Study on Popularization of Science and Technology Infrastructure Development in China

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Abstract—In 2009, a project of monitoring and evaluation on China's Popularization of Science and Technology Infrastructures (PSTI) development was conducted. The index system for China's PSTI development was studied and established. By using these evaluation indexes, monitoring and evaluation on China's PSTI was carried out and abundant detailed data were collected. Through the analysis of the monitoring data, a comprehensive understanding of China's PSTI development status was obtained, the reason was analyzed, and the trend of China's PSTI development was forecasted. These results can not only lay a solid foundation for annual monitoring and evaluation project of China's PSTI in future, but also provide a policy making support for accelerating China's PSTI construction. And the authors believe this research will be a precious reference for other countries and regions on PSTI development.

Keywords: Popularization of Science and Technology Infrastructures (PSTI), development status and trend, monitoring and evaluation, index system

I. INTRODUCTION

Many people are motivated by intrinsic interests outside of formal learning settings. In fact, a common memory of an early science-related experience is likely to be that of an informal science event—visiting a zoo or science exhibit, seeing a science program on television, talking to a scientist about his or her work, exploring nature in the backyard, or even doing kitchen “experiments” [6]. Dr. Friedman pointed out that even those who receive PhDs spend 92% of their life outside of classrooms, so informal education must usually be the predominant mode of lifelong learning [11].

The U.S. National Science Foundation (NSF) has supported Informal Science Education (ISE) programs since earlier 1950s. That not only funded organizations to do a variety of informal science education activities, including museum exhibits, television series and programs for youth or the general public and so on, but also supported some institute for evaluating such ISE programs, particularly held in natural history museums, science-technology centers, aquaria, nature centers, biological gardens, arboreta, zoological parks, and libraries [6].

In 2006, the Chinese Government promulgated the Outline of the National Scheme for Scientific Literacy (2006–2010–2020). The construction project of Popularization of Science and Technology Infrastructures (PSTI) was taken as one of the four basic projects in the Outline [3]. Subsequently the Infrastructure Development Planning on Popularization of Science and Technology (2008–2010–2015) was issued to promote a comprehensive, coordinated and sustainable development for China's PSTI, and then to provide the Popularization of Science and Technology (PST) service support for enhancing of civic scientific literacy.

PSTI is an important base for PST work [10]. It is the key component in the entire public service system and informal science education in China. Hence Chinese government put much effort to improve it and promote the scientific literacy of general public through the Outline and the Planning. But how the PSTI situation is and what role it takes is not known exactly in China, so it needs to be committed to investigate and evaluate the PSTI development.

In the international context, there have been many researchers focusing on evaluation of development status, the Human Development Index of United Nations Development Programme (UNDP) for example. As for the informal science education or popular science field, more researchers are concentrating on performance evaluation[1,4-5,7-9,12-13,17-18], whereas, there is hardly a research report or essay discussing the integral development evaluation when taking all sorts of venues and facilities intended to informal science education or popular science as an entire system.

II. CATEGORY OF CHINA’S PSTI

According to the Planning, the majority of PSTI categories in China is including: Science and Nature Museum, Internet PSTI, Grassroots PSTI, and other popular science education venues (such as the Science and Technology Education Bases) [10].

The Science and Nature Museums are those museums that are main means for the public to carry out the main function of science education and display natural sciences, engineering sciences, agricultural sciences, and medical sciences [14]. It includes the Museum of Science and Technology (Science Centre), Natural Museum (Natural History Museum, Planetarium, Geological Museum, etc.), Engineering (professional) Science and Technology Museum and so on.

The Internet PSTI (Digital Science and Technology Museum) mainly refers to the use of modern information technology, integration, development of science-related network resources to the Internet as a platform for the public on the popular science education infrastructure. Those are
including a number of science museums, science websites, science channel and other comprehensive sites.

The Grassroots PSTI main means venues of counties (cities, districts) and towns (sub-districts) and villages (communities), to carry out science activities. This kind of science facilities includes the popular science activity stations (center or activity room), community science schools, science parks, science bulletin boards (Science Gallery), science wagons and other facilities.

