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RESEARCH ARTICLE

Understanding the Connotation, Impact and Measurement Concerning Informatization of Science Popularization in China

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Abstract

Informatization is the new direction of the effort in the field of science popularization in China. It refers to the change not only in the technological approach and the channels of science popularization, but also to the idea and the model of science popularization. This paper shed light on the connotation concerning informatization of science popularization (ISP) in three dimensions. It illustrates that ISP produces profound impact on the science popularization practice, the individuals, and society. Regarding practice, ISP in China includes the digitalization period, networking period and intelligentializing period. ISP makes the practice more powerful and efficient. It is of importance for ISP to promote the construction of the knowledge society and create the atmosphere of scientific culture in society. Finally, the measurement framework of ISP is proposed, which aims at promoting the working process and achieving the ultimate goal through a monitoring method.

Keywords: Informatization, Knowledge Management, Measurement Science Popularization, Information, Education

Introduction

Owing to the arrival of the modern information revolution and knowledge society, informatization has brought more opportunity to the field of education, science and communication along with a big challenge. Currently, 'informatization of science popularization' (ISP) has been advocated through great effort in the field of *Science Popularization* (this term is similar to *Science Communication*) in China. And informatization is

considered to provide the guiding role in the major construction of projects of science popularization that will be initiated in 2015. Therefore, the elaboration of ISP's connotation, impact and measurement is of significance in the new era. Based on the former research results on informatization, further theoretical study and practice exploration are expected in the field of science popularization.

The Origin and Connotation of Informatization

In essence, the contemporary information revolution is about the production, dissemination and application of information and knowledge in human society (Zhou, 2009). The origin and connotation of 'information', and related concepts are the primary issues to discuss in ISP. Hence, it is necessary to review different understandings of 'information' in various disciplinary backgrounds. The literature survey is the major methodology applied in this part.

Understanding the Definition of Information from Science and Philosophy

The definition of 'information' is diverse. In the 1940s, the founder of Information Theory, Claude E. Shannon in his work 'The Mathematical Theory of Communication', developed information entropy as the measuring scale to indicate uncertainty (Shannon, 1978). Even though he did not provide a clear definition of information, he pointed out that information has the function of eliminating uncertainty, a suggestion that produced profound influence on the follow-up definitions of information. Thereafter, many theories such as the difference theory, entropy theory, independent element theory and attribute theory about information were developed on the base of science or philosophy (Wang, 2007). Some scholars defined information from the aspect of pragmatic information theory, which is lacking universality and generality; while the definitions derived from philosophy are abstract and universal. From the philosophical perspective, information, material and energy are the three dispensable elements that make up the real

world. Depending on the material and energy, information is the property of things reflected. Chinese scholars such as WU Kun and Zhong Yixin made their own definitions (Zhong, 2002). Although those have the differences in description, the main opinions of several definitions are consistent.

Understanding of Information and Related Concepts from Knowledge Management

Information, Data, Knowledge and Wisdom are close in relationship concepts in the field of knowledge management. All of the four concepts are humankind's subjective consciousness that show their reflection on objective things. The former is the base and precondition for the latter and the latter develops from the former and influences the former's accessibility. These concepts are also the foundation of knowledge management system. They promote the construction of classified bases of data, information and knowledge for the convenience of searching, exploiting or sharing (Jing and Cheng, 2005).

The definitions of Data, Information, Knowledge and Wisdom are also diverse, but their natures are uniform to a large extent. Alavi M. and Leidner D. E. (Barnes, 2004) argued that Data is raw with no meaning except for existing; information is the processed data that can be used to answer the questions about 'Who', 'What', 'Where' and 'When'; Knowledge is the application of Data and Information, being able to respond to questions about 'Why' and 'How'. Some other scholars visualized the relationship of concepts as a pyramid structure with the lowest layer of data, a middle layer of information and the top layer of knowledge (Tu, 2014).

Understanding the Concept of Information from Communication

Since Warren Weaver, a mathematician, introduced the concept of 'information' into the field of communication, information has become the central concept in western communication study (Rogers, 2002). When information was transferred from the field

of engineering & technology to that of communication, the change has taken place in the aspect of meaning and model. For instance, in the typical one-way 'Shannon-Weaver' Communication Model, information is derived from the information source, then is dealt with the coding and decoding process through the transmitter, channel and receiver, and finally put into the recipient. This model is used to explain the channel capacity of delivering information in the field of engineering information, but the scholars in the area of communication generally keep their focus on the dissemination effect. Generally, information is the contents of communication, which is the object of transmission and exchange in certain social relationships. In citizens' oral language, information is usually understood as the content instead of technology or dissemination effect (Jiang, 2006).

