FIRE: Forum for International Research in Education

Volume 3 | Issue 3 Article 4

2016

Ten-Year Change in the Scientific Literacy of Primary Science Teachers in China: Reflections on Training Programs and Personnel Policies

Hongshia Zhang
Nanjing University, China, hzhang@nju.edu.cn

I. H. Shamsi
Nanjing University, China, cutecastle2003@yahoo.ca

Iffat Batool
Zhejiang University, China, ibrhus.dhnju@yahoo.com

Dongsheng Wan
Jiangsu Second Normal University, China, wandongsheng@126.com

Bo Yu
The National Institute of Education, China, yubo4866@sina.com

Recommended Citation

Zhang, H., Shamsi, I., Batool, I., Wan, D., & Yu, B. (2017). Ten-Year Change in the Scientific Literacy of Primary Science Teachers in China: Reflections on Training Programs and Personnel Policies. *FIRE: Forum for International Research in Education, 3*(3). http://dx.doi.org/10.18275/fire201603031084

Ten-Year Change in the Scientific Literacy of Primary Science Teachers in China: Reflections on Training Programs and Personnel Policies

Abstract
Using two rounds in 2003 and 2013 of large sample longitudinal surveys of science teachers in primary schools from 21 provinces and autonomous regions of China, results suggest that Chinese teachers' basic scientific literacy was still low with only a slight increase in the procedural knowledge of science. The evidence also suggests little increase in epistemological knowledge of science among teachers, especially concerning with the classic nature of science. Chinese teachers' non-scientific teaching behavior remained unchanged. This phenomenon associated with the relative ineffectiveness of in-service training teachers' received and with the discriminative personnel policy of recruitment and promotion for primary science teachers. The implicit cultural impact of these findings is also discussed.

Keywords
Scientific literacy; Science teacher; Training programs; Personnel policy; Chinese culture

Cover Page Footnote
The authors acknowledge support from the "2011 Project" of Jiangsu Province titled, "Educational Innovation for Primary and Secondary Schools," which was hosted by Nanjing Normal University.

FIRE: Forum for International Research in Education
Vol. 3, Iss. 3, 2016, pp. 16-31

TEN-YEARS OF CHANGE IN THE SCIENTIFIC LITERACY OF PRIMARY SCIENCE TEACHERS IN CHINA: REFLECTIONS ON TRAINING PROGRAMS AND PERSONNEL POLICIES

Hongshia Zhang[1]
Nanjing University, China

Imran Haider Shamsi
Nanjing University, China

Iffat Batool
Zhejiang University, China

Dongsheng Wan
Jiangsu Second Normal University, China

Bo Yu
The National Institute of Education, China

Introduction

It is widely acknowledged that public scientific literacy is one of the most important indicators of the international competitiveness of a country, and the national quality as well. Therefore, governments of many countries have paid much attention to science education and have increased investment in it. In China, much effort has been put into the reform of teacher training programs and teacher evaluation mechanisms in the science education sector over the past decade. For example, the Ministry of Education (MOE) and Ministry of Finance jointly initiated a "National Teacher Training Program" in 2010 on an unprecedented scale with a 550 million RMB annual budget from 2010 to 2012. One of the targets of the program was setting up several in-service teacher training bases for science education across the country (Zhang & Wan, 2015). In 2013, MOE issued a document for deepening reform of the teacher training model through establishing a national evaluation standard. Several research projects have been set up for this purpose. Furthermore, the 9th national survey of public scientific literacy conducted in 2015, which has been planned by the state council since 1992, announced the exciting result that the scientific literacy level of the public in Shanghai, Beijing and Tianjin, the top three on city ranking in China has reached the height of USA and Europe at the end of the 20th century. These enthusiastic endeavors and overall improvement of educational resources converged with the well-known persistent high status of Shanghai PISA grades to create a prosperous scene of Chinese science education.

[1] Correspondence: Prof. Hongshia Zhang, Institute of Higher Education, Nanjing University, 22 Hankou Road, Nanjing 210093, The People's Republic of China. E mail: hzhang@nju.edu.cn

However, a large sample national survey on the quality of the teacher training programs in 2012 found that the content of the training courses did not fit the trainees' needs; the teaching mode was mainly in traditional lecturing; and the trainees gave their trainers very low evaluation (Xue & Chen, 2012) scores. In terms of scientific literacy development of primary science teachers, a cohort study in Beijing conducted by C. Wang (2014) revealed a surprising pattern: there was no difference or even some regression in teachers' scientific literacy after their five years teaching experience. Although there was some progress after ten years teaching, their scientific literacy was generally immature even after fifteen years of teaching experience.

Therefore, it is far more than a matter of financial investment for science education in developing countries. The incompatibility between scientific culture and local non-scientific culture challenges the feasibility of implementing science education theories and experience from western countries, which is reflected not only in the pedagogical domain like teacher training, but also the policy domain of personnel administration like teacher evaluation systems for recruitment and promotion. In fact, in the Report on the Work of the Government delivered by the premier Li Keqiang at the Fourth Meeting of the Twelfth National Congress in Beijing on 5th of March, 2016, it has been re-affirmed that it would carry out a national reform of the teachers' professional title system. The biggest target of the reform is to abolish the old discriminating system between primary and secondary teachers by approving the introduction of a full professoriate title into the primary education system which had only the associate professoriate title as the top one. Another target of the reform is to re-assign the number of teachers in accordance with the structure of the titles in order to improve fairness between primary and secondary schools, rural and urban areas, and attract more qualified graduates to join the teaching profession especially those from science and technology majors.

In order to test the previous findings and make clearer understanding of primary teachers' scientific literacy, this study tries to investigate the development and changes of the scientific literacy of primary science teachers by use of the data from two rounds of national surveys across the past decade. Furthermore, this study tries to explore some possible influencing factors for the development and changes of teachers' scientific literacy, which include teacher training programs, the explicit teacher evaluation system for recruitment and promotion, and implicit cultural elements, in order to promote the pertinence of teacher training programs for Chinese science teachers.

Literature Review

The Definition of NOS

J.D. Miller (1983) is one of the pioneers for proposing operational definition of scientific literacy which includes: understanding the nature of science (NOS in short), basic knowledge of science and the relationship among science, technology and society. This three dimension scheme of scientific literacy has been adopted as a reference by many researchers despite introducing some variations, e.g. Lederman (1992) shifted the sociology of science to the dimension of the nature of science. The important policy document of the Project 2061 in USA, Science for All Americans (AAAS, 1990) clarified the concept of scientific literacy in six aspects which were also conformed with the principle of the three dimension scheme: 1. being familiar with the natural world and recognizing its diversity and its unity; 2. understanding concepts and principles of science; 3. being aware of some of the ways in which science, mathematics, and technology depend upon one another; 4. knowing that science, mathematics, and technology are human enterprises and knowing about their strengths and limitations; 5. developing a capacity for scientific ways of thinking; 6. and using procedural knowledge and ways of thinking for individuals and social purposes. In the new century, the OECD official document of PISA 2006 (Program for International Student Assessment, hold by OECD) gave a more general version of scientific literacy for students: "knowledge of science" and "knowledge about science" with the latter actually embraced of the nature of science and the relationship among science, technology and society in the Miller's scheme. In PISA 2013 version, the "knowledge about science" seems to be split into two parts – "procedural knowledge" and "epistemic knowledge". This new scheme of PISA viewing the nature of science as "procedural knowledge" and "epistemic knowledge" is adopted in this study for constituting the framework of constructs about NOS in our questionnaire.

Among the various dimensions of scientific literacy, NOS is agreed by most scientists, science educators as a critical element for developing scientific literacy of a person (AAAS, 1990). So, correctly understanding NOS becomes the core educational objective and constitutes many countries' science curriculum standards for both student education and teacher training (Lederman, 2014), which include China after 2000 (Wan, 2014).

However, the operational definition of the concept of NOS has not gained complete consensus amongst science education experts, and even among philosophers of science, historians of science, professional scientists, because NOS changes not only along with the history of science but also with the societies where science is embedded. In fact, according to a survey of 210 professors in philosophy of science from American colleges and universities, they did not agree with the definition of NOS proposed by experts in science education, and their own views were also divergent (Alters, 1997).

The nature of science itself is evolving tremendously. Before the sixteenth century, the natural world was often interpreted by superstition and theology. People's views on NOS (VNOS in short) were ambiguous featuring intuition and surmise until the late sixteenth century when Newton's classical mechanics system came into being, which is normally termed as "classic science" in the academic community today. The characteristic view on the nature of classical science is empirical and positivistic. Teachers with the classic VNOS typically intend to believe in the objectivity of scientific observation, the uniformity of the scientific method, the truth of scientific theory and the disinterestedness of scientists. This kind of epistemology changed later with the emergence of cutting-edge scientific theories like the Principles of Quantum Mechanics in the early 20th century. Up to the 1960s, a kind of new VNOS emerged in the field of science education in supplement to the "classic VNOS", which is called "contemporary/modern VNOS" in the academic community of science. In addition to these two evolutionally linked views of NOS, there was a revolutionary kind of VNOS which was popular in 1980s: the "post-modernist VNOS" featuring prominent anti-science ideology. This extremist viewpoint was caused by the negative impact of science and technology on the environment and societal development in post-industrial societies, and was very often equipped by misinterpretation of the Principles of Quantum Mechanics. Extremist post-modernists thoroughly deny the classic VNOS and excessively focus on the aspects of subjectivity and uncertainty of science, which had exerted negative effects on science education (Osborne, 1996; Nehm & Schonfeld, 2007) especially in China, due to its non-scientific traditional culture (Zhang & Yu, 2004).

Nevertheless, experts in science education believe that in order to facilitate student understanding of NOS, a simplified or learning-targeted version of contents of NOS is necessary prior to a comprehensive and in-depth version in the future (Osborne, 2003). For this purpose, many experts in the science education community have tried to seek a resolution to the problem (McComas & Olson, 1998; 2002; Osborne, 2003). Osborne et al. (2003) applied the

Delphi method for this purpose to solicit 23 experts of scientist, historians, philosophers, sociologists, and science educators. Broad agreement was obtained on nine major themes after the solicitation: science and certainty, creativity, scientific method and critical testing, historical development of scientific knowledge, science and questioning, diversity of scientific thinking, hypothesis and prediction, analysis and interpretation of data, and cooperation and collaboration, which embraced the elements of both classic and modern natures of science.

Teacher's View on NOS and Teacher Training Effectiveness

A recent survey of junior secondary school science teachers' views on the nature of science in China showed that the teachers had difficulties in understanding NOS (Wu, 2011). The survey was conducted with 222 teacher participants from ten counties or cities in Zhejiang province where science education was one of the most advanced in this country. The instrument applied in the survey for measuring VNOS includes three dimensions: the world view, the understanding of inquiry and the nature of the scientific profession. An earlier survey (Wang, 2010) conducted in the same districts using the instrument developed by an American scholar Liang et al. (2008) corroborated these findings. The researchers of the both surveys called for more pertinence in science teachers' professional development programs so as to enhance their effectiveness.

Many scholars in science education criticized the training model which emphasis on knowledge transmitting regardless of the knowledge construction process of the trainees; emphasis on presenting results but neglecting the underlining attitude and value issues (Xing, 2011). Although it had been argued a long time ago to overcome the rigidly mechanistic view of knowledge in Chinese science education (Yu & Meng, 2004), the situation either stayed with little change, or went to the other extreme which made science teaching lose its identity, as science is a kind of culture which is different from that of arts (Zhang, 2004). So some Scholars argued for science teachers to be aware of their mission as transmitting science culture rather than sheer factual knowledge provided (Gao, 2013).

Culture Context of VNOS

Many empirical studies conducted around the world have revealed that the VNOS of students and teachers seems to be closely related to their specific cultural mileau/contexts. Peng & Knowles (2003) found that Asian primed undergraduate students endorsed dispositional explanation for physical events to a lesser degree and contextual explanation in a greater degree than the American primed participants in their experimental studies. With regard to the higher scores of Asian students in PISA in international perspective, many studies pointed out the paradox that they had lower scores in "self-concept of science" and "attitude towards science" (HKPISA Centre, 2011). A naturalistic qualitative approach using comparative design between mainland Chinese college students and their Australian counterparts found that the traditional views derived from Confucianism might have an impact on the Chinese conceptualization of Nature (Slay, 2000).

In an international comparative study, Liang and Chen et al. (2008) found that Chinese teachers possessed higher scores than their American counterparts in an assessment of VNOS in all dimensions except the most traditional one: "observation and inference. A more recent qualitative study through an-depth interview of 30 pre-service seniors and juniors from two normal universities in Nanjing, China, found that the VNOS of the majority of interviewees was theistic or naturalistic intertwined with Confucianism in terms of its inseparability from interpersonal relationship context when they were exemplifying their understanding of the concepts of NOS such as objectivity, repeatability etc. (Wan, 2014).Thus, it was argued by one of the authors of this study that Chinese education reform should follow the evolutionary rule by emphasizing the classic science concepts and beliefs before introducing any post-modern ideas of science or nature (Zhang and He, 2012).

Moreover, a quantitative investigation conducted by Wang (2010) indicated that the VNOS of American science teachers was at the transition stage from the classic to that of the modern. Ding (1999) also found that Taiwanese primary school science teachers' views on nature of science were between the stages of the traditional and the modern one. Similarly, Chai, Deng & Tsai (2012) found that science teachers in Taiwan were more inclined to relativism than those in Mainland China.

Ten years ago, the first author of this study and her colleague carried out a national survey of science teachers' scientific literacy at primary schools in China, and identified their low level of scientific literacy. In that research the authors also proposed that the teachers' VNOS was greatly influenced by the extremist post-modernist philosophy of science, which was harmful and adverse to the aims of science education (Zhang and Yu, 2004).

Given the fast development of Chinese science, technology and society in /over the past decade, this study will demonstrate the results of the follow-up survey carried out in 2013 through trend analysis of primary science teachers' changes in scientific literacy in order to see:(1) What aspects of teachers' scientific literacy have changed in the past ten years in respects of procedural knowledge, views of/on the classic nature of science, views of the contemporary nature of science? (2) Have their teaching behaviors concerning applying inquiry learning in classrooms changed? (3) Do the in-service training time of the teachers and the level of their scientific literacy positively correlate each other so as to manifest the effectiveness of the training? (4) Are there any clues for understanding the cultural impact on the development of teacher's VNOS which may help to inform a more pertinent training program for them?

Research Method

Sampling. The survey districts, in 2003,included 21 provinces and autonomous regions in China: Beijing, Tianjin, Shenzhen, Zhejiang, Sichuan, Chongqing, Fujian, Hubei, Shandong, Liaoning, Jilin, Heilongjiang, Shaanxi, Shanxi, Henan, Gansu, Ningxia, Inner Mongolia, Yunnan, Guizhou and Xinjiang. The total number of investigated regions in 2013 remained the same but there were four different provinces: Hubei, Shanxi, Ningxia and Xinjiang which were replaced by Jiangsu, Anhui, Jiangxi and Qinghai and are considered more developed areas in China. This change is undesirable, of course, but it would not lead to devaluating the improvement of teachers' progress. The participants in the surveys were the in-service science teachers in primary schools from one or two major cities in each of the above districts. The valid questionnaires obtained in 2003 and 2013 were 1737 and 2005 respectively. In terms of the population of the sampling, there were totally 150,983 science teachers in primary schools in 2003; 173,505 in 2011 in China, according to the website of CERNET (Chinese Educational Research Network).

Questionnaire. This study paid special attention to NOS as the measuring focus for scientific literacy considering that factual knowledge of science was too broad to measure with sufficient validity, in addition to the primary principle that the NOS was a critical part of scientific literacy (AAAS, 1990). In terms of the operational definition of NOS, the scheme of PISA 2013 was adopted for this research, i.e. "procedural knowledge" and "epistemic knowledge" constituting two main constructs of NOS in the questionnaire. The "procedural knowledge" referred to the methods and processes of the scientific approach; the "epistemic knowledge" referred to the relationship among science, technology and society. In addition, with regard to the under developing state of Chinese science teachers' VNOS as indicated by previous researchers, e.g. the theistic or naturalistic explanation of science (Wan, 2014), and having extreme high scores in contemporary NOS without basic knowledge of classic NOS (Liang and Chen, et al., 2008), the classic NOS was emphasized in this study for increasing the validity of the measurement for the Chinese case. Actually, the construct of the contemporary NOS was not included in the 2003 version of the questionnaire; it only appeared in the 2013 version as a supplementary construct in order to mediate the relationship between the classic VNOS and other causal variables. Thus, the definition of basic scientific literacy in this study was presented as the combination of two constructs: (a) procedural knowledge of science; (b) views on the classic nature of science. There was another important part in the questionnaire: teaching behavior of teachers reflecting their application abilities of their views on NOS. The contents of the whole questionnaires then included five parts as follows.

Part 1: the demographic and sociological characteristics of respondents. The variables in this part include gender, age, undergraduate studies major, professional title and cumulative time of participating in-service training of science education, which are mostly ordinal variable. Part 2: the procedure knowledge of science. The questions of scientific methodology and processes are put in the context of everyday life reflecting the themes of differentiation between science and superstition, consistency of science, concept of evidence and experimental thought. The answers of the questions are in the form of multi-item single choice. The maxim score is 4; the minimum score is 0 for this sub-scale. For example, the question regarding the investigating the experimental concept is articulated as follows:

> In case that a kind of new drug for treating hypertension is doubted regarding its curative effect, what kind of approach should scientists adopt to make further research?
> [1] Do an investigation on the opinion of the patients and then make statistical analysis.
> [2] Do the questionnaire investigation on patients and doctors and then make statistical and comparative analysis of the two sets of survey data.
> [3] Judgment of the practically and curative effect of new drugs using the latest theories in medicine.
> [4] Dividing the patients into two groups; one group takes the new drug and the other group takes the old drug and then make a comparative analysis.
> [5] Have no idea.

Part 3: the classic view on the nature of science. This part contains 11 self-compiled subjects (items) of the nature of science, characterized by an emphasis on three dimensions of the basic nature of science: scientific observation, objectivity and uniformity. The subjects as well as their answers for coding in this part of the questionnaire were consulted with three distinguished scientists in Nanjing University with consensus responses (two of them are Academicians in Physics and one of them is an oceanographer trained in the UK with Ph.D. degree). The model answering was divided as follows: "agree", "neutral" and/or "disagree", as showing in Table 2. The maximum score is 33 and the minimum score is 11 for this sub-scale. The coefficient of internal consistency of this sub-scale in 2013 survey is 0.48 (Cronbach's alpha) which is 0.11 lower than that in 2003. The phenomenon of lower internal consistency in the measurement of scientific literacy compared with normal psychological measurement is quite popular (Kim & Nehm, 2011).

Part 4: the contemporary view on the nature of science. Only the 2013 version of the questionnaire includes the scale of contemporary view of the nature of science (23 items) which is characterized by reflective thinking of the nature of reality, objectivity, and uniformity of science. The items in this part are in Likert scale formation with 5 points, which were translated from the instrument compiled by Liang and Chen et.al. (2008). This instrument includes six dimensions: observation and inference, nature of scientific theory, scientific law and theory, influence of social culture on scientific research, creativity and imagination in scientific research and the diversity of scientific method. The coefficient of internal consistency was 0.71 (Cronbach's alpha), which is a bit higher than the original English version of the scale as reported by Liang and Chen et.al. (2008). Since this part did not appear in the 2003 version, the changes or development of the contemporary view on NOS will be discussed mainly on the basis of the content analysis of the answers qualitatively.

Part 5: the inquiry teaching behavior. The content of the questions in this part can reflect teachers' scientific attitude and behaviors in classrooms. For example, "do you ask students to finish experiment or exploration activities within the teaching hour?" The form of answers is multi-items of frequencies in ordinal measurement.

Survey Administration. The related department of the authoritative Central Institute of Educational Research of China (currently, National Institute of Education Sciences) contacted the relevant provincial and municipal education authorities to invite the teachers in their districts to fill in and hand over the questionnaires collectively when they were assembling for meetings or training. The questionnaires were filled in by the participants anonymously. The response rate was 100% and the scratch volume were only about 1% for both surveys, with the unanswered questions mainly in the two parts of the nature of science.

Data Analysis. By use of the software SPSS 11.6 ten-year change of the basic scientific literacy of teachers was described and statistically tested from the perspectives of procedural knowledge, views on the nature of science and teaching behavior. Since the study lacks 2013 data on the view on the contemporary nature of science, the comparison across the period was only conducted for the views on classic nature of NOS. The t-test and ANOVA techniques were applied between the variables of the basic scientific literacy (i.e. procedural knowledge, views on the classic nature of science) and demographic and sociological variables (i.e. education degree, the major of education, professional title, and participated training time etc.). The variable of teaching behaviors was also analyzed by connecting to the same demographic and sociological variables.

Results

The Participants. Among the participants involved in the survey, men accounted for 35.4% and women accounted for 64.6% in 2013. The proportion of men was decreased by 1% compared with 2003. There was an increase in the majority age groups from 21-30 years to the 31-40 years, which reflected the establishment of science education at primary school level for the first time in this country ten years ago when many young graduates were recruited as science teachers. The number of bachelor degree owners increased from 17.3% to 63.8%, but the number of teachers from the Majors in natural sciences or mathematics dropped from 29.3% to 21.2%. The number of teachers with the professional title of "senior teacher in primary schools" which was largely equivalent to Lecturer in universities increased from 35.5% to 59.6%.

Changes in Scientific Literacy and Teacher Behavior. The average score of the science teachers in the procedural knowledge was 2.69 in 2013. By converting it into a centesimal system, it was 67 which increased 24% of that in 2003. The score of "the classic VNOS" was 60 in 2013, which was 13% higher than that of in 2003. The score of teaching behavior was only 43 in 2013, which dropped by 1% of that recorded in 2003 (see Table 1). Statistical tests for the changes in procedural knowledge and the classic VNOS showed the significance level at $P<0.001$. But the change of "teaching behavior" was statistically insignificant with $P=0.182$. In addition, the standard deviations of the data increased for all the three sub-scales, as shown in Table 1.

Table 1. Change of scientific literacy and teaching behavior.

Sub-scales	Year	n	Mean (%)	SD	t-statistic	p-value
Procedural knowledge	2003	1733	2.19 (54.75)	0.87	-15.543	0.000
	2013	2005	2.69 (67.25)	1.05		
Classic VNOS	2003	1686	21.49 (47.68)	1.65	-35.393	0.000
	2013	1842	24.21 (60.05)	2.73		
Teaching behavior	2003	1677	9.36 (43.60)	1.56	1.336	0.182
	2013	1951	9.28 (42.80)	2.11		

To be specific, the progress of teachers in procedural knowledge was mainly on understanding the differences between science and theism with the proportion of right answers improving from 34.8% to 74.2%. However, it was still hard for them to understand the discrepancy between science and conventional superstition with the accurate rate declining from 77.3% to 73.9%. The big problem of the participants in understanding procedural knowledge was the lack of a clear conception of experiment (the specific question is shown earlier in this paper as an exemplar item) and the accurate rate just exceeded fifty percent, which, however, was much better than that of ten years ago, i.e. 22%. In addition, there was still a problem in their understanding of the difference between evidence and authority, and the accurate rate dropped from 85.5% to 62.2% in the past decade.

In terms of the changes of the teachers' views on classic NOS, as shown in Table 2, their understanding was very vague with half of the items showing degenerated situations compared to those of ten years before. For example, to the incorrect statement that "Earnest and meticulous analysis can make up the deficiency in step of observation", 59.8% of teachers chose "agree", which was more retrogressive than that in 2003 (i.e. 46.3%). Similar answers appeared for the item "Observation is easily disturbed by various factors which bring about deviation, so that scientific study should not depend on observation but logical inference." On the contrary, to the correct statement that "Observation is the most basic step for scientific inquiry", correct answers decreased from 97.2% to 90.6%. The low coefficient of internal consistency of the scale as stated earlier could also indicate the vague perceptions of classic NOS of the participants.

In addition to the vagueness of the teachers' conceptions on classic NOS, many participants believed in the more extreme post-modernist viewpoints. For example, 67.5% of the participants believed that the design of inquiry activity should follow the imaginative steps of children instead of the steps used by most scientists, which was an improvement on the 86.5% rate of ten years ago. Besides, as for the question: "do children consider the course of dissolution in chemistry as a kind of vital movement?" Only 24.8% of the teachers chose to "correct it in time", which was slightly better than that of ten years ago, but the rest of the participants responding to this question chose the following answer:" to let students make exploration freely or encourage them so as to develop their imagination".

Table 2. Change of teachers' view of "the Classic NOS".

Statements (Coding)	N 2003/2013	Answers	2003 (%)	2013 (%)
1. Earnest and meticulous analysis can make up for the deficiency in observation. (Wrong)	1720/1989	Agree	46.3	59.8
		Unsure	52.3	39.2
		Disagree	1.4	0.9
2. Observation is easily disturbed by various factors which bring about deviation, so that scientific study should not depend on observation but logical inference. (Wrong)	1722/1988	Agree	6.8	8.4
		Unsure	91.7	89.7
		Disagree	1.5	1.9
3. Observation is the most basic step for scientific inquiry. (Right)	1732/1992	Agree	97.2	90.6
		Unsure	2.5	7.8
		Disagree	0.3	1.7
4. The Scientific method is different in different countries. (Wrong)	1726/1980	Agree	18.8	11.6
		Unsure	80.4	84.7
		Disagree	0.8	3.7
5. In cases where social history repeats itself, scientific history may be different. (Wrong)	1730/1947	Agree	46.6	34.9
		Unsure	50.5	51.8
		Disagree	2.9	13.4
6. In cases where there is only observational records lacking analysis and theory, there is no scientific value to it. (Wrong)	1718/1947	Agree	41.3	61.8
		Unsure	54.2	34.9
		Disagree	4.5	3.3
7. Human beings can find all laws from cosmos to gene sooner or later. (Right)	1730/1925	Agree	5.4	33.0
		Unsure	25.5	52.8
		Disagree	69.0	14.2
8. Scientific findings of many generations of scientists and successors become closer and closer to the objective reality. (Right)	1729/1921	Agree	3.6	12.4
		Unsure	22.8	75.3
		Disagree	73.5	12.3

Finally, the unscientific behavior of teachers changed little compared with the above two dimensions of teachers' basic scientific literacy. The data in 2013 showed that more than half of teachers (53.3%) "always" or "often" , as they chose, arranged inquiry activities in the form of competitions, which was worse than that ten years before (i.e. 29.6%). Only 3.2% of teachers had not taken the form of competitions in science classes, which was similar to that in 2003, i.e. 4.0%. In fact, 53.6% of teachers agreed with wrongly that "in inquiry activity, cultivating the sense of competition of students should become one of the teaching objectives". In addition, 63.5% of teachers, due to an inability to understand the function of the spirit of freedom in inquiry, "always" or "often" asked students to finish the/an? experiment or inquiry activity within class time, which was better than the result of 75.7%often years before.

Effectiveness of in-service training. The connections between the demographic factors, i.e. training time, professional title, educational degree and the Major for undergraduate education, and the constructs of the basic scientific literacy informed the effectiveness of teacher training programs and the administrative policies associated with teachers' evaluation, promotion and personnel recruitment.

The number of teachers who participated in the in-service training of science education for more than 13 weeks increased from 0% in 2003 to 32.9% in 2013, which should put down to large scale national training programs implemented over the past decade as mentioned earlier. The impact of the training practice on teacher's scientific literacy, however, was minimal but interesting according to the data of 2013. T-test result proved that the training time had no obvious correlation with procedural knowledge and the teaching behavior, but rather is connected to their views on NOS (Table 3). Moreover, it seems that the classic VNOS regressed with training time while the contemporary-modern view made much progress with the increase of training time. The obvious inference of this finding is that while the training was effective on improving the contemporary VNOS of the teachers, it damaged the classic one.

Table 3. Impact of training on teachers' scientific literacy and behavior.

Sub-scales	Training time*	N	Mean	SD	t-statistic	p-value
Procedural Knowledge	≤13 weeks	749	2.93	1.17	-1.226	0.220
	>13weeks	1256	3.00	1.17		
Classic VNOS	≤13 weeks	682	42.85	4.13	2.859	0.004
	>13 weeks	1085	42.27	4.06		
Contemporary-modern VNOS	≤13 weeks	607	76.51	8.13	-2.182	0.029
	>13 weeks	1065	77.40	7.95		
Teaching behavior	≤13 weeks	732	10.58	1.75	-0.754	0.451
	>13 weeks	1218	10.64	1.84		

*"13 weeks" is a significant turning point in its non-normal distribution curve.

