracted dynamically to form a new page for further reading. Online visitors can have a quick and direct access to their interesting resources by using a keyword-based or full-text search. In addition, all resources listed in this part can be downloaded for further use. For example, science teachers may download pictures or animations for demonstration in a classroom teaching. School students may need an illustration for their presentation to explain a natural phenomenon. Public users may desire to understand a technique mechanism reported in news. The metadata description and searching tools make these requirements easy to locate their intended information within CDSTM. In a word, educators and anyone who are interested in promoting science can draw resources online and produce their own digital contents for science education and learning.

3. CDSTM applications

The most straightforward application of CDSTM is to aid science education. It serves education purposes by (1) enhancing formal school curriculum by providing extra materials to explain concepts, phenomena and processes in various ways to help understanding and promote deep learning; (2) expanding perspectives by providing knowledge that explain phenomena relevant to daily life beyond school learning.

For example, earthquake is fundamental content of natural hazards chapter in middle school science curriculum. In contrast of comparatively limited length and space of textbooks, CDSTM represents a holistic picture of earthquakes and helps to understand the nature and origin of earthquakes, as well as what to do before, during and after an earthquake. Teachers could utilize those contents to enrich their lecture demonstration while students could browse them as a supplement after class. Earthquake related contents in CDSTM are organized both by the subject-based virtual museum mode and experience-based interactive mode. In the former mode, for instance, in *Earth's History* virtual museum, it portrays the underlying physical processes of earthquakes with three-dimensional illustrations and interactive animations. In *Earthquake* interactive experience zone, users could learn how scientists measure and locate an earthquake by studying seismic waves with an interactive simulation program. Also, they are allowed to change variables to 'witness' how instrument calculates the amount of ground motion and pinpoints the location, depth and size of an earthquake. Some great historical earthquakes over the world are also presented and analyzed in *Earthquake* virtual museum, including their mechanism, intensity and the way scientists record earthquake by seismometers up to a great distance.

Besides of the online learning service, CDSTM also provides offline services to fulfill its educational purposes. Most pictures and images in CDSTM are in high resolution which can be downloaded freely and inserted into posters for science popularization activities or exhibition designs in physical science centers. For example, after the 7.9 magnitude earthquake which hit Wenchuan in western China in May 2008, CDSTM developed a column named *Wenchuan earthquake* and attracted a wide attention from the public. China Association for Science and Technology also constructed posters and brochures with the aid of texts, images, illustrations downloaded from this column and organized a Wenchuan earthquake oriented exhibition in Science Center of Shenzhen City, which attracted nearly 40,000 visitors.

Table 1
CDSTM visiting statistics from September 20, 2006 to June 30, 2009.

Item	Data
Page views	68,364,840
Network flow (Mega byte)	16,848,610
Daily unique visitors	6,726
Page views per day	74,068
Page views per user	11

Table 2
Most expected themes from CDSTM.

Themes	Percentage[a] (%)
Science literacy which close relate to daily life	26
Scientific principle and viewpoint	24
Latest science and technology news and newly applications	21
Funny scientific games	19
Others	10

[a] This column is normalized from the original data.

4. Assessment and evaluations

CDSTM was released online in the late of 2006. From September 20, 2006 to June 30, 2009, there are 68,364,840 page views according to web log record (Table 1). In 2008, an online survey was conducted to assess users' satisfactions on CDSTM and therefore offer suggestions for modifications and further improvements with aspects of contents, knowledge distribution modes, exhibition designs and so forth. Two thousand one hundred and sixty-five anonymous users have participated in this online survey and submitted their feedback from January to June, 2009.

The survey tells us what themes that the public mostly expect CDSTM to reflect (Table 2). They are (1) science literacy which closely relates to daily life, such as air pollution, water conservation, disease and health; (2) principles and viewpoints of science and technology; (3) latest science and technology news and newly applications.

Moreover, over 50% of participants expect CDSTM to help them expand their science knowledge, and over 40% hope they could get assistance to solve real problems, either in work or at home, shown in Table 3.

