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Research Article

Research on Relationships between Two Kinds of Scientific Epistemology Held by High School Science Teachers from Beijing and New York*

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Abstract

Scientific epistemology is important issues in the International science education, of which teachers' views of nature of science and scientific inquiry as the two core topics, become the principal part of research, also have an important influence on the theory and practice of science curriculum. The purpose of this study was to investigate and compare the relationship between views of NOS and SI held by high school science teachers from Beijing and New York. This sequential mixed research method study involved 102 high school science teachers, each 51 high school science teachers from Beijing and New York, through questionnaires Views of nature of Science-Form C (VNOS-D) and Views of Scientific Inquiry-Form S (VOSI-S), followed by in-depth interviews responses. This investigation indicated that science teachers' views of two kinds of scientific epistemology were at different stages, categories and causality, and therefore, it has great effect on the cultural research in science education.

Keywords

Scientific epistemology • Nature of science • Scientific inquiry

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Epistemological belief in science refers to the characteristics of scientific knowledge and the development of cognitive or views of scientific knowledge, which is a personal scientific philosophy belief (Elder, 2002). The nature of science (NOS) and scientific inquiry (SI) are the core proposition of scientific literacy, which belong to the category of epistemological belief in science. Researchers explain the NOS with the two concepts of “a way to acquire knowledge” and “epistemology,” in other words, science is a way to understand the world (Matthews, 1998). Epistemological belief in science is a big conception, in which the NOS and SI is often confused, and they have a certain relationship, but also a great difference. SI is referred to the process of scientific knowledge development, as a result of the practice and hypothesis of this process, the knowledge production has inevitable characteristics, which related to the NOS. Epistemological belief in science of teachers mainly includes the understanding of the NOS, SI, and so on. In science teaching, teachers not only enable students to learn scientific knowledge, but also to train students’ basic skills and methods of thinking through the process of scientific knowledge generation, therefore, promote the international K-12 science education advocates to explore the teaching methods and course contents which take inquiry as the core goals. When inquiry teaching is advocated, the inner relationship between the NOS and SI is often ignored, this dynamic relationship of which directly affects teachers’ scientific teaching and their epistemological development.

Literature Review

The researchers suggest the epistemological belief in science should be the main part of science education (e.g., Chinn & Malhotra, 2002; Duschl & Grandy, 2005), because students not only need to understand the scientific content, but also the evolution of scientific ideas and the process of proof. Inquiry teaching is considered to be the most appropriate teaching strategies in science education, to participate in the inquiry process could help students to understand the scientific knowledge (Sandoval, 2005). American Association for the Advancement of Science (AAAS, 1989) indicates that the standards of science education are the core objective of science education, and science education should teach students the concepts and processes of science. Therefore, it is very important to test the way that students participate in science learning activities, which could build their views of science. The scientific process is a bridge between the epistemological belief and science education, including the construction and demonstration of concepts. The epistemological belief is related to the nature of knowledge, and understanding the nature of scientific knowledge is an important aspect of understanding of science meaningfully, many researchers study the epistemological belief from the perspective of teaching practice (e.g. Hammer & Elby, 2003; Wang, Wen, & Jou, 2016). One of the goals of science education is to guide students to develop the effectual conception of nature of scientific knowledge, referring to the development of views

on the results of scientific knowledge to guide them to participate meaningfully in the current and future scientific study (Chai, Deng, Wong, & Qian, 2010). This concept itself includes the belief and practice, used to understand how to construct and support the meaningful participation of the scientific learning environment, to support the development of students' epistemological belief in science.