Demographic factors versus scientific literacy. According to the statistical analysis result from the survey data of 2003, the primary factor relating to the level of scientific literacy of the participants was their academic degree level, which was followed by the factor of the length of training time they obtained, the secondarily significant factor. The variable "Major" had only weak correlation with teaching behavior ($F=2.88$, $P\leq0.01$) and no significant correlation with the procedural knowledge and the classic VNOS (Zhang & Yu, 2004). In 2013, the primarily significant factor of the academic degree/diploma has been replaced by Major, which might reflect the recent development of science Majors in pre-service teacher education in China. However, the titles of teachers still had no obvious statistical relationship to the three aspects of scientific literacy in 2013 compared to that of ten years ago except that the contemporary VNOS had some relations with the title (Table 4). That meant the basic scientific literacy excluding the contemporary VNOS was not reflected in the evaluation criteria as important indicators for the quality of a science teacher.

Possible influence from the contemporary NOS. In terms of the influence of contemporary NOS on the views and behaviors of the teachers, the direct effect was little according to the data. However, if we compare it with that from the classic VNOS, there would be some implication. The correlation coefficients between the contemporary views of NOS with the procedure knowledge was 0.180 (P≤0.001), with the teaching behaviors was -0.022 (P=0.33). In comparison, the correlation coefficients between the classic views of NOS with the procedure knowledge is 0.105 (P≤0.05), with the teaching behaviors is 0.098 (P≤0.05). This difference seems to imply that the development of Chinese teachers' contemporary VNOS did not make positive a contribution in the same way as that of the classic one to science teachers' professional development. Meanwhile, the data in Table 4 demonstrated ironically that the higher their scores of the contemporary VNOS obtained the higher the professional title of the teacher concerned.

Table 4. ANOVA of VNOS and Behavior with Degree, Title and Major.

Demographics			Procedural Knowledge	Classic VNOS	Contemporary VNOS	Teaching behavior
Variables	Categories	n				
Degree	High school	79	4.391**	0.868	1.946	2.546*
	Junior college	642				
	Bachelor	1229				
	Master	41				
Title[2]	High Grade	91	2.014	1.862	3.016**	1.699
	First Grade	1041				
	Second Grade	677				
	Third Grade	85				
Major	Arts/Humanities	553	2.434*	1.085	2.527*	1.097
	Social Sciences	736				
	Mathematics and Natural Sciences	332				
	Computer, science and Engineering	93				
	Others	262				

*p≤0.05; **p≤0.01.

Discussion and Conclusion

Generally speaking, although significant progress has taken place over the past decade in terms of procedural knowledge and the understanding of the classical nature of science, the general level of basic scientific literacy of Chinese primary school science teachers was still very low. The average score in the procedural knowledge test was only 67%; and more than a

[2]The title labels are based on the new system and transformed from the complicated old system with discriminated category terms between primary and secondary schools. The High Grade here, as the top grade in the new system, was equivalent to the associate professoriate in higher education. In the coming new system, the top grade will be upgraded into Full High Grade which is equivalent to the full professoriate. So during the survey time there has not been teachers with Full High Grade title.

quarter of the teachers could not differentiate scientific procedure from superstition. In terms of their understanding of the classical nature of science, it was very much limited and vague given that half of the questions in this part of the questionnaire showed degenerated scores compared to those of ten years ago. In particular, their views on “observation”, the most basic step of scientific inquiry deteriorated. Most of them believed that “earnest and meticulous analysis can make up for the deficiency in step of observation”, because “observation is easily disturbed by various factors which bring about deviation.” On the other hand, more than half of the participants believed in extreme post-modernism, consenting to design their classroom inquiry activities by following imaginative steps that children put forward, allowing children to explore freely wherever they like to go. So it is understandable that there was not significant progress in their teaching methods in association with inquiry and learning. In fact, even if some inquiry, learning and cooperative activities appeared in the classroom today, oftentimes they still follow the prescribed textbook approach which is too rigid to adapt to the individual student’s background, so classroom atmosphere in science education tended to be either undemocratic or disorderly.

In-service training programs might be/is likely the key factor for the current situation. The classic VNOS of the participants regressed with the increase of training time whereas the contemporary VNOS progressed obviously with the increase of training time. However, it is the classic VNOS rather than the contemporary one that made positive contributions to the teachers’ professional development in terms of both procedural knowledge and scientific teaching. This verifies the conclusion made by Xue & Chen (2012) that the content of in-service training courses did not fit the trainees’ needs, which was largely adopted from developed countries against the principle of cognitive evolution or learning progression from the simple and basic to the complicated and sophisticated.

It was the teacher’s educational background, especially his or her professional level which on the whole correlated with their basic scientific literacy. Primary school teachers in China were largely graduates from the traditional normal colleges with three year programs at the tertiary level, which had no science major offered up until ten years ago. Even for some teachers from the institutions with four year programs, the science courses only constituted a limited part of the programs for science majors (Yan, 2009). In addition, the program is typically arranged in separate disciplines such as physics, chemistry, biology and geography (Hao, 2014) until 2001 when the new undergraduate program “Science Education” was established in dozens of selected normal colleges and universities (MOE. 2001), even then the teaching quality of this program was not satisfactory as reported by their student teachers (Zhang & He, 2012). For most pre-service and in-service training programs, therefore, they implemented factual knowledge-centered curricula by implanting teaching methods thus discouraging inquiry learning.

The manpower of science teachers in primary schools in China seems to have improved greatly over past decade in terms of the increased Mode of age from the 20s to 30s, the increased proportion of Bachelor degree holders, and the increased proportion of title holders among its participants. But these rosy figures are largely put down to the growth in higher education since 1999, when the average gross enrolment rate in higher education increased from 9.8% in 1998 to 37.5% in 2014. However, the quality of higher education has been decreasing (Zhang, Foskett, Wang, et.al, 2011). Meanwhile, all subject areas in colleges and universities have been facing a decline of male student enrollment especially in science and technology majors. One of the reasons is that the quota of high grade titles for primary and secondary school teachers was very limited and most of the quota was nominal only disconnecting to salary. As a pilot city for teachers’ title reform, for example, there were only

11 primary and secondary schoolteachers of all subject areas in the famous coastal city Qingdao accredited with the High Grade title (equivalent to that of full professoriate in higher education) in 2012. The total population of the city is nine millions (Yu, 2015）.

In addition, the unfairness in the current professional title promotion system is apparent. The participant teachers with higher basic scientific literacy and better behavior seemed not to be encouraged by their head teachers according to the findings above. In fact, the evaluation standard is not made public. The evaluation does not include a consultation of the public before the final decision process. Some criterion is extremely onerous and having low validity so that corruption and unfairness were easy to develop especially for the underdeveloped areas. For example, applicants had to obtain a certificate in information technology of education, for which the prerequisite condition was providing a pack of auto-video records of class teaching to demonstrate the strength of IT application ability of the candidate (Wang & Ma, 2015). Very recently, the Ministry of Human Resources and Social Security, and the Ministry of Finance of China jointly issued an important document on reforming the current professional title system of primary and secondary school teachers, which lists several key points to be reformed: unifying the discriminated systems between primary and secondary school teachers so as to elevate the status of primary teachers; Improving the fairness of the criteria and standard of teacher evaluation especially for the interests of poor rural areas; establishing a peer review system which emphasizes on class teaching quality instead of publications and academic degrees; increasing the transparency of the administrative process of teacher evaluation to prohibit corruption; abolishing the old life-tenure institution of the old title system. These tasks are planned to be completed at the end of 2016.

Finally, traditional Chinese culture might offer some explanation for the slow progress in the improvement of scientific literacy among some teachers between classic VNOS and the contemporary one. Prior to the 20th century, the Confucian classics being the only textbooks introduced into the school system in China, ignored and looked down on objective scientific observation which led to its unavoidable inability of the new education model to yield to modern science. As a result, many generations of teachers trained in colleges in China had little chance to understand and practice “scientific observation”. This background made them sympathetic to anti-scientific post-modernist ideas on education and classroom teaching which let children construct their own “theories”, without any proper guidance by adults since they believed that professional scientists produced theories just like this. A very recent qualitative study by some of the authors on the pre-service students’ views on the nature of science in some Chinese normal universities revealed that most of the participants in science majors could not manipulate/fully comprehend the concept of experiment, the objective nature of science, among scientists etc. Objectively, they transformed them into a context of human relationship, which reveals the impact of the traditional Chinese philosophy of “Zhong Yong” on students’ learning, as interpreted by the author (Wan, 2014). “Zhong Yong” as the typical doctrine of Confucianism has been recognized by most Chinese scholars as the core of Chinese culture which deals with the principles and strategies of inter-personal relationships.

In conclusion, Chinese science teachers’ training programs and the supporting personnel development policies need to be reformed in order to improve teachers’ scientific literacy. In reference to the history of science teacher’s education progress in developed countries (DeBoer, 2000), it is arguable that the training programs in developing countries like China should follow a progressive principle by starting with the earliest stage of classical science education, and the focus of teacher training programs should be on the fundamental elements of scientific inquiry such as objective observation, before developing on to contemporary modern thought. Moreover, it is the classical content of science education that confirms the current Chinese industrializing society where the students and teachers live. Of course, all these arguments need to be further studied especially for establishing a sound and precise relationship among the classic VNOS and modern VNOS of science teachers in developed countries.

References

AAAS (1990) . *Science for all Americans.* New York: Oxford University Press.

Alters, B. J. (1997). Whose nature of science? *Journal of Research in Science Teaching*, 34(1), 39-55.

DeBoer, G. E. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, 37(6), 582-601.

Gao, X. Y. The culture mission of science teachers and its realization. *Modern Education Science*, 2013(18), 9-11. (In Chinese).

Hao, Q. L. (2014). Teacher preparation for integrated science course. *Continuance Education Research*, (5), 66-68.

Kim, S. Y. & Nehm, R. H., (2011). A cross-cultural comparison of Korean and American Science Teachers' vies of evolution and the nature of science. *International Journal of Science Education*, 33(2), 197-227.

Lederman, N. G. (1992). Students' and Teachers' Conceptions of the Nature of Science: A Review of the Research. *Journal of Research in Science Teaching*, 29(4), 331-359.

Lederman, N. G. (2014). Nature of science: Past, present, and future. In N.G. Lederman & S. K. Abell (Eds.). *Handbook of research on science education*, *Volume II*. New York, NY: Routledge. Ch. 28.

Liang, L. Chen, S., & Chen, X. et.al. (2008). Assessing pre-service elementary teachers' views on the nature of scientific knowledge: a dual-response instrument. *Asia-Pacific Forum on Science Learning and Teaching*, 9, 1-20.

Liu. X. F. (2009). Beyond Science Literacy: Science and the Public. *International Journal of Environmental & Science Education*, 4(3): 301-311.

McComas, W. F., & Olson, J. K. (1998). The nature of science in international science eduction standards documents. In W. F. McComas (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 41–53). Dordrecht, Netherlands: Kluwer Academic Publishers.

Miller, J.D. (1983). Scientific literacy: A conceptual and empirical review. *Daedalus*, 112 (2), 29-48

MOE (2001). *An Outline for the Basic Education Curriculum Reform (Trial Version)*. Beijing: Ministry of Education of China. 17. (In Chinese).

National Research Council. (1996). *National Science Education Standards.* Washington, DC: the National Academies Press.

Nehm, R.H. &Schonfeld, I.S. (2007). Does increasing biology teacher knowledge of evolution and the nature of science leads to greater preference for the teaching of evolution in schools? *Journal of Science Teacher Education*, 18(5), 699-723.

HKPISA Centre. (2011). *The fourth HKPISA report PISA 2009 Monitoring the quality of education in Hong Kong from an international perspective.* Hong Kong: HKPISA Centre.

Osborne, J. (1996). Beyond Constructivism. *Science Education*, 80(1), 53-82.

Osborne, J., Collins, S., Ratcliff, M., et.al. (2003). What 'ideas-about-science' should be taught in school science? A Delphi Study of the 'Expert' Community. *Journal of Research in Science Teaching*. 40(7), 692 - 720.

Paletz, S. & Peng, K. (2009). Problem Finding and Contradiction: Examining the Relationship between Naive Dialectical Thinking, Ethnicity and Creativity. *Creativity Research Journal*, 21(2-3),139-151.

Peng, K., & Knowles, E. (2003). Culture, education, and the attribution of physical causality. *Personality and social psychology bulletin*, 29(10), 1272-1284.

Slay, J. (2000). Culture and conceptualizations of Nature: An Interpretive Analysis of Australian and Chinese Perspectives. Doctoral dissertation, Curtin University of Technology.

Smith, P. B. (2004). Acquiescent response bias as an aspect of cultural communication style. *Journal of Cross-Cultural Psychology*, 35(1), 50-61.

Wan, D. S., (2014). Research on Chinese Pre-service Science Teachers' Naïve Views of the Nature of Science and the Cultural Impact. Doctoral dissertation, Nanjing University. (In Chinese).

Wang, C. G. (2014). The development of scientific literacy of primary school science teachers in Beijing. *Journal of Beijing Institute of Education (Natural Science Edition)*, 3, 60-64. (In Chinese).

Wang, G.D. & Ma, W.Q. (2015). Corruption phenomena in professional title promotion practice for school teachers in China. *Science Popularization & Science Education*, 12, 40-41. (In Chinese).

Wang, J. Y. (2010). Comparing the fulfillment of the teaching objectives in their inquiry teaching between USA and Chinese teachers. *Global Education*, 39(4), 79-84. (In Chinese).

Wu, Y. Y. (2011). A survey of the secondary science teachers' view of the nature of science: a case from Zhejiang Province. *Global Education*, 40(3), 82-87. (In Chinese).

Xing, L. C. (2011). Issues and strategies for continues education of the teachers who teach "Science" course. *Continue Education Research*, 9, 87-89. (In Chinese).

Xue, H. N. & Chen, X. M. (2012), X. A national survey on the quality of present teacher training programs. *Educational Science*, 28(6), 53-57. (In Chinese).

Yan, Y. H. (2009). A century changes of Chinese science teacher training programs. *Higher Education of Science, Math and Technology*, (4), 10-13. (In Chinese).

Yang, G. S. (2004). *Chinese Psychology and Behavior: Localized Study*. Beijing: Chinese People's University.

Yu, H. B. Meng, S. H. (2004). Post-modern orientation of the views on science and its implications for science education reform. *Modern Education Science*, 5, 63-65. (In Chinese).

Yu, Z. (2015). An investigation into the status quo of professional titles of primary and secondary school teachers. *The World of Labor Assurance*, 28, 10. (In Chinese).

Zhang, H., & He, H. (2012). Effectiveness of Undergraduate Science Education Program in China: Perceptions of Seniors and Alumni. *International Journal of Science Education*, 34 (13), 1991-2013.

Zhang, H., & Wan, D. (in press). *Chinese Science Education in the 21st Century: Policy, Practice, and Research*. Springer. http://www.springer.com/us/book/9789401798631.

Zhang, H. & Yu, B. (2004). A survey of primary science teacher's scientific literacy. *Educational Research*, 11, 58-67. (In Chinese).

Zhang, H., Foskett, N., & Wang, D.M. et. al. (2011). Student satisfaction with undergraduate teaching in China – A comparison between research-intensive and other universities, *Higher Education Policy.* 24,1-24

Author Bios

Hongshia Zhang graduated from Nanjing University with B.Sc. in Physical Geography and M.Sc. in Oceanography, and from the University of Southampton in the UK with Ph.D. in Education, is now working in the Institute of Education, Nanjing University, China. She is the member of General Education Committee and International Students Education Committee in this university. Prof. Zhang is also the committee member of the Chinese Society of Higher Education and the standing committee member of the Chinese Society of Science Education. Her present academic specialty covers broad areas of higher education research, comparative education, science education, educational philosophy, and research methods. She has published more than ninety refereed papers in domestic and international journals including Higher Education Policy and International Journal of Science Education.

Imran Haider Shamsi is a Ph.D. scholar at the Institute of Higher Education, Nanjing University. His research areas are higher education and comparative education.

Iffat Batool is a Ph.D. scholar at the College of Education, Zhejiang University. Her research areas are higher education and comparative education.

Dongsheng Wan graduated from Nanjing University and is an associate professor in School of Education, Jiangsu Second Normal University, China. His research interests are principally international comparisons of science education, education about the nature of science and cultural Influences on science education. He has published 10 articles in domestic journals. At present, he is presiding over the project "Research on the Mechanism of Cultural Influences on Scientific Literacy of Students and Educational Paths (15YJCZH157)", which belongs to the Humanities and Social Sciences Research on Youth Fund Project of Ministry of Education, China.

Bo Yu is a senior research fellow in the Sector of Curriculum and Instruction, the Chinese Institute of Education Research. She is the member of the National Advisory Committee for Curriculum and Text book Reform at the elementary and secondary education level. She is also the chief editor of the influential school science text book, published by the Education Science Publishing Co. She was a member of the board for the National Science Curriculum Standard. She has hosted several national science curriculum research projects and published relevant reports and monographs.