12. Construction of PUS Index in China–An Empirical Study on the Database of China 2010 Civic Science Literacy Survey

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Abstract. This paper is concerned with an empirical study on the database of 2010(the 8th) Civic Science literacy Survey of China. By learning from latest theoretical achievements of relevant scholars and considering the features of Chinese practice, the author extracted a Model of China Public Understanding of Science(PUS) Index from the latest Civic Scientific Literacy questionnaire .The constructed China PUS Index contains 5 indicators as following: Knowledge (public knowledge of S&T), Attitude (public attitude toward S&T), Interest(public interests in S&T), Engagement (public engagement of S&T)and Information (the information channels of S&T). Confirmatory factor analysis (CFA) accompany with other relevant statistical methods, was applied to evaluate the validity of this Index model. Under the framework of China PUS Index, the Author profiled several characteristics of China public understanding of science at present stage, and provided an open platform for further comparative study under different social and cultural contexts in PUS field.

Keywords: Public understanding of science, Confirmatory factor analysis (CFA), PUS index

Introduction

Since the Scientific Literacy of Chinese citizens was firstly carried out in China 1992, how to assess the level of civic scientific literacy, as the core content of previous investigations, remained as the focal point by people of various circles. Using the percentage to show public Science literacy level has shown significant limits already, which has been in application since the first survey in China. On one hand, the duality logic by which to assess whether a respondent obtains a qualified level in scientific literacy or not, is a rather arbitrary evaluation. At the meantime, the duality logic was on the loss of gradate information in scientific literacy level of respondents. On the other hand, by the percentage method can only get a simple category variable from survey results, which can hardly support the in- depth follow-up data analysis.

For the above, during the data analysis course of the seventh survey of Chinese Public Scientific Literacy (2007), the research group created the Chinese Public Scientific Literacy Scientific Index (CSLI). The CSLI index integrated a number of core indicators of scientific literacy into a single form. The CSLI index stands for the total score of all the correct answers in tested questionnaire for a respondent, while for groups the CSLI index shows the weighted average scores of every individual in the group. Compared with the percentage result, the introduction of China Scientific Literacy Index has several advantages as following:

(1) The adoption of all respondents reply information improved the efficiency of survey data application.

(2) Survey results will be adopted as a continuous variable, which can support the division of citizen's scientific literacy level to be more accurate.

(3) Provide a basis for integration of 'public access of science and technology information indicators, 'public attitude towards science and technology' indicators and citizen science literacy indicators.

In 2010, the sample designing for the 8th scientific literacy survey of China was based on the population in mainland China, while take 32 provincial-level units in mainland China for the sub-population. In each provincial unit a three-stage stratified sample of the PPS was applied. To take provincial units as sub-population for sampling was designed on biggest advantage to describe the situation of each provincial unit and to enable comparative study on provincial level. The index system in 8th survey followed the major structure of previous surveys. The core questionnaire was composed by three parts: 'public science and technology information sources', 'public understanding of science and technology', 'public attitude towards science and technology'. Some relevant static indicators were also including in the questionnaire such as: gender, age, education level, district, social groups, professional and some other background variables. This paper intends to extract a Model of China Public Understanding of Science (PUS) Index from the latest Civic Scientific Literacy questionnaire. With reference to the CSLI index and the international model of PUS, the China PUS index has also been combined with the questionnaire items related to the PUS content

Selection of Indicators

In fact, the 'public understanding of science' model is taking PUS index as a complex has strong-related with the public interest, knowledge and positive attitude toward science and technology. However, it becomes a priori definition: one has the 'scientific literacy' only if he expressed a 'certain level' of interest on science and technology, obtains "adequate" S&T knowledge and holds a 'positive' attitude towards the role of science and technology.

Based on the questionnaire and the follow-up data analysis principles, we defined the model of the Chinese public understanding of science index in five dimensions ,including scientific knowledge, attitudes, interests, participation and information indicators. As for the five dimensions, there are 8 items from former scientific literacy indicators to make up of scientific knowledge, 6 items about interests in the interests dimension, 12 subjects formed the participation indicators, 4 items for the informness index, 4 attitude indicators involved in the formation of attitude indicator.

