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The Preservice Science Teachers' View about the Nature of Science in the Explicit Nature of Science Course

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ABSTRACT

This research aimed to study preservice science teachers' view about nature of science. The participants were the first year preservice science teachers who enrolled in 232110 the nature of science and technology, academic year of 2008. Research methodology regarded the interpretive paradigm. The intervention provides the explicit NOS instruction to draw the key aspect of the NOS through discussion and written work following engagement in hands-on activities based on inquiry cycle (5Es). The intervention include eight lesson plan (16 hours) The 1^{st} – 7^{th} lesson plan allowed students to learn science based on inquiry cycle (5Es) with reflected the learning activity they done to clarify the issues related to the nature of science. The 8^{th} lesson plan, the activity of puzzling box allowed student teachers to come explicitly up with the nature of science. Research instruments include teaching reflection form, students' journal writing, and the VOSE questionnaire. The teaching reflection and students' journal writing suggested that the scientific worldview, scientific inquiry and scientific enterprise should be clarified for linking the relationship among them after finishing of teaching and learning activities of the nature of science. Teaching activities should pay more attention in the issue of scientific enterprise. The VOSE revealed that preservice teachers perceived some issues of NOS concept and held positive attitude toward some issues of teaching NOS.

Keywords: Nature of Science, Inquiry Cycle 5E, preservice teachers

INTRODUCTION

The goal of science education is to acquire students to think by considers the relationship between science, technology and society. This goal requires people who must understand science in level of multidimensional scientific and technological literacy in order to make decisions about issues of science technology and society that affect living across the world (IPST, 2002). To attain the goal of science education, the science teachers were in general agreement with the need for making science teaching more meaningful

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by emphasizing on student-centred learning and concern life-long learning that should play on the relationship between science, technology and society. However, many teachers in Thailand still do not appreciate the need for change. Science teachers rely heavily on theory, lectures, textbook reading and teacher-centered instruction rather than practice and experience enhancement. They still emphasize to what extent prospective teachers acquire knowledge rather than how they apply acquired knowledge to various instructional purposes (ONEC, 2000). Preservice science teachers also derive strong experiences in memorizing factual knowledge from the courses, which is often not meaningful for them, and rarely applied, in their classrooms. To obtain Thai goal of science education, science teaching and learning that emphasized knowledge rather than a chance for practice in analytical thinking, self-expression and acquiring knowledge by themselves. Science teachers concerning the nature of science in their teaching may support them to teach science related to technology and society.

Research indicates that science teachers must understand the nature of science to teach it (Lederman, 1992). Several studies have reported results of attempts to teach about the nature of science to preservice teachers (Abd-El-Khalick, Bell, & Lederman, 1998; Bell, Lederman, & Abd-El-Khalick, 2000; King, 1991; Pomeroy, 1993). In general, these studies show that it is difficult to teach science teachers to understand and implement nature of science instruction, possibly because the nature of science is often addressed apart from any real science context in science methods courses. Some of the more successful efforts in achieving nature of science outcomes have been the result of explicit instruction in which the teacher guides learners in examining specific aspects of the nature of science reflected in the science lesson. The explicit-reflective instruction approach (Khishfe & Abd-El-Khalick, 2002) provides students with a framework to analyze science activities for nature of science aspects and to reflect upon the similarities and differences between the classroom science experience and the experiences of practicing scientists. Based on the literature regarding explicit and contextual instruction, we hypothesized that elementary preservice teachers could effectively learn about the nature of science through explicit instruction presented in the context of a socioscientific issue. Therefore, we designed the instruction treatment in this study around the complex and controversial topic of global climate change. Explicit instruction refers to drawing the learner's attention to key aspects of the NOS through discussions and written work following engagement in hands-on activities. Reflective NOS instruction requires learners to think about how their work illustrates the NOS and how their inquiries are similar to or different from the work of scientists.

Preservice program in Faculty of Education, Khon Kaen University (KKU) enhance students regarding NOS for him or her teaching. The 1st year undergraduate students have to enroll the 232110 the nature of science and technology. The 232110 course provide undergraduate students the element of NOS through reflection of their science learning based on inquiry cycle (5Es). After passed this course, they were expected to hold concept of the nature of science and technology for science teaching. Next courses of the preservice program in KKU will provide contextual instruction in order to give undergraduate students chance to reflect their pedagogy that suite for science content, students, context, and particular nature of science. The reflective NOS instruction, therefore, was provided in the KKU preservice program. Gradually gaining concept in teaching may support them to practice their pedagogical content knowledge and skills during the 5th year of school internship.