The Connotation of Informatization

Informatization was induced by the modern information revolution. Some important works or political documents in China and abroad constituted the description or definition of informatization. In 1963, the Japanese scholar Tadao Umesao, addressed the society by proclaiming that the center of information is consolidated within the informatization society (Zhou, 2009), and predicted that the development and application of information science & technology would lead to the revolution of the whole society. In 1998, Mansell wrote in 'Knowledge society: Information Technology for Sustainable Development' that informatization is not only a technological process, but also a social process, which requires reform in the aspect of management process, institutional framework, techniques and tools of productions (Mansell and Wehn, 1998). As the document of China 'National Informatization Development Strategy (2006-2020)' points out, informatization refers to the historical process of adequately using the information technology, exploiting and utilizing information resources, promoting the information communication and knowledge sharing, enhancing the quality of economic growth,

and pushing forward the transformation of economic social development.

The Connotation of ISP

This paper aims at illustrating the connotation of 'Informatization of Science Popularization' (ISP) based on the above literature survey on information and informatization. It is certain that this concept has a general meaning and a special meaning in this particular domain. Therefore, the characteristic of science popularization should be taken into account. The methodology of comparative analysis is applied in the distinction between similar concepts.

The contents of science popularization are the important ingredient of knowledge system. Thus, the basic principles of knowledge management on knowledge production, obtainment, organization and sharing are instructive to understand ISP (Li, 2009). At the same time, science popularization has an intimate connection with education. Accordingly, educational informatization brings enlightenment to ISP from the aspects of exploiting the excellent digital educational resources by providing the facility for teaching the learning (Ministry of Education, 2012) However, the particularity of ISP should never be neglected. Compared with the educational informatization, ISP has two specialties. Firstly, the contents are special. Generally, there is a syllabus for education, while there is no benchmark text version for science popularization. Nevertheless, the content requirement in the field of science popularization is to some extent higher than that in education. It is not only the common scientific knowledge but also the frontier science knowledge that is required to be included in the content coverage for dissemination. Secondly, the working field is special. Science popularization is considered as a social responsibility, which needs different governmental departments, social associations and nongovernmental organizations to engage. The target population of science popularization ranges from the minors and famers to the workers and public servants. In comparison, the task of educational informatization is simpler because it is mainly fulfilled by the Ministry of

Education that has strong ability in coordinating the required issues at diverse schools. Therefore, ISP is in a complex situation, which results in more difficulty to realize the goal.

In order to make clear the complicated connotation of ISP, the dimensions and the logic structure between different dimensions need to be investigated and designed. Based on the above understanding and analysis, this paper proposes a three-dimension connotation of ISP that includes Idea & Technology, Production & Communication, and Utilization & Effect (Table 1). The logic structure among the three dimensions is the modified complex model that combines the information process model, information element model and the 'Driving force State-Response' (DSR) model (Wang & Pan, 2012) usually used in the ecological field.

Each dimension of ISP is explained as follows. Concerning 'Idea &Technology', ISP means that the advent of knowledge society produces the driving force to provide the public service about science popularization and make efforts to enhance people's cognitive and discrimination ability with massive information; the emerging modern information technologies such as the mobile internet technology, the internet of things, cloud computing, and big data drive the innovation to meet people's personalized behavior and habits through science popularization resources and assist them to grasp a study-skill much better. Concerning 'Production & Communication', ISP means the resources of science popularization are exploited, accumulated and shared in line with the new stands, and the new working mechanism of science popularization is explored; the dissemination channels with a high degree of credibility and awareness in society are stimulated to be engaged in the activities of science popularization. Concerning 'Utilization & Effect', ISP means that the regional imbalanced distribution of science popularization resources is alleviated, and the information gap of science popularization between regions and populations becomes narrow; the scientific life style with wisdom and civilization is coming into being in community, and the level of citizens' scientific literacy is greatly increased.

Table 1 — The Three Dimensions of the Connotation of ISP

Dimensions	Description of the connotation
Idea & Technology	Meeting the requirement of knowledge society, providing the public service about science popularization, enhancing people's discrimination and cognitive ability upon massive information; Meeting the people's personalized behavior habit in obtaining science popularization resources, assisting people to grasp study skill better via emerging information technology;
Production & Communication	Exploiting, accumulating and sharing the resources of science popularization in line with the new stands, exploring the new working mechanism of science popularization; Stimulating the dissemination channels owning high degree of credibility and awareness in society to join in the activities of science popularization;
Utilization & Effect	Alleviating the regional imbalanced distribution of science popularization resources, Narrowing the information gap of science popularization between regions and populations; Forming gradually the scientific life style with wisdom and civilization in community, and greatly increasing the scientific literacy level.

The Impact of ISP

The impact of ISP in China is discussed from the three aspects: practice, the individual and the society.

The Impact of ISP upon Working Practice

In retrospect of the practice of science popularization in China, it is a 'surprising' conclusion that ISP is not a new emerging thing. The practice with partial characteristic of ISP has been carried out from the beginning of the 1990s. In the earlier ISP practice stage, information technology was usually applied rather as an advanced technique than as the driving force for the reform of idea and model in the field of science popularization.

In line with the characteristic of Chinese practice of science popularization, the ISP historical process includes three periods:

digitalization period, networking period and intelligentializing period. It is noteworthy that each of the periods has a starting point that facilitates the development without a specific end in mind.

With the digital tide in the world, digitalization in the field of science popularization developed. By virtue of the information technology, the traditional resources of science popularization were transformed into resources that could be stored, transmitted and applied in computers. The literature verify that the construction of digital resources in museums was sprung up earlier in 1990. Compared to the resources in the form of paper and analog information, it is easy to realize the stable storage and high speed transmission in the digital form. On the base of digitalization resources, the new networking period meant that resources could be transmitted and shared in LAN and WAN. The channel of science popularization was exploited from so called 'off-line' to 'on-line', which rapidly increased the speed of (rather dissemination?). In 1995, the breakthrough in science popularization was through the online version of a popular science newspaper named *Beijing Science & Technology Report.* Since then, a group of websites on science popularization had been designed and opened to the public, such as *Chinese Public Science & Technology* website (by China Association for Science and Technology, CAST) and *China Science Popularization Expo* website (by Chinese Academy of Sciences, CAS). In 2004, the Union of Internet-based Science Popularization under Internet Society of China was founded. The organization spares no effort to promote the development of internet-based science popularization. In 2007, it was a milestone that the China Digital Science and Technology Museum website was awarded 'e-Science' in the *World Submit Award* (WSA) (Zhang, 2010).

Thereafter, great changes have taken place with the appearance of mobile internet, under which social media such as WeChat merge the instantaneous property with science popularization. For instance, the famous Chinese scientist, Raoyi created 'Mr Science' and CAST set up 'China Science Communication' in the WeChat platform. Moreover, the new emerging technologies such as Cloud Computer

and Big Data have also been integrated with science popularization. Next, the emergence of wearable intelligent products and smart homes laid the foundation for the coming of the intelligentialization period of science popularization. Through artificial intelligence (AI), human beings' ability of perception, thinking, reasoning can be imitated, which leads to profound reform in the idea and model of science popularization.

To what extent does ISP impact on the practice of China science popularization in the near future? ISP is expected to make the future practice of science popularization more powerful and profound. As shown in Table 2 the four aspects are illustrated respectively: idea, efficiency, extension and influence.

Table 2 — The Impacts of ISP on the Future Practice

Aspects of Impact	**Characteristics**		
New Idea	Ubiquity	Autonomy	Discrimination
High Efficiency	Universality	Convenience	Transmissibility
Large Extension	Interaction	Experience	Expressiveness
Deep Influence	Enlightenment	Innovation	Attraction

Firstly, the idea of science popularization is new. ISP meets with the public's personalized habit of obtaining science popularization information and adapts to the style of ubiquitous (anyone, anytime, anywhere and any device) and autonomous learning via the modern information technology. The public's discrimination ability is emphasized in the wave of information. Secondly, the efficiency is high. Advanced information technology breaks the restriction of time and space, and the coverage of the pubic is much wider than before. The public feels it convenient to access scientific knowledge, and the transmissibility is stronger. Thirdly, the extension is large. The vision, hearing, feeling and smelling sensors of human beings are mobilized in ISP. The public can interact and have a personal experience in the learning process because the expressive ability is powerful enough. Fourthly, the influence is deep. ISP aims at

the enlightenment and innovation that are significant for the economic and social development. Attraction is obvious towards both individuals and society.

The Impact of ISP upon Individuals

The public's behavior of obtaining information is changing along with the advent of the information tide. More and more public citizens obtain science popularization information and knowledge through new information technology. According to the statistic results of 2010 (Ren, 2011), the percentage of Chinese citizens who obtain science and technology information through the internet channel was ranked 4th (26.6%), followed by those of TV channels (87.5%), newspapers (59.1%) and interpersonal communication (43.0%). Compared with the results of 2005, the percentage of the citizens' (Knowledge? Participation?) increased about 20.2 percent. Further, China Internet Network Information Centre (CNNIC) reported that until the June of 2014, the mobile phone was ranked 1st amongst internet terminals. Therefore, the trend is obvious that more and more members of the public prefer to get science popularization information by means of the internet.

On the other hand, as ISP is in such an open and equal stage of internet access, the public's independent choice plays an important role. As shown in the survey carried out in 2011, 69.4% of the internet users in China would rather use the search engine than choose the fixed websites to access information of science popularization (CNNIC, 2011). Different groups of people have their personalized needs. Thus, in order to obtain the focus of the public, the construction of the science popularization resources must consider the individuals' need carefully.