Scientific knowledge dimension is the base of the model of public understanding of science. Taking the feasibility for international horizontal comparative analysis into account, we selected nine items from the questionnaire (two knowledge items in the survey conducted in China were combined) which already widely adopted in PUS surveys, the specific as follows: (Table 1)

Table1 The construction of Knowledge indicators

knowledge	Item
k_earth	Geocentric temperature is very high.(C1_1)
k_around	It takes one day the earth to turn around the sun .(C2_9)
k_oxygen	The oxygen for breathe comes from plants. (C2_2)
k_gene	It is mother's gene to determine the gender of kids. (C2_3)
k_electron	Electron is smaller than atom.(C2_8)
k_antibiotics	Antibiotic can kill virus.(C1_4)
k_continents	Millions of years, continents have been slowly drifting, and will continue to drift (C1_5)
k_evol	So far as we know, human being is evolved by early creatures. (C2_5)

Public interest in science and technology indicators made up by the respondents interests in six topics, including: new scientific discoveries, new inventions and technologies, new medical advances, agricultural development, industrial technology development and conservation of resources and energy.

Limited by the difference in ways of questioned, information sources dimension was mainly through the participation in S&T activities of the respondents during the last year as pay visits to the popular venues and science popularization activities.

Cos of there was not directly address the degree of the public awareness of science and technology information in latest questionnaire, we took how citizens participate in scientific and technological affairs as items to constitute an informness degree approximately. According to the respondents experience in taking part in the S&T affairs and business including: talking about technology topics, participating in technology-related discussions or hearings related with atomic energy, biotechnology or environmental topics, the extent of public S&T informness dimension was constituted.

There were quite a lot of items including in the questionnaire on the attitude dimension. To avoid too many interference items in this dimension, we applied the factor analysis on all of the attitude items and two main factors were selected from two topics. (Table 2)

Table 2 Rotated Component Matrix (a) on attitude indicators

Public attitude towards S&T			
Component			
	1		2
Modern science and technology will provide more opportunities for new generations.	.748		.057
Scientific and technological progress will help to treat AIDS and cancer and other diseases.	.667		.143
Science and technology do not solve any problems we faced.	.025		.711
Continuous application of technology will eventually destroy our planet.	.186		.664

Finally on each dimension we get an indicator with its value range and the code of score for each item was given in Table 3.

Table 3 Value for each indicator

indicator		code
value knowledge		1,0
[0,8] interest		3,2,1,0
[0,18] participation		1,0
[0,15] informness		3,2,1,0
[0,12]		attitude
2,1,0,-1,-2	[-4,4]	

Indicator Analysis and Construction of Index

After the Correlation Analysis between knowledge indicator and other 4 indicators, we found the standard assumption of linear relationship in PUS model showed some interesting phenomenon. Mapping the correlation with the fitting curve equation, we get the relationship between knowledge and other 4 indicators. (Data stands for each provincial unit)

Knowledge and interest

Although citizens in each province may vary a lot from their interest in science and technology, science literacy level has no obvious correlation with interest. So the interest on S&T may come from the influence of the local media environment rather than the knowledge level. (Figure 1)

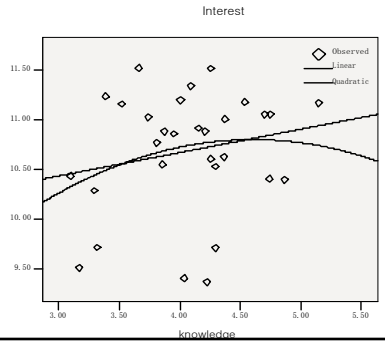


Figure1: Correlation between Knowledge and Interests

Knowledge, engagement and informness

Public Engagement in S&T means the frequency respondent visited S&T popularization venues in last 1 year to assess the extent of public participate in science and technology activities. Knowledge and engagement indicators are in line with the linear relationship assumption. It means that people with high level of S&T knowledge usually participate in science and technology activities, visit science and technology venues more frequently. According to Figure 2, the right axis of knowledge indicator shows that people from major cities and some developed provinces in eastern part of China visit to science and technology museums and participate in scientific activities more frequently, while people from western part of China has lower frequency of engagement in S&T activities. This phenomenon indicates the uneven distribution of public resources in science and technology popularization in China currently.

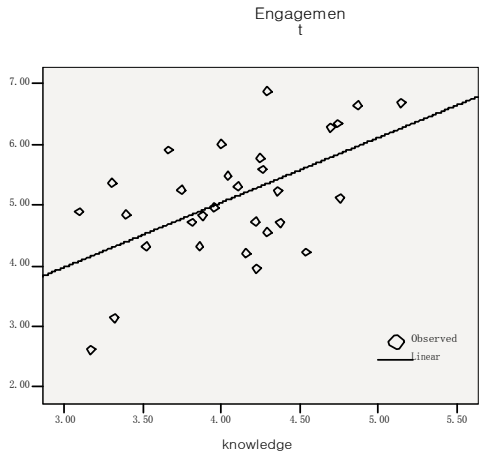


Figure 2 correlations between engagement and knowledge

The informness indicator in China PUS index stands for the extent of involvement of people in science and technology affairs. We can tell from Figure 3, the correlation between knowledge indicator and informness indicator is also consistent with the linear hypothesis.

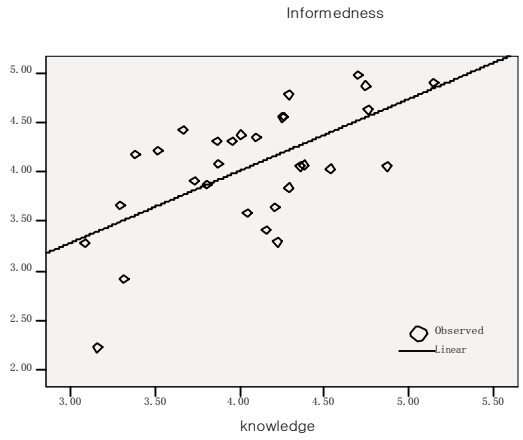


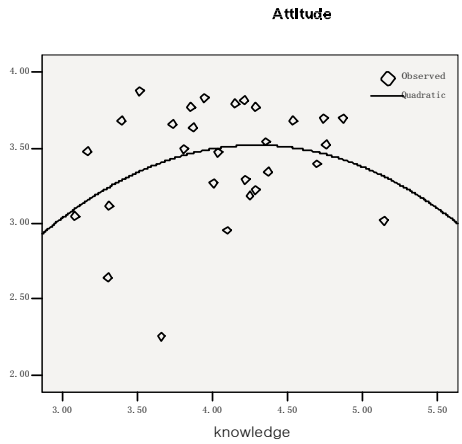
Figure 3 correlations between knowledge and informness

Knowledge and attitude

The ‘two cultures’ model in PUS research shows that only in a specifically circumstance, the interests indicator, knowledge indicator and attitude indicator will be in strongly positive correlated. The mutual correlations were significant impacted by level of industrial development of the regional environment within a certain range. (Bauer, Durant & Evans, 1994; Bauer, 1993)

In industrialized societies knowledge indicator has a positive correlation with positive attitude, while in post-industrialized societies the relationships among knowledge, interest and attitude have great difference from industrialized societies. Especially, the correlation between knowledge and positive attitude was no longer as we got from industrialized social background. This is also the key argument from 'two cultures' model theory.

Among provinces of China the relationship between knowledge and attitudes also showed a similar law. Under a certain level of S&T knowledge level, people with higher level of scientific knowledge tend to obtain the more positive attitude toward science and technology. When people's knowledge level exceeds the certain range, attitudes and knowledge will show an opposite relationship. By nonlinear analysis, we found that the separation point for the 'two culture' groups is the point which knowledge score 4.3and attitude score is 3.5. It can be concluded from figure 4 that on the both sides of separation point the relationship between attitudes and knowledge showed totally opposite result. According to further comparative data analysis, the developed provinces in eastern part of China and special municipalities showed the PUS characteristics of post-industrial society, while the western region near the border areas showed characteristics of industrialized society.