The course 232110 of KKU allowed us to provide the explicit NOS instruction. The 232110 course description aimed undergraduate students to understand "the meaning of science and technology; the philosophy of science; the relationship between philosophy of science and science; the evolution of philosophy ideas about the nature of science and the relationship between science, technology, society and environment". The explicit NOS instruction in the course 232110 may allow the 1st year undergraduate students to draw the key aspect of the NOS through discussion and written work following engagement in hands-on activities based on inquiry cycle (5Es). An Inquiry Cycle (5Es) consists of five main stages, that is, engagement, exploration, explanation, elaboration and evaluation (IPST, 2002: 148-149). The key ideas of each stage can be summarized as Table 1.

Table 1 Key Ideas of Inquiry Cycle (5Es)

Stage	Key Ideas
Engagement	• Teacher introduces students to engage lesson within their interesting topics • Students ask questions and determine issue to study
Exploration	• Students plan and determine methods to explore or investigate their interesting topics • Students set hypothesis, determine potential choices and use various methods to collect data and information to test hypothesis
Explanation	• Data and information are analyzed and interpreted to derive results of study that may support or reject the hypothesis
Elaboration	• Students elaborate and apply acquired knowledge by linking it with existing knowledge and using it to explain situations or events
Evaluation	• Students evaluate learning with respect to both processes and products of learning

Research question

The first year preservice science teachers who enrolled in 232110 have learn about the nature of science and technology through learning activities based on inquiry cycle (5Es). What do they gain their perception about the nature of science and attitude toward teaching of nature of science?

The Nature of Science

The nature of science (NOS) is a complicated concept. It is difficult for experts to define as it is for students to learn. NOS involves a wide variety of topics related to the history, philosophy, and sociology of science. Many have claimed that no consensus exists among philosophers of science, science educators as to a precise definition or characterization of the nature of science. However, there is consensus on many aspects of the nature of science that are relevant to K-12 students (Bell et al., 2000; Kourany, 1998; Good et al., 2000; Lederman, 1999; Lederman & Abd-El-Khalick, 1998; Smith et al., 1997). These included the concepts that scientific knowledge is (a) tentative (subject to change); (b) empirically based (based on observations of the natural world); (c) subjective in that science is a human endeavor and investigations are conducted within the context of particular theoretical frameworks; (d) partly the product of inference, imagination, and creativity; (e) socially and culturally embedded (can be influenced by contextual factors outside of the scientific community); and (f) developed from a combination of observation and inferences.

In order to evaluate both pre- and in-service teachers' conceptions about NOS and attitude toward teaching NOS, Chen (2006a) drawn the consensus of NOS from previous research (e.g., Kourany, 1998; Good et al., 2000; Schwartz & Lederman, 2002) for developing the questionnaire about NOS. These focus on seven aspects of NOS including: (1) tentativeness of scientific knowledge; (2) nature of observation; (3) scientific methods; (4) hypotheses, laws, and theories; (5) imagination; (6) validation of scientific knowledge; and (7) objectivity and subjectivity in science.

1. Tentativeness of scientific knowledge. On the one hand, scientific knowledge is durable and not easily changed. On the other hand, all scientific knowledge is subject to change. The change could take at least two forms, evolutionary (Popper, 1975/1998) or revolutionary (Kuhn, 1970). New knowledge may arise by refining the old knowledge according to new evidence or interpreting data from a new standard and worldview.

2. Nature of observation. Observations may be affected by the observers' anticipation and preconceptions, i.e., observations are theory laden.

3. Scientific methods. There is no universal scientific method. Scientists apply various methods in doing research.

4. Hypotheses, laws, and theories. A hypothesis is generally used to represent an immature theory, a speculative law, or a prediction of experimental results (McComas, 1996). A law is used to express what has been observed and to predict what has not yet been observed. In fact, a theory is defined in many ways by philosophers of science. In Chen (2006a)' study, theory is defined as an explanation of phenomena and associated laws according to Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993). Furthermore, scientists create theories and laws to interpret and describe phenomena. Theories and laws are two different types of knowledge. They both have substantial supporting evidence, and one does not become the other.