The Impact of ISP upon the Society

Nowadays, knowledge plays a dominant role in the economic and social development. There is an urgent need that the economic morphology should match the social morphology. Knowledge and human resources become the primary resources. Intellectual labor is the main social labor and innovative talents

become the pillar of society. The speed of knowledge update becomes faster than before, which makes the idea of lifelong learning widely recognized. ISP would echo the above requirement. The so-called internet spirit of openness, equality, sharing and cooperation are popular in modern society. The social organizations are encouraged to be evolved in ISP and they provide the excellent channels for science popularization.

Unavoidably, the long-time difficulty in the field of science popularization is to cultivate scientific thinking and establish the spirits of scientific inquiry and rational criticism among the citizens. It is of significance to form a good atmosphere of scientific culture for the whole society. In an information explosion society, there is a potential risk of information overload for the public when the information channels are increasing. If the public cannot make an appropriate choice, this accessibility is supported? by clarity and quality. On the one hand, ISP pays attention to provide an authorized platform for the public to approach science. A group of experts in various disciplines are mobilized to review the contents, and the public is also encouraged to point out the neglected areas and errors. On the other hand, when the spirit of scientific inquiry and rational criticism is rising in society, the new scientific culture in society is gradually shaped.

The Measurement of ISP

According to the USA scholar Eliezer Geisler's 'the Ladder of Abstraction' model (Wang and Zheng, 2006), the measurement of the complicated social phenomena should be initiated from the concept. It then goes along the ladder of abstraction from the top to the bottom. The concept is eventually decomposed into specific indicators that can be expressed with measured value. The measurement of ISP is also based on such a concept and its connotation. In turn, the construction of the ISP indicators is helpful to seek the consistency between the concept and the social phenomenon.

Although the ISP only focuses on the informatization in the field of science popularization, it is still a very complex social

system. It is influenced by several elements from society, economy and nature. Therefore, the indicator system is not easy to be identified. Some research results from informatization are instructive. For example, China announced the 'National Informatization Indicators Composition Scheme' in 2001, which designed 20 indicator items. They included the total capacity of the internet resources data, index of information (the personal consumption level for information products) and so on. In Zheng's opinion, the measurement indicators of social informatization should include the information resources, information facility, information subjects' literacy, information industry, and e-governmental information (Zheng, 2011). Wu suggested that the indicators of educational informatization cover the infrastructure of educational informatization, digital educational resources, application of teaching and learning, management of informatization and guarantee the mechanism (Wu *et al*., 2014). To sum up, the capacity to access resources and the information on the subject's literacy are generally considered as the core indicators for informatization by scholars.

In line with the principles of indicator design, such as representativeness, ease of collection & statistics, the indicator system of ISP is formed by the primary contents as shown in Table 3. The overall objective is to measure the ISP development level in the society. The standard layers coincide with the 3 dimensions of ISP and the 8 indicators are proposed to compose the indicator layer. Besides the capacity of resources (3) and the quality of the information subject (6, 7) mentioned above, the numbers of policy documents and research papers (1) about ISP are included. They reflect the social idea and value about ISP. The degree of integration about information technology in ISP (2) is to assess the fusion of IT and science popularization. The numbers of social organizations (4) and media channels (5) that are involved in ISP are also contained (constrained?, which indicates the social cooperation status. The consumption structure of the intelligent products (8) is designed to reflect the smart life style.

Table 3 — The Measurement Indicators System of ISP

Objective Layer	**Standard Layer**	**Indicator layer**
ISP Development Level	Idea & Technology	(1) The number of policy documents and published research papers about ISP
		(2) The degree of integration about information technology in ISP
	Production & Communication	(3) The capacity of the on-line accessible science popularization resources
		(4) The number of social organizations engaged in ISP
		(5) The number of Media channels that provide science popularization service
	Utilization & Effect	(6) The public's click rate of the online resources per year and the percentage of watch or read completion
		(7) The percentage of the citizens who get the science information from internet
		(8) The consumption structure of the intelligent products related to scientific literacy

Conclusions

ISP is a relative and dynamic development concept. This paper traces back the concept 'information' from several aspects by literature review, and compares the same and difference between 'knowledge management', 'educational informatization' and ISP. Inspired by the process or element model of information and the 'Driving force-State-Response' (DSR) model, the three dimensions of ISP are set up in this paper, which include Idea &Technology, Production & Communication, and Utilization & Effect. Then, the impact on practice, individuals and society are analyzed. Based on the understanding of connotation of ISP, the eight indicators are suggested to measure the development level

of ISP. The empirical study will be done in future, which can improve the quality of indicator system and reflect the social phenomenon well.

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