The research on epistemological belief proposed that personal belief in the nature of knowledge can affect the interpretation of the cognitive learning and information (Kuhn, Cheney, & Weinstock, 2001; Schommer-Aikins & Hutter, 2002). Tsai (1999), Yager and Lutz (1995) and others studies indicated that teachers could enhance students' views of NOS promoted from positivism to constructivism through STS teaching (with social themes related to science and technology, using the role playing, debates, group discussion and other teaching methods). He also proposed that epistemological belief in science affected students' information processing model during the teaching, and someone who with constructivist epistemological belief in science tended to use the model of conditional inferential reasoning when they did the information processing. The research on the topic of social-scientific issues judgement in decision and teaching showed that discussing the nature of the value of faith and knowledge in the issue teaching, can improve students' understanding of the complexity issues and the way of judgment and thinking (e.g., Grace & Ratcliffe, 2002; Yang & Anderson, 2003). Zeidler, Sadler, Simmons, and Howes, (2005) attempted to explore the relationship between the issue decision making and the NOS, and the results showed that teachers' understanding of the cultural aspects of science and society can affect the interpretation of the subject. Several other respondents believed that scientific knowledge is determined after it was proved, so in the issues, it lacks of depth understanding when presented in different views. However, in this study, the relationship between the decision making and the NOS is only inferred from a small number of interview data, which is completely difficult to explain the relationship between them. Through the analysis of the literature, although they proposed the interactions between epistemological belief in science and issues decision and judgment, studies did not detect the relationship between the epistemological belief in science and issues judgments, or only indicated the relationship between the two from implicit component in the process of testers' reasoning on the issues. In addition, Bell and Lederman (2003), Sadler and Zeidler (2004) found that understanding the NOS did not directly affect individual's issues decisions. They indicated that we should consider students' moral development, cognitive inference development, emotional beliefs and other factors to integrate the teaching of social-scientific issues and enhance students' epistemological belief in science. Furthermore, the authenticity and relevance of issues may also cause the respond difference between the participants, so that the impact of the issues decision making caused by their understanding of faith can't be found in the explicit way.

In the international science education, it has been considered that the epistemological belief in science is a larger category, and the epistemological belief in science contains the understanding of NOS and SI (Lederman, 1992). The NOS refers to the characteristic of scientific knowledge and the values and beliefs related to their development, while SI is the characteristic of the development process of scientific knowledge. They have a close relation which is interrelated and inseparable, both of whom should be considered into the framework of the epistemological belief in science (Campanile, Lederman, & Kampourakis, 2015). Individual epistemology is situational, the epistemology in scientific contains the NOS and SI (Schommer-Aikins, Duell, & Hutter, 2005). The process of SI is benefit to learning NOS, and the promotion of understanding of NOS helps to develop a higher level of epistemological belief in science. To investigate the inner relationship between the two kinds of scientific epistemology held by science teachers from Beijing and New York, the differences between the science teachers from Beijing and New York have been investigated in this paper.

Research Methodology

General Background of Research

A sequential mixed research method is used to investigate the relationship between two kinds of scientific epistemology held by high school science teachers from Beijing and New York. Open-ended questionnaire and follow-up interviews are conducted to collect data and to compare scientific epistemology stage, correlation and causation of the teachers from those two kinds of different countries through the quantitative study. Two types of scientific epistemology and the correlation of science teachers between Beijing and New York also are compared by the qualitative study. The three main research questions of this study are as follows:

1. What are the cognitive stages of NOS and SI held by science teachers from Beijing and New York?
2. What's the relationship between Beijing and New York science teachers' views of NOS and SI?
3. What are the cognitive types of the NOS and SI held by science teachers from Beijing and New York?

Sample and Instrument

Because both of the developed and developing countries have the situation of uneven development of education in different cities and regional imbalance of educational resources development, two well-developed cities (Beijing and New York) from China and the United States are chosen. Both of the cities share the similarity of the biggest city in the country. In China, if a school is closer to the city center, the quality of education in that school will be better than other schools in outer suburbs, because the outer suburbs is relatively backward. But there may be a different situation in the United States. So the location of the school is considered as the second key factor in the sampling process. With the principle of convenience, basic characteristic like sampling city, school type, grade, subject and other aspect are kept the same. 12 high schools are chosen in Beijing and New York respectively, with 4-5 science teachers in one school selected in both demonstrative and average schools distributed in rural and urban areas. The number of Beijing science teachers majoring in physics, chemistry and biology is 19, 16 and 16 with 50% degree of graduate, while for New York teachers 12, 16 and 23 with 100% degree of graduate, and they all have more than 5-year experiences as a science teacher. Science teachers in Beijing only have taught the subject of their majors in undergraduate, while science teachers in New York could be competent for all the science, technology and engineering courses. Overall, the Beijing teachers' pedagogical Content knowledge, background of curriculum and teaching are relatively simple, because they could competent only one science subject.

The paper mainly uses two international accepted questionnaires, VNOS-D (Views of Nature of Science, version D) and VOSI-S (Views of Scientific Inquiry, version S), then combines with the followed-up interviews to study (Lederman, 2007). Quantitative and qualitative analysis methods are adopted to analyze the results of the two sets of questionnaires and interviews. In quantitative analysis part, the open-ended questionnaires are used for four-level coding to get quantitative data, and in qualitative analysis part, three-level coding method of Strauss and Corbin (1990) for system coding textual analysis has been conducted, which is open coding, relational coding and core coding.

Procedure and Data Analysis

The main process of the open-ended questionnaires and the interview include: questionnaire collection, quality and time control, questionnaire survey and interview. The questionnaires are collected in the form of on the scene with pen and paper, and the way of the Internet instant answer, then the subsequent or additional interviews by computer, telephone or face to face for the teachers who with the unclear views are conducted. Because the two methods of on the scene and the internet have the real

name system and the answers are under quality control with time requirements, there is no essential difference between those two kinds of research methods.

In this study, the quantitative and qualitative methods are used to analyze the open-ended questionnaires and interviews, the quantitative evaluation uses a method of level coding, which has the rating standard of VNOS-D and VOSI-S developed by Lederman to analysis the qualitative data of the open-ended questionnaires changed to the quantitative ones. Each topic of the questionnaires has its own assessment standards, which could be divided into four grades of different topics of NOS and SI, and the assessment level from low to high is named as unclear, naïve, traditional and informed, with the evaluation value from 0 to 3. According to the evaluation description and standards of the questionnaires, as well as the results of the interview, there are three researchers of the China and the United States who would agree with the grading (the author and two doctoral students in the United States, B and H, and the other two doctoral students in China, W and Z) as a final assessment results.

As for scoring guide for VNOS-D, the grading standard has seven dimensions of Subjectivity, Empirically Based, Observation vs. Inference, Tentativeness, Socially-Culturally Embedded, Creativity and Theory vs. Law. Description of score based on analysis of student's responses is also divided into four kinds of evaluation stages called unclear, naïve, transitional and informed. For example, in the Empirically Based dimension, it could be expressed as Unclear-- unintelligible responses or no evidence, Naïve--Based on something other than observations of the natural world, Transitional--Seeming contradiction among responses, and Informed--Based upon observations of the natural world. As for scoring guide for VOSI-S, the grading standard has nine dimensions of Begins with a Question, Multiple Methods, Inquiry Procedures Guided by Question, Same Procedures May Not Give the Same Results, Inquiry Procedures Can Influence Results, Research Conclusions Must Be Consistent with Data Collected, Data \neq Evidence, Criteria for Scientific Explanations, and Views of Experiment. Description of score based on analysis of student's responses is also divided into four kinds of evaluation stages called unclear, naïve, transitional and informed. For example, in the first dimension of *Begins with a Question*, description of score based on analysis of student's response could be divided into four stage from unclear to informed, Unclear--unintelligible responses or no evidence, Naïve--Do not start with a question, Transitional--Some but not all investigations begin with a question or that they all require a hypothesis, Informed--Scientific investigations all begin with a question, but do not necessarily test a hypothesis.

Result of Quantitative Research

Quantitative research is mainly to quantify the qualitative data of open-ended questionnaires by coding the quantitative grade, concluding the average level of the two scientific understanding of each teacher, comparison of two kinds of cognition stage, analyzing the correlation and causality, meanwhile the two kinds of scientific understanding of teachers from different countries are investigated.

Comparison of Two Kinds of Scientific Understanding Stage

In order to understand the cognitive stage of SI held by teachers from Beijing and New York, each teacher's scientific understanding stage of inquiry is calculated and put in ascending sequence according to the data. In terms of the cognitive level of SI, more than a third (35%) of Chinese teachers are under the traditional stage (2), and the 65% of them are between traditional and informed stage, but 79% of whom lie in the lower middle part, namely primary part (2-2.5). About one of six (16%) American teachers' levels are under the traditional stage, and more than half of (53%) the teachers are in the advanced part (2.5-3) between traditional and informed stage. Thus, the level of understandings of scientific inquiry held by Chinese teachers are mainly in the traditional stage and the primary part of traditional to informed stage, while half of the American teachers are in the advanced part of traditional to informed stage, and the overall level goes higher than the traditional stage (Figure 1).

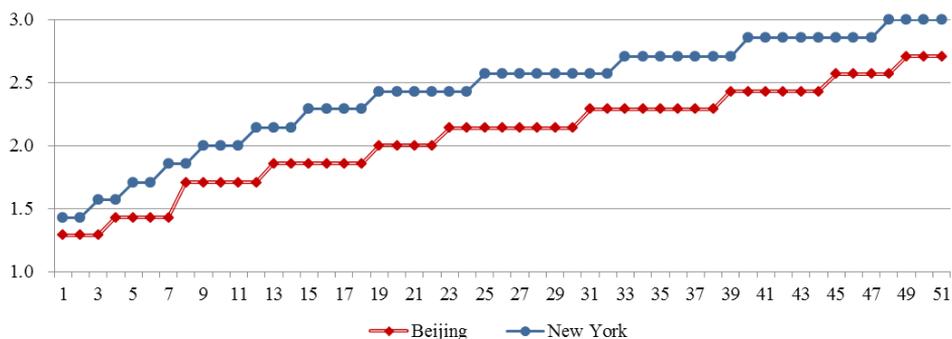


Figure 1. The distribution on Chinese and American science teachers' cognitive stages of scientific inquiry.

Chinese and American teachers' understanding of NOS (Figure 2) is slightly higher than their understanding of SI, and most of the teachers are above the traditional stage. The differences between them are less than scientific inquiry. In terms of cognitive stage of NOS, 61% of Chinese teachers are in the primary part of traditional to informed stage (2-2.5), and American teachers in an advanced part

of traditional to informed stage (2.5-3) are a little more than the primary part, 49% and 39% respectively. Thus, the understandings of NOS held by Chinese teachers are basically in the primary level of traditional to informed stage, and the American teachers are in the advanced level from the traditional to informed stage.

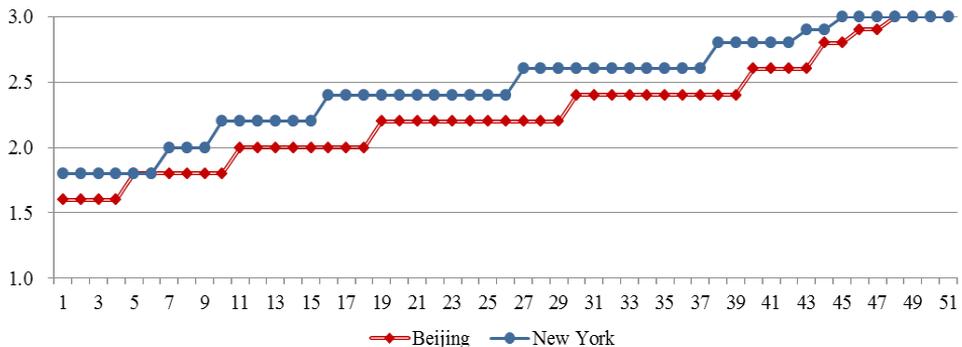


Figure 2. The distribution on Chinese and American science teachers’ cognitive stages of nature of science.

Result of Qualitative Research

Textual analysis includes the questionnaire and interview of 102 science teachers from Beijing and New York. When half of the teachers’ textual materials are analyzed, it achieved “theoretical saturation,” without a new type appeared, so the sample size of this qualitative analysis could cover the basic types of teachers’ views of NOS and SI. Both the American and Chinese teachers’ views have six types. But the proportion of the teachers who held a certain type in two countries is different. Each of the understanding from the two countries has some correlations and further study is conducted by the schema and textual analysis.

The Text Analysis of Open-Ended Questionnaire

Starting with distinguishing the themes of 5 topics of the NOS and 9 topics of scientific inquiry from the open-ended questionnaire when open coding is conducted, and then some characteristics considered as secondary category from each topic is found, called the key words to describe that topic. The open-ended questionnaire is extracted to find out the dimensions of the key words, and the key words are represented in the integral of the NOS and SI. The NOS is divided into 7 dimensions such as what is science, differences, scientific knowledge, dinosaur issue, weather forecast, science models and creativeness, and the SI is also divided into 7 dimensions such as activity characteristic, scientific work, bird issue, characteristics of work, data analysis, and evidence of data. An open coding category is chosen to be considered

as a core in the research process when a relational coding is conducted. Then the core is related to other categories, for example, the core category of the NOS is the dimension of “what is science,” using teachers’ key words is this category to analyze the causation and effect factors between the other six dimensions. In fact, when core coding is conducted, 7 dimensions of the NOS formed in relational coding are interacted and reinterpreted to clarify the relationship among different dimensions represented by categories. Then all the teachers’ core categories are compared, getting different types until the amount of types is saturated. This study achieved theoretical saturation when half of the questionnaires are analyzed, forming the basic types.

Types of Teachers’ Two Scientific Epistemology

Based on the textual analysis of the three-level encoding, Chinese teachers’ views of NOS could be divided into six types: structure and function, empirical research, cognitive style, regularity theorem, knowledge system, scientism. In the same way, there are six types of teachers’ cognition of scientific inquiry: inquiry skills, situational construction, cognitive ability, subject knowledge, setting process and subject ideology. The meaning of the six types of NOS are as follows: the structure function emphasizes that the science is organized and every part has its corresponding function; empirical research pursuits the truth and positivist of science; cognitive style means that science can be used as a way of thinking or as a way of life; regularity theorem emphasizes the truth of science; knowledge system is centered on the scientific knowledge; scientism advocates the scientific theory is universal. The meaning of the six types of the SI are as follows: inquiry skills emphasize basic skills and process skills; situation construction pays attention to the situation in the process of inquiry and the construction of students’ knowledge and process; cognitive ability means teachers should regard the students’ cognition as the teaching goals; subject knowledge means knowledge is the center to inquiry; setting process emphasizes the immobilization process and steps of inquiry; subject idea emphasizes the basic idea of science subjects.

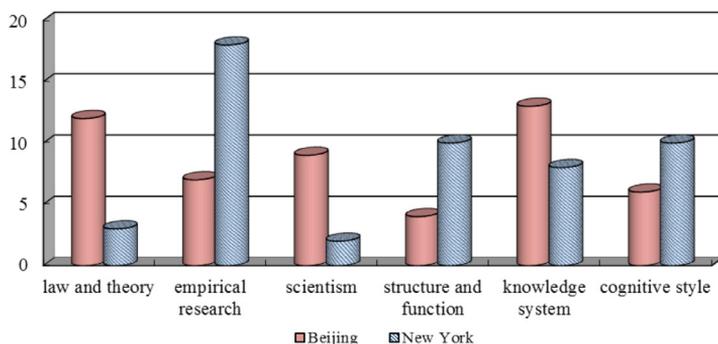


Figure 3. Comparison of views of nature of science held by teachers from Beijing and New York.

The number of teachers in each of the types of knowledge is counted to compare the differences in Figure 3 ordered from large to small. The horizontal axis represents the type of the NOS, and the vertical axis represents the number of teachers. The number of Chinese teachers' type of regularity theorem is greater than American teachers, while the number of American teachers' type of empirical research is greater than Chinese teachers. The number of Chinese teachers' type of scientism is greater than American teachers, while the number of American teachers' type of structure function is greater than Chinese teachers. Chinese teachers' type of knowledge system is greater than American teachers, while the number of American teachers' type of cognitive style is greater than Chinese teachers. The descending order of the types of Chinese teachers' understandings of NOS is knowledge system, regularity theorem, scientism, empirical research, cognitive style, structure and function, while the type of American teachers is structure and function, cognitive style, knowledge system, regularity theorem, scientism. The views of SI are conducted in the same way, which is shown as Figure 4 for differences of the types of American and Chinese teachers' understandings ordered from large to small: the number of Chinese teachers' type of setting process is greater than American teachers, while the number of American teachers' type of situation construction is greater than American teachers; the number of Chinese teachers' type of subject knowledge is greater than American teachers, while the number of American teachers' type of inquiry skills is greater than Chinese teachers; the number of Chinese teachers' type of subject ideology is greater than American teachers, while the number of American teachers' type of cognitive ability is greater than Chinese teachers. The descending order of types of Chinese teachers' understanding of SI is setting process, subject knowledge, cognitive ability, subject ideology, situational construction and inquiry skills, while the descending order of American teachers is situational construction, cognitive ability, inquiry skills, setting process, subject ideology and subject knowledge.

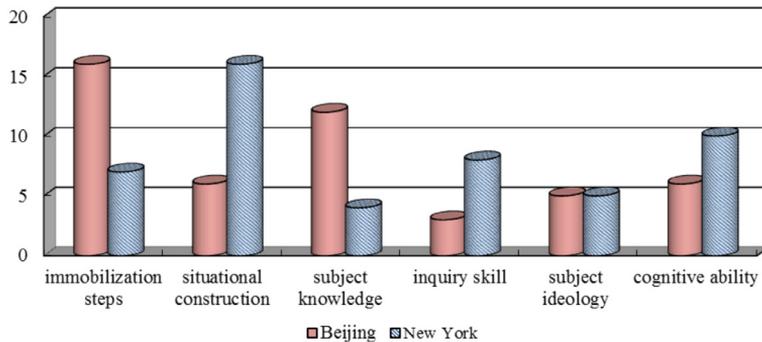


Figure 4. Comparison of views of scientific inquiry held by teachers from Beijing and New York.

The Qualitative Analysis of the Relevance between the Two Types of Teachers' Understanding

The correlation and causation of the two types of teachers' understandings from a quantitative respect are analyzed in the above section, and then the corresponding schema analysis from each of the teacher's two types of epistemology understanding is conducted to find their relationship by the schema analysis. Firstly, the number of teachers with specific type of understandings of NOS and SI are counted. Linking the type of NOS and SI, different lines stands for the number of teachers who belongs to a specific type as shown in Figure 5. The number of different types of lines on the bottom represents the number of the teachers who belongs to this type. The lowest linking number of only one teacher is deleted, and the basic relationship lines could be divided into three types, which are week correlation, moderate correlation and strong correlation, with the number of teachers for 2, 3-4 and 5-8. From the schema analysis of Beijing teachers on the left of Figure 5, the correlation of the two epistemology understandings of Chinese teachers is as follows: the primary correlation between NOS and SI is regularity theorem corresponding to the setting process and knowledge systems corresponding to the subject knowledge; secondly, the empirical research corresponds to the situational construction and inquiry skills, and the cognitive style corresponding to the cognitive ability; Finally, the empirical research corresponds to the cognitive ability, the cognitive style corresponding to the situational construction, and scientism corresponding to the subject knowledge and subject ideology. There is mutual effect among the empirical research, cognitive style and situational construction.

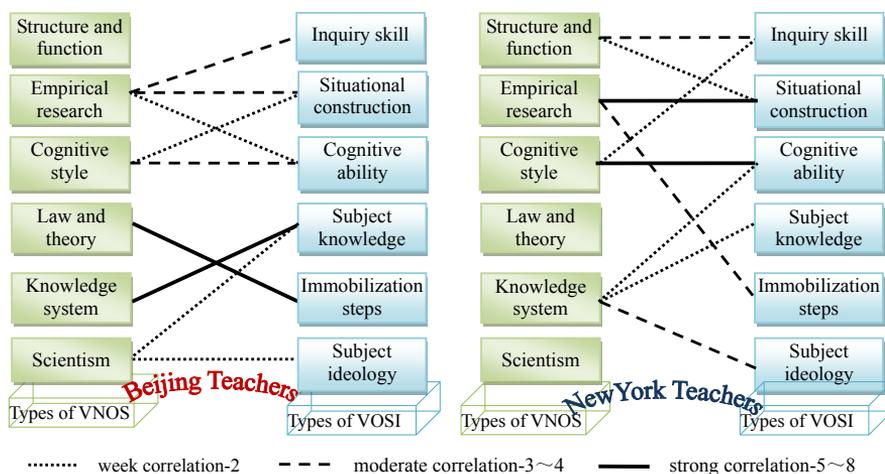


Figure 5. Schema analyses of the relationship of VNOS and VOSI held by teachers from Beijing and New York.

From the right of Figure 5, the correlation of the two epistemology understandings of American teachers is as follows: the primary correlation between NOS and SI is empirical research corresponding to situational construction and knowledge systems corresponding to cognitive ability; Secondly, structure and function corresponding to the inquiry skills, empirical research corresponding to the setting process, knowledge system corresponding to the subject ideology; Finally, the structure and function corresponds to the situational construction, cognitive style corresponding to the inquiry skills, knowledge system corresponding to the cognitive ability and subject knowledge. There is mutual effect among the views of NOS except for the regularity theorem and scientism, and the SI except for the subject knowledge. Further comparison of the schema correlation of the teachers from Beijing and New York have shown that Chinese teachers have the following kinds of subjectivity connection, “regularity theorem--setting process,” “empirical research--inquiry skills,” “knowledge system- -subject knowledge,” but American teachers may not have any kinds of these correlations. American teachers have the following kinds of subjectivity connection, “empirical research--situational construction,” “cognitive style--cognitive ability,” and some of Chinese teachers have these kinds of correlations. The particular correspondence of teachers in both countries is the scientism connection of Chinese teachers and the structure and function of American teachers. Besides, Chinese teachers’ knowledge system corresponds to subject knowledge, while American teachers’ knowledge system corresponds to cognitive ability and subject ideology. On the contrary, Chinese teachers’ setting process corresponds to regularity theorem, while American teachers’ knowledge system corresponds to empirical research.

The connection of two kinds of Chinese teachers’ epistemology is based on “regularity theorem--setting process,” “knowledge system--subject knowledge,” while American teachers’ epistemology is based on “empirical research--situational construction,” “cognitive style--cognitive ability.” Chinese teachers’ VNOS type of knowledge system corresponds to the VOSI type of subject knowledge, while American teachers emphasized the cognitive ability and the subject ideology. The views of setting process of the SI of Chinese teachers are mainly affected by the regularity theorem, while American teachers are affected by the empirical research.

Textual Analysis of the Interview

Based on the analysis of the open-ended questionnaire, a further textual analysis of the teachers’ interview record is conducted. It is found that teachers’ understanding of scientific inquiry is not limited to scientific inquiry issues mentioned in the VOSI-S, while they also discuss and explain the academic point of inquiry in discipline. Therefore, the relevant issues on inquiry are not only added in the additional

interview, but also the following two questions are increased: please talk more about your understanding of SI and NOS? Specific to the subject you teach, how do you consider the inquiry teaching and NOS teaching? Based on the in-depth interviews and its analysis, it is found that teachers' understanding of scientific inquiry is mainly focused on the basic principles of SI and the belief in the subject inquiry, and a further examination was conducted on the correlation of the two kinds of epistemology. For example, Teacher A emphasized the universality and uniqueness of science, so he proposed that scientific inquiry should pay attention to the subject ideology, which is unique to Chinese teachers. Teacher B proposed that NOS is empirical research, and SI should pay attention to the situational construction, so he emphasized the understanding of processes and methods, which is universal to American teachers. Teacher W approved NOS are empirical research, and she proposed that "Scientific inquiry is a way to teach students some truth reality with a decisive significance for the pursuit of the life in the future. In the examination-oriented education we just simply tell them the results, and have no time to teach them the method to explore the truth. We all like to pursue the college entrance examination scores, and no one dare to take risks with their own future to tell the students the results and methods they can't see." When asked about the connection between scientific inquiry and scientific experiment, she answered, "Scientific inquiry, includes scientific experiment, in other words, experiment is a way to inquiry. The ultimate goal of teaching students the method to pursue truth is to cultivate students' scientific attitude, developing scientific literacy." She suggested, "Scientific inquiry is a gradual experiment according to several factors mentioned in the national standard." The interview also involved the status of scientific knowledge, the teacher proposed, "Scientific knowledge is the basic content of scientific inquiry, associated with life, a topic that can be verified by less complex experiment, and suitable for inquiry;" when asked about specific examples, she said, "Yes, there are many examples at the back of the textbook," "Do you have your own examples?", "No, we don't usually teach the examples with less relevance to the college entrance examination.".....Teacher S suggested that NOS is a cognitive style, and inquiry should be focused on the cognitive ability. From his interviews, it showed that he might think more, but there is the myth for the understanding of the conceptions related to the science inquiry.

By briefly analysis of the five teachers, the results of textual analysis are similar with the schema analysis. The type of structure and function is the unique characteristics of American teachers, emphasizing inquiry skills. Empirical research emphasizes situational construction, and cognitive style emphasizing cognitive ability. The regularity theorem is the unique characteristics of Chinese teachers, emphasizing regularity and principles, corresponding to setting process. As for Chinese teachers, knowledge system corresponds to subject knowledge, while it corresponds to cognitive ability and subject ideology of American teachers. Scientism is also the unique

characteristics of Chinese teachers, corresponding to subject knowledge and thinking. From the teachers' interviews, teachers mainly discuss the understanding of scientific inquiry from the basic principle of SI and the inquiry belief in subject, and the level of their understanding is quite low, which also has great misunderstanding. There are five misunderstandings of science teachers: firstly, they could not distinguish between experiment and inquiry. Many teachers think that the experiment is the same to inquiry, and they do not know there are a variety of methods to obtain scientific knowledge, such as observation, analysis, prediction, literature review, experiment and so on. For example, some Chinese teachers pointed out the observation of bird's beak are not scientific, and the observation and analysis are not a kind of inquiry method. Secondly, they may make confusion between inquiry and other learning concepts. The majority of teachers could not distinguish between the discovery learning, inquiry learning and project learning, and they often confused with these concepts, and even some teachers have never considered the differences. For example, in the Chinese teacher S interview, he suggested that teachers often take the operation of discovery as inquiry, and he found that the results of the discovery learning is closed, while the inquiry learning is open. Thirdly, they may believe in scientific authority. Chinese teachers tend to their authority, and their analysis of conclusion is not based on data or evidence, but the authoritative theory, laws or books. Even when the data and evidence do not meet with the theory, they would not critique the theory based on their real evidence. The majority of Chinese teachers suggest that it used computer technique in the establishment of weather model so that we could accurately determine the change of the weather when they were asked the certainty of weather forecasters in VOSI-S. When asked the teaching examples of inquiry teaching, teacher W suggested finding in book. Fourthly, many Chinese teachers have the idea of formalized and immobilized methods of inquiry, and it is common that there is routine process of inquiry which could be explained in a scientific way. Lastly, some Chinese teachers could not distinguish the relationship among evidence, data and the conclusion. They do not understand some important issues of inquiry: inquiry procedures are guided by the question asked and influence the results; scientific investigations all begin with a question, but do not necessarily test a hypothesis; scientific explanations are developed from a combination of collected data and what is already known.