Other PSTI (Science and Technology Education Bases) mainly refers to the teaching, research, production and service institutions, which open for society and the public with specific science and technology education functions. That includes cultural centers, Youth Palaces and other similar cultural or educational venues; zoos, ocean parks, forest parks, nature reserves, tourist and historical sightseeing of Science and Technology features and other public places; research institutions and universities, laboratories, showroom or research centers, astronomical and Meteorological observatories, field observation stations; enterprises, rural and other production facilities open to the public (or processes), technology zones, exhibition halls, etc.; the other Science and Technology education organizations or facilities which open to the public.

As one of the main science infrastructure in urban area, Science and Technology museums are the cities’ service center for Science and Technology communication. Science and Technology museums usually have relatively large spaces, obtain ambulant science education resources and hold important positions among all sorts of PSTI. PSTI facilities locating on the grassroots level are small in construction scale and huge in number. They play a "moisten things silently" role at the grassroots level for science popularization work. Internet PSTI is a rising star, developing rapidly and becoming the new force of PSTI’s construction and development. The science and technology education bases are helping make full use of social resources of science facilities, playing an important complementary and supporting role for PSTI construction and development.

III. ASSESSMENT OF CHINA’S PSTI DEVELOPMENT

A. The Method of Evaluation

According to the category of PSTI, there was a huge amount of varieties science and technology venues and facilities in China. In the last 20 years, China’s PSTI development achieved a rapid progress. From a macro-level point, PSTI was taken as a whole and assessed by system analysis method.

PSTI is a supporting system for the science popularization work, which is constructed by the subsystems of PSTI. The PSTI system is a stratified, structural and integrated system.

During the process of assessment, the PSTI system’s overall function, development status and prospect were evaluated, meanwhile different sort of PSTI facilities was taken as separate component of the whole PSTI system.

Firstly, to determine the purpose of the assessment. The purpose of China’s PSTI research and evaluation is to get an overall understanding of the development status and main problems at present in order to promote a healthy development of China’s PSTI in future.

Secondly, to determine the assessment content. The final target for PSTI construction and development in China is to provide more chance for public informal science education. Whether or not the Chinese public can get access to informal science education often and conveniently is one of the assessment elements for PSTI evaluation. The scale of PSTI construction is another element for assessment, since the scale of PSTI construction status will interfere directly on the scale of public informal science education service. Furthermore the sustainable informal science education public service depends on a healthy structure of PSTI system, so the assessment on software and structure of PSTI system is also included. Scale, structure and effect are three elements of China’s PSTI assessment. These three elements as a whole can entirely reflect China’s PSTI development and capability of informal science education.

Lastly, to construct the assessment model. Assessment on China PSTI is applying the evaluation index system [15]. The main advantage of evaluation index system is better for comparison analysis, including province comparison and historical comparative research. On the other hand, the deficiency is difficult to design indicators that can fully describe the PSTI development.

B. The Process of Evaluation

1. The Index System of Evaluation

China’s PSTI development assessment has the comprehensive character. On the basis of SMART rule for index designation and considering the three key elements for PSTI (scale, structure and effect), China’s PSTI development evaluation index is composed of 3 dimensions, 7 indicators and 23 items. (Table 1)

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1 SMART: Specific, Measurable, Achievable, Realistic, Timed.
The index system is not only a quantitative measurement of the development of different sorts of PSTI, but also a measurement of the quality of the assets of China’s PST infrastructure and personnel, as well as facilities capacity of self-building and sustainable developing. Meanwhile, the index system helps to monitor the situation of the main group of beneficiaries; use ratio of facilities and benefited scale among the entire population, etc.

To investigate the PSTI scale, the index system monitors the human, financial and material of PSTI by the indicators such as type, amount, resource, and property and manning. By the application of this index, we can measure the level and capacity of science popularization service; understand PSTI’s service scope and educational function.

By monitoring the investment, expense, resource application and efficiency along with development of exhibition resource, we can comprehend government and social support on PSTI, expense on facilities fund as well as application and development of facilities. We can assess the sustainable capacity of PSTI to estimate its life cycle, service scope, health status and service performance.

By monitoring the social effect and citizen benefit rate, we can realize the social impact, application efficiency, capital input-output ratio and universal benefit degree to inspect the PSTI’s social effect. Through the indicators PSTI service quality and sustainable development effect can be measured and data reference for the health, coordinated and sustainable development of China’s PSTI can be provided.

2. Data Collection and Process
a) Data collection
According to the mentioned evaluation index, special questionnaires were designed for different sort of PSTI. In 2009, a survey on PSTI was conducted in mainland China (not in Hong Kong SAR, Macao SAR and Taiwan). 5492 questionnaires were collected among 31 provincial districts. Except for null and invalid questionnaires, there are 618 from science museums, 3468 from science education bases, 440 from grass-root science facilities, 250 from science wagons and 601 from online science facilities.(the validity of the data close to the end of 2008)

b) Index weighting
A Delphi rule was adopted in the index weighting process [2]. The evaluation index was distributed to relevant scholars, officials and PST current employed people to fix the weight of each item and three dimensions. Finally we fix the weight of PSTI evaluation index as: scale weight of 0.3, framework weight of 0.3 and effect weight of 0.4.

c) Non-dimensional processing of data
Standardized treatment methods were applied on the data non-dimensional processing [16]:
set item \( x_j \) \((j = 1,2,3...m)\) observed value is \( x_y (i = 1,2,3...n \mid j = 1,2,3...m) \). \( x_y \) stands for the sector(i) value of item(j)

\[
X'_y = \frac{X_y - \overline{X}_j}{s_j}
\]  

\( \overline{X}_j \) stands for the average score of sector(j). \( s_j \) stands for SD of sector(j). \( X'_y \) is the standard observation value.

3. The Results of Evaluation
According to the survey data, we got the result of the evaluation on the present development of PSTI in china. The evaluation result is shown as Table2.
TABLE 2  CHINA’S PSTI DEVELOPMENT EVALUATION RESULT
(scores in table range from 0 to 100)

<table>
<thead>
<tr>
<th>district</th>
<th>score</th>
<th>district</th>
<th>score</th>
<th>district</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaanxi</td>
<td>100</td>
<td>Hebei</td>
<td>77.96</td>
<td>Xinjiang</td>
<td>64.93</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>98.09</td>
<td>Ningxia</td>
<td>76.97</td>
<td>Fujian</td>
<td>63.32</td>
</tr>
<tr>
<td>Beijing</td>
<td>93.49</td>
<td>Guangxi</td>
<td>75.86</td>
<td>Sichuan</td>
<td>62.41</td>
</tr>
<tr>
<td>Liaoning</td>
<td>90.06</td>
<td>Huizhou</td>
<td>75.11</td>
<td>Shanxi</td>
<td>62.27</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>86.67</td>
<td>Anhui</td>
<td>70.59</td>
<td>Jiangxi</td>
<td>60.56</td>
</tr>
<tr>
<td>Tianjin</td>
<td>86.38</td>
<td>Henan</td>
<td>70.36</td>
<td>Shanghai</td>
<td>60.12</td>
</tr>
<tr>
<td>Hunan</td>
<td>84.72</td>
<td>Chongqing</td>
<td>68.06</td>
<td>Qinghai</td>
<td>60.07</td>
</tr>
<tr>
<td>Shandong</td>
<td>84.68</td>
<td>National average</td>
<td>67.89</td>
<td>Gansu</td>
<td>33.42</td>
</tr>
<tr>
<td>Guangdong</td>
<td>81.17</td>
<td>Heilongjiang</td>
<td>67.86</td>
<td>Tibet</td>
<td>14.33</td>
</tr>
<tr>
<td>Inner Mongolia</td>
<td>79.91</td>
<td>Yunnan</td>
<td>67.81</td>
<td>Hainan</td>
<td>8.72</td>
</tr>
<tr>
<td>Hubei</td>
<td>79.09</td>
<td>Jilin</td>
<td>67.40</td>
<td>The Xinjiang Production and Construction Corps 0</td>
<td></td>
</tr>
</tbody>
</table>

Note: Because it is the first assessment, the indicators of the growth rate are obtained directly from investigating data instead of growth rate.

It can be learned from Table 2 that the mainland’s 11 provinces and cities locating on the eastern part, such as: Beijing, Tianjin, Hebei, Liaoning, Jiangsu, Shandong and Guangdong rank relatively higher. Shanghai got a lower score which can not reflect the real situation. Maybe the inadequate amount of samples in Shanghai resulted in the deviation of the survey result. The central region such as Hunan, Hubei, Henan, Anhui ranked a relatively better position compared with the western provinces such as Chongqing, Yunnan, Xinjiang, Sichuan, Qinghai, Gansu and Tibet. In general, the eastern region's PSTI development status is better than that of the western regions and ranks higher above the national average level.

According to the further analysis of survey data, China’s PSTI currently experiences a good momentum of development, undergoing a new wave of construction boom. According to the survey, the PSTI emerged as showing a rapid development trend on both form and scale aspect, with further expanding the scale of public participation.

Science and Technology Museum has become a more reasonable communication system, with scientists, engineers and the public stand on an equal exchange and communication platform. According to the incomplete investigation by the research group, there are approximately 600 Science and Technology Museums in China currently. Among them, there are 270 comprehensive S&T Museums, 120 professional S&T Museums and 200 Museums of Natural Museums. A diversity and wide range museum system has been formed, which is including Science and Technology Museums, Museum of Natural Science, Industry Science and Technology Museum (such as transportation museum, telecommunications museum, railways museum, geological museum and agricultural museum, etc.).

The Grassroots PSTI are divided into two major categories as fixed and mobile science facilities, which are constructed according to local conditions, flexible development and distributed throughout urban and rural areas. The fixed science facilities including popular science bulletin boards (Popular Science Gallery) and the science activity stations (centers or science activity rooms) located through sub-districts, communities and towns, science schools, science parks, agricultural science service stations, science information stations and so on. According to recent statistics, there are more than 270,000 science activity stations with the site area of more than 11 million square meters; 32 million science bulletin boards (Science Gallery), with a total length of over 2.1 million linear meters; over 2000 electronic science bulletin boards (Science Gallery), which can last more than one million hours. The mobile science facilities included science wagons, popular science show vehicles and other mobile facilities for science advocacy services. So far, there are 270 Science Wagons which are dispensed by China Association for Science and Technology (CAST).

There were more than 600 science popularization websites and 90% of them were running well. Online science popularization concerns to more than 50 subjects, including mainly 5 fields as: natural sciences, agricultural sciences, medical sciences, engineering and technological sciences, humanities and social science. The founders of online science facilities are mainly composed by social organizations and CAST on all levels. At the meantime, individual science popular websites got rapid development, science blog has become an interactively network for public participation in science and technology.

The science and technology education bases in China mainly refers to the 'popular science education base' and ‘youth science and technology education base’, a ‘pyramid’ type framework has been formed among national, provincial, and municipal and county-level. There are 650 state-level science education bases, about 1,390 provincial science education bases, and more than 10,000 built on local-level and county-level bases. The number of the science and technology education bases in eastern part accounts for more than half of the total number in the whole country, and the vast majority of the popular science education bases were built by high-tech enterprises, universities and research institutes.

IV. MAIN PROBLEMS OF CHINA’S PSTI DEVELOPMENT

Although China’s PSTI has achieved a good development, but at the same time, PSTI development still can’t meet the
public demands on science and culture in the whole country. According to the assessment result (the eastern region's PSTI development status is better than that of the western regions and ranks higher above the national average level.) and further analysis of secondary indicator survey data (type and quantity ,staff, yearly input and output, exhibition resource and activities, etc.), China’s PSTI’s healthy development is faced with many problems and bottlenecks, such as funding, policy issues, human resource and science resources shortage. To sum up, all of those problems mainly locate in the following two aspects.

A. Balanced Development

At present, China’s PSTI is not only faced with the problem of insufficient volume, but also faced with the problem of imbalanced development. Shortfall can be solved with the development, but if an overall planning is neglected and imbalanced development cannot be controlled, these problems will persist and may become worse, resulting in uneven distribution of resources and coursing waste.

Imbalanced development has two aspects: regional imbalances and imbalanced development inside PSTI framework itself. Imbalanced development can be divided into a nationwide problem of regional imbalance development and an imbalanced development in local area. Imbalanced development across the country is mainly due to the impact from local economic development differences. PSTI development of eastern part of China progresses significantly better than central and western regions.

Almost half of the country's PSTI was built in eastern region. For example, over half of S&T museums were built in eastern China, but in western provinces such as Tibet and Gansu even in their capital cities, there is not any comprehensive S&T museum so far (Hainan doesn’t have as well). In many provinces, such museums are more in areas of better economic development than in areas of poor economic situation, and more in urban areas than in rural areas.

Data shows that there are some museums about science, but fewer museums for pharmaceutics and agriculture. There are only 8 comprehensive Museums of Natural Science up to the state level, only one facility that could be counted as ‘true’ planetarium, and so far there is not a comprehensive science industry museum in China.

B. Sustainable Development

Sustainable development for China’s PSTI is to concern about the problems occurred during the sustainable development of PSTI, including policy, funding, human resources, PSTI resources, operation strategies and management system. According to the result of investigations, almost the entire PSTI is faced with a sustainable development issue [14].

S&T museums in China were mostly built in last century. Most of the S&T museums in China cannot display to their full effect. How to make these venues to revitalize and maintain sustainable development has already become a problem to carry out the work of the current science popularization. At the same time, Science and Technology museums newly built or under construction will soon follow up and face with the sustainable development issues if not well managed by learning from the past experiences. Among all these issues, the primary problem is the lack of fund, and then the problems of insufficient PST human resources, operation strategies, and management system. And public regulation can also impact the sustainable development of China’s PSTI.

Similar to the museums of Science and Technology, the popular science education bases, grassroots science facilities (including science wagons), online science facilities are all faced with the problem of sustainable development, and the problems are still pointing to fund, science human resources, operation strategies, management system and regulation.

Because there is lack of associated financial and policy support, science education bases are either difficult or reluctant to provide science popularization services, which in turn brings out no ideal effect. As for primary funding status for the operation of China’s PSTI, runners can barely maintain normal science expenses, very few of them can guarantee the sustainable development of their PST facilities, which including training, exhibits designing, updating and maintenance and so on. Taking poorly developed western regions for example, even the cost around 100,000 yuan a year to maintain the science wagons is a heavy load. On most cases, it depends on the personal ability of managers to find ways to raise funds, as much as possible to carry out science activities.

V. MAIN REASONS FOR PROBLEMS

The main reason for the unbalanced development in China PSTI is mainly due to the unbalanced economic development on regional level throughout the country. It is suggesting that PSTI construction and development has a strong and positive correlation with the regional economic development. Considering the overall level of the national per capita income at the end of 2008, China's PSTI development status is adapted with the economic development, showing the correlation between PSTI and economic development from another aspect.

In the next place, standard regulations and policies related to China’s PSTI development are incomplete, which also worsens the unbalanced and unsustainable development situation. Because of lack of overall plan on the state level, it results in excessive construction in some developed areas, and inadequate construction in underdeveloped areas. The current operating fund for China PSTI is mainly from the government budget. But because of inadequate policies and regulations, the PSTI operating expenses can not be effectively guaranteed, which results in non-sustainable development.

Lastly, lack of science popularization workforce and theoretical research also contributed to the non-sustainable development of China’s PSTI. In last 20 years, compared with the rapid expansion of PSTI, human resource and theoretical
VI. PROSPECT OF CHINA’S PSTI

According to the Planning and the currently development trend, China’s PSTI in the future can be viewed as follows.

A. PSTI Continues Growing, to Reach a Relatively Rational Layout for PSTI as a Whole

The government should play a leading role in China’s PSTI construction, and an overall strategic plan on national level need be strengthened.

First of all, the government is trying to build up a rational layout for S&T museums in different regions of China. In municipal cities and some counties which already obtained necessary conditions, a number of S&T museums with specialized themes, topics, and other distinctive factors are encouraged to be built by government; some qualified research institutions, universities, enterprises and small towns, which have vital resources or local priority conditions, have been asked to construct a number of professional display facilities or industrial technology museums; by taking full advantage of major construction projects or used production facilities that belong to state-owned enterprises, some industrial technology museums will be constructed in future.

Secondly, the government will further promote research institutions and universities to open to the public to carry out science activities, promote Youth Palaces, women and children activity centers, parent-schools, culture palaces to add more science popularization content in their daily service, encourage qualified enterprises to open their R&D production facilities (process) or exhibition halls to the public and to establish science sites; guide aquaria, safari parks, theme parks, nature reserves, forest parks, geological parks and zoological gardens to enhance their science education functions.

Thirdly, the government will promote the construction of county-level integrated science venues, which can provide PST education, training, exhibition, and other PST services, across all of the country's counties (cities, districts). Rooted in full use and integration of existing resources, the government plans to make more than 60% of the sub-districts (townships) and communities (villages) obtain a science activity station (room); to make popular science galleries (bulletin boards) cover 60% of the communities and villages, and the content be updated more than 10 times within a year; to increase science popular caravans to 1,500 to cover all the prefectures (cities) and the counties (cities, districts); to urge some qualified primary and secondary schools to create conditions to establish youth science studios by using of existing education and training establishments.

B. The Service Performance of PSTI to be Increased Significantly and the Opportunities for the Public to Promote Their Science Literacy to be Significantly Increased as well

The government makes full play of its leading role to provide macro guidance on the national level to strengthen the infrastructure construction of science popularization. In accordance with the Science and Technology Museum building standards, those museums that are neither facilitated with qualified exhibiting capacity nor in sound functional condition could be refurbished with necessary renovations. There is a need to engage researches in developing construction standards, warrant criteria, management regulations and regular monitoring and evaluation system for science popularization infrastructures. And the overall service capacity of the infrastructures should be improved through enforced managing operations.

C. A Substantive-development Indemnify System of PSTI to be Established

Relevant policies, regulations, fund, organizations and implementation, are all important guarantees to mobilize all social forces to engage in the development of PSTI. Government should implement the state's relevant regulations and policies accompanying with further formulation of PST institution system, and improve the public PSTI management system and operational mechanism to strengthen the operation management of PSTI. The PST construction plan should be put into the national economy and social development overall plan in line with the increase of the portion of public input on PST facilities construction and operation fund. The government should puts efforts to concretely carry out the existing tax incentives, to encourage enterprises, social groups and individuals to get involved in PSTI construction and operation management.

VII. CONCLUSIONS

First, evaluation index system was applied in the assessment on PSTI development in China for the first time.

Second, the assessment result shows that the current state of PSTI development in China is going well, while the overall status is worse than average in world range. The results from the evaluation show that the PSTI index is a reasonable and valid index. Evaluation results are objective reflection of China’s PSTI development level.

Third, through in-depth analysis of survey data, not only a comprehensive understanding of the PSTI in China was gained, but also two key problems for PSTI development were found. The unbalanced development and non-sustainable development are the two main issues in PSTI development in China. Meanwhile, according to China’s PSTI current development situation and the Chinese government's efforts, prospect in the future of China’s PSTI development trends is given at last.

Fourth, the result of the assessment has been adopted by the
Chinese government, as the data support for making the Civic Scientific Quality Action Plan (2011-2015). China’s PSTI assessment practices will also provide reference to other countries and regions.

This research as the first assessment on the development of PSTI in China, both the index system and assessment methodology, still has the space for improvement. In 2011 a second assessment will be launched on the basis of the index and data base.

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