In addition, the web log analysis from December 2006 to June 2009 is consistent with the above results. Among its 6,207,818 page views during this period, diseases, energy conservation, earth-

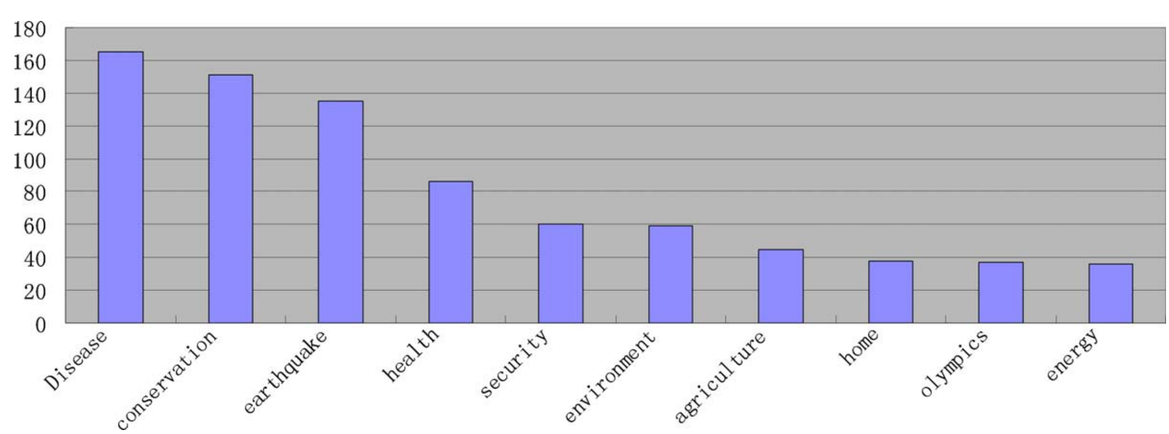

Fig. 4. Ranking of user concerning themes.

Table 3
What the public expect most to get from CDSTM.

Aspects	Percentage[a] (%)
Learn and expand knowledge in science and technology	51
Help to solve problems in daily life	22
Help to solve problems in work	19
others	8

[a] This column is normalized from the original data.

Table 4
Public' satisfaction on CDSTM.

Item	Percentage[a] (%)
Very satisfied	33
Satisfied	52
Not satisfied	14
Not sure	1

[a] This column is normalized from the original data.

quakes, health and security were top 5 most visited themes (Fig. 4), which are all tightly related to human's daily life and contain basic scientific theories and principles.

Besides, among three representation modes, the experiment zone and resource bank are more welcomed than the virtual museum for the reason that interactive representations are more attractive than still representations. Over half users approved the knowledge distribution mode of CDSTM by Internet, except that few gave negative feedback.

In general, most of survey users gave positive feedbacks to CDSTM (Table 4). Meanwhile, around 95% survey users expressed that they would like to visit CDSTM again, while only 5% said they would not visit CDSTM any more.

5. Discussion and conclusions

CDSTM is intended to serve as an online garden of science popularization for the public. On this platform, the public could enrich their knowledge of science, experience science processes, arouse their creativities, learn recent advancements of science and technology, as well as share extensive resources for science popularization.

CDSTM tackles the problem of a wide call for science literacy education and inequitable distributed science literacy resources and opportunities. It provides an equal access and diverse multimedia-rich exhibitions online without borders. Current feedbacks from online surveys, visiting statistics and application cases affirm that CDSTM has effective and practical properties in formal and informal science education. On the other hand, construction of CDSTM has not yet completed. Current practice and study also suggest two directions for further developments. Firstly, there are growing needs for wide aspects of digital exhibitions. The content development should concern public's requirements and help them expand scientific viewpoints. Latest science and technique news, new digital contents should continuously be updated to CDSTM. Secondly, different educational levels of user intend to have different and specific interests in themes and representation modes. Web logs and cookies are a good way to trace users' online habitats while evaluations and questionnaires are always good ways to get familiar with our audience for iterative modifications and improvements.

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