5. Imagination. Imagination is a source of innovation. Scientists use imagination, along with logic and prior knowledge, to generate new scientific knowledge. Imagination and creativity are often presented together in documents of science education reforms. However, the pilot study found that students who object to imagination and creativity as aspects of NOS have more doubts about imagination but fewer problems with creativity.

6. Validation of scientific knowledge. This issue focuses on how a theory is accepted by the science community. In principle, the merit of a theory is evaluated based on empirical results. Nevertheless, the science community may also choose a theory by conventions like simplicity and the reputation of the theory's proposers. Furthermore, the

norm of the paradigm such as a particular way of practicing science, a worldview, and core theories may influence the science community's judgment of competing theories.

7. Objectivity and subjectivity in science. Scientific knowledge is empirically based. Scientists try to be open-minded and apply mechanisms such as peer review and data triangulation to improve objectivity. On the other hand, personal beliefs, values, intuition, judgment, creativity, opportunity, and psychology all play a role in scientific activities. Additionally, science and scientists are influenced by the society, culture, and discipline in which they are embedded or educated. This subjectivity may be reflected in their observations, interpretations, use of imagination, and theory choice. In this text, subjectivity is used to represent factors other than objectivity and rationality.

An understanding of the nature of science has been advocated as one attribute of the scientifically literate individual. Although the nature of science has been defined in variety way, it most commonly refers to the values and assumptions inherent to development of scientific knowledge. (Lederman and Malley, 1990). AAAS (2006) explained the characterization of the nature of science to represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing. The NOS was presented as "knowledge of the way science works is requisite for scientific literacy." It focuses on three principal subjects including scientific world view, scientific methods of inquiry, and the nature of the scientific enterprise.

Scientific world view is scientists' basic beliefs and attitudes of viewing and doing their work. These have to do with the nature of the world and what can be learned about it. AAAS (2006), therefore, proposed that scientific world view could be simplified and classified into three aspects including (1) the world is understandable, (2) scientific ideas are subject to change, (3) scientific knowledge is durable, and (4) science cannot provide complete answers to all questions. "*The world is understandable*" represents scientific belief of attempting to understand the nature of the world. Scientists believe that people can discover patterns in all of nature through the use of the intellect and with the aid of instruments for extending their sense. "*Scientific ideas are subject to change*" represents scientists' beliefs and attitudes of producing knowledge. The process of producing knowledge depend both on observations of phenomena and on inventing theories for making sense out of those observations. Change in knowledge, therefore, is inevitable because new observations may challenge existing theories. "*Scientific knowledge is durable*" reflects how scientists view scientific knowledge. Scientific knowledge is not absolute truth. It is durable. It can be modified to new ideas as norm in science. The powerful constructing ideas tend to survive and grow more precise and to become widely accepted. Continuity and stability are as characteristic of science as change is, and confidence is as prevalent as tentativeness. "*Science cannot provide complete answers to all questions*" reflect how the limitation of scientific knowledge and process of understanding the world is. There are many matters that cannot usefully be examined in a scientific way such as the existence of supernatural powers and beings, or the true proposes of life.

Scientific inquiry reflects how scientists go about their work. Scientific inquiry is not easily described apart from the context of particular investigations. There are common understandings among scientists about what constitutes an investigation that is scientifically valid. But, there is no fixed set of steps that scientists always follow, no one path that leads them to scientific knowledge. However, there are certain features of science as mode of inquiry. These include (1) science demands evidence, (2) science is a blend of logic and imagination, (3) science explains and predicts, (4) scientists try to identify and avoid bias, and (5) science is not authoritarian. "*Science demands evidence*" reflects the validity of scientific claims that is settled by referring to evidence from observations of phenomena. Scientists concentrate on getting accurate data. Such evidence is obtained by observations and measurements taken in situations that range from natural settings (such as a forest) to completely contrived ones (such as the laboratory). Because of this reliance on evidence, great value is placed on the development of better instruments and techniques of observation, and the findings of any one investigator or group are usually checked by others. "*Science is a blend of logic and imagination*" suggests that the scientists' process of formulating and testing hypotheses require not only the use of logic but also imagination because knowledge and creative insight are usually required to recognize the meaning of the unexpected. Inventing hypotheses or theories to imagine how the world works and then figuring out how they can be put to the test of reality is as creative. Aspects of data that have been ignored by one scientist may lead to new discoveries by another. "*Science explains and predicts*" indicate to attempting scientists to make sense of observations of phenomena by constructing explanations for that. Such explanations, theories, may be either sweeping or restricted, but they my be logically sound and incorporate a significant body of scientifically valid observations. "*Scientists try to identify and avoid bias*" indicate the validity of scientists' interpretation for drawing that something is true. Scientists usually respond by asking evidence to support it. However, those evidences can be biased in how the data are interpreted, in the recording or reporting of the data, or even in the choice of what data to consider in the first place; because scientists are human. "*Science is not authoritarian*" reflected that no scientist is empowered to decide for other scientists what is true. Scientists must reach on the basis of their investigations. Challenges to new ideas are the legitimate business of science in building valid knowledge. When someone comes up with a new or improved version that explains more phenomena or answers more important questions than the previous version, the new one eventually takes its place.