Conclusions and Implications

Chinese science teachers understanding of NOS and SI is still in a traditional stage, while American's is in the transition period from traditional to informed stage. The understandings of scientific inquiry in both America and China could be divided into six types: inquiry skills, situational construction, cognitive ability, subject knowledge, setting process and subject ideology. Among them, Chinese teachers emphasize setting process, subject knowledge and cognitive ability, while

situational construction, cognitive ability and inquiry skills are the major emphases for American teachers. The number of setting process and subject knowledge held by Chinese teachers has surpassed American teachers, while the capabilities of situational construction and scientific skills in America are better than the capabilities in China. It can be seen that subject knowledge is the center of Chinese teachers' understanding of SI, while situational and skills are the center of American teachers, which indicates Chinese teachers' subject knowledge lacks of inquiry.

There is also a great difference between Chinese and American science teachers' understanding of NOS, which could be divided into six types: structure and function, empirical research, cognitive style, regularity theorem, knowledge system, and scientism. Chinese teachers emphasize knowledge system, regularity theorem and scientism, while empirical research, cognitive style and structure and function are the major emphases for American teachers. The amount of regularity theorem and scientism in China has surpassed the amount in American, while the quantities of empirical research and cognitive style in America are bigger than those in China, and there are some certain connections among the corresponding types of NOS and SI. By the further analysis, it shows that Chinese teachers' understanding of NOS is centered on knowledge theorem and authority, while American teachers' is centered on empirical research. Chinese teachers is lacking of empirical understandings, which is affected by Bacon's theory of knowledge and empirical scientific method. At the same time, the imperfection of subject content knowledge makes the teacher to confuse the inquiry with other learning concepts, which advocates scientific authority in their science teaching.

Based on the differences in essential factor relationship between the scientific epistemology held by Chinese and American science teachers, the inquiry teaching training of Chinese science teachers should be reformed based on the specific differences between the teachers in both countries. Chinese teachers should adopted "do inquiry" to learn content knowledge and teaching knowledge of scientific inquiry by the situation of NOS and scientific knowledge (Wang, Guo, & Jou, 2015). Based upon this methods, teachers should do inquiry to experience and reflect on the "teach inquiry," and enhance the level of the understandings of SI, and constantly reflect on teaching strategy in teaching practice, deeply realizing the profound understanding of SI as well to achieve scientization, mastery and automation in the inquiry teaching.

Although much research on science education across culture has been pursued (Hacieminoğlu, 2014), such research has rarely been directly and systematically related to views on NOS and SI. Cobern's research (2000) showed that NOS may be a subset of one's worldview or is at least affected by one's worldview. Of primary importance is how to teach NOS and SI across cultures. Sutherland and Dennick

(2002) investigated conceptions of NOS in students with clearly different worldviews. They also found that both language and culture affected students' views, in addition to those factors that affect western students' views. Teachers from different culture would have its own teaching method, so that Chinese teachers suggested more routine practice of paper and pencil text from the cultural tradition of imperial examination system. Within the context of science education, culturally related knowledge refers to the knowledge that can be treated as science, but has different cultural origins from that of Western Modern Science or Euro-centric science (Aikenhead & Ogawa, 2007). Different points of view about the NOS and the relationship between science education and culture have a direct influence on people's opinions of the content and pedagogy of science teaching in school (Ma, 2011; Wang, Lv, Jou, & Zhang, 2016), while different instructional and learning experiences also shape teachers' understandings of science and its place in modern society. Reiss (1993) criticizes the dominance of a Western view of science in school syllabi and textbooks, and points out that it is an obstacle to equal opportunities in science education in a pluralist society. Aikenhead (2000) argues that a pluralistic multi-science approach is the only way to attain the goal of science for all. In terms of teaching a pluralistic science curriculum in the Chinese cultural context, likewise, the teachers' classroom practice is influenced by both their personal values and the society's common values. The latter may be more important in the context of Chinese culture, in which the teachers often emphasize collective values (Ma, 2011). Innate differences between scientific cultures and the Chinese Confucian culture (Morris & Peng, 1994) had led to differences in the understanding of NOS and SI between Chinese and Western science teachers (Wang & Jou, 2016). However, further exploration is needed of science teachers' views of teaching method and its interactions with science-related personal and social issues in different culture background.

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