Separation point P(Y=3.52 x=4.3)

Figure 4 nonlinear analyses between knowledge and attitude

Because of the nonlinear correlation of knowledge and attitude indicators, we need do linear transformation on knowledge and attitude value before get the final formulation of PUS index.(Figure 5) Here is the relevant mathematical conversion:

Ki stands for the score of knowledge value of the ith (i=1, 2,…, 32) province; kp stands for the knowledge value of separation

Attitude= Attitude if ki<=kp

Attitude = 2*Attap - Attitude if ki > kp

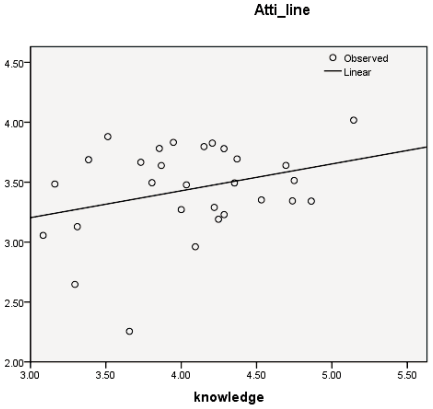


Figure 5 Correlation between knowledge and attitude after liner transformation

Chinese public understanding of science index and validation test

As already discussed before, we already made it clear on the composition of public understanding of science index and the correlation between each indicator with scientific knowledge. As for built up the index formulation, we need to determine the coefficient of each indicator. These factors reflect the importance for each dimension to the total score.

In this paper, the index coefficient was determined by factor analysis method. The factor loading coefficient shows each factor's contribution to common factor, and the variance contribution ratio stands for the extent of common factor's representative to all sample variance. Therefore, the result of factor loading coefficient multiply with variance contribution stands for each indicator's contribution in the whole sample. The contribution of each index divided by the contributions of all the indicators can get the weight of each indicator; the formula is expressed as:

$$\omega_i = \frac{\sum_{j=1}^{m} \beta_{ji} e_j}{\sum_{i=1}^{p} \sum_{j=1}^{m} \beta_{ji} e_j}$$

$$(i = 1, 2, \cdots, p \quad j = 1, 2, \cdots, m)$$

At last we get the formulation for China PUS index as follows:

PUS=0.1612*Knowledge+0.1211*Attitude+0.1014Interest+0.2394Informedness+0.2465Engagement After

get the result of PUS index and average scores of PUS index in mainland China, we classified 3 groups in mainland china respondents (by two-step cluster analysis),the characterize of each group was shown in Talbe4.

Table 4 cluster analysis of PUS index in Chinese citizens

Cluster	Mean	SD	Gender Education level	Rural/Urban	Region
1	2.23	0.87		More female	
Primary	More rural	western			
2	4.56	0.67		average	
Medium	average	average			
3	6.96	0.91		Moremale	
college	More urban	eastern			

Cluster analysis by pus index can largely profile the distribution of the various background variables. This result of cluster analysis generally meets the actual situation in China and shows the selection of pus indicators is reasonable.

Conclusions

Due to space limitations, this paper can not make further discuss on the formed PUS index and make abundant analysis by applying this PUS index. There are all sorts of method on subjective attitude measurement theory, while each country and culture has its own characteristics and complexity. Based on the eighth survey of Chinese citizens' scientific literacy, we applied a more accepted index for public understanding of science under international circumstance to Chinese practice for the first time. Then the research group tried to construct a new evaluation index on Chinese public understanding of the science. At present, we can conclude some key features for Chinese people from PUS index result. To get more accurate analysis and valuable conclusion, further improvement in the index system and in-depth data mining are very necessary. We expect this discuss can lay a solid foundation for PUS index research in china and open a new platform for international comparative research.

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