Scientific enterprise represents scientific activities as an enterprise has individual, social and institutional dimensions. AAAS (2006) suggested the main features of scientific enterprise including (1) science is a complex social activity, (2) science is organized into content disciplines and is conducted in various institutions, (3) there are generally accepted ethical principles in the conduct of science, and (4) scientists participate in public affairs both as specialists and as citizens. "*Science is a complex social activity*" refers to scientific work involving many kinds of work and some degree having cooperation by many nations. As a social activity, science inevitably reflects social values and viewpoints. The direction of scientific research is affected by informal influences within the culture of science itself, such as prevailing opinion on what questions are most interesting. Scientists tend to decide processing their projects which research proposals receive funding. Science goes on in many different settings such as scientists in universities, hospitals, business and industry, government, independent research organizations, and scientific associations. They may work alone, in small groups, or as members of large research teams. "*Science is organized into content disciplines and is conducted in various institutions*" reminds people about the structures and institutions related to science. Regarding the purpose and philosophy, all fields are equally scientific and together make up the same scientific endeavor. Scientific disciplines do not have fixed borders. Physics shades into chemistry, astronomy, and geology, as does chemistry into biology and psychology, and so on. New scientific disciplines also are continually being formed at the boundaries of others. Universities, industry, and government are also part of the structure of the scientific endeavor. "*There are generally accepted ethical principles in the conduct of science*" reflect that scientists also regard the ethical norms of science to conduct their work. Most scientists strongly held traditions of accurate recordkeeping, openness, and replication, buttress by the critical review of one's work by peers. In another word, there is the tradition of getting credit for being the first to publish an idea or observation. Another domain of scientific ethics relates to possible harm that could result from scientific experiments. Modern scientific ethics require that due regard must be given to the health, comfort, and well-being of animal subjects. Moreover, research involving human subjects may be conducted only with the informed consent of the subjects. "*Scientists participate in public affairs both as specialists and as citizens*" could be recognized as scientists' bringing information, insights, and analytical skills to bear on public concern. Scientists could be viewed also people who can help the public and its representatives to understand the likely causes of events (such as natural and technological disasters) and to estimate the possible effects of projected policies (such as ecological effects of various farming methods).

METHODOLOGY

The purpose of this study was to assess the 1st year undergraduate students' understanding about the nature of science. Their drawing key aspect of the NOS will be interpreted from reflection following the hands-on activities based on inquiry cycle (5Es) of the explicit NOS instruction in the course 232110.

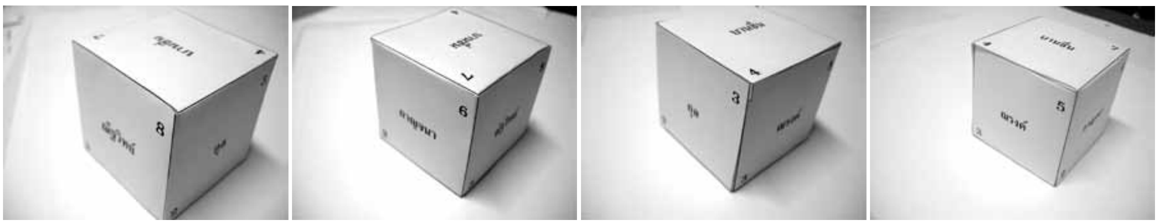
Participants

Participants were the sixty of 1st year undergraduate students who enrolled the 232110 of KKU in academic year of 2008.

The Course

The course 232110 of KKU allowed us to provide the explicit NOS instruction. The 232110 course description aimed undergraduate students to understand "the meaning of science and technology; the philosophy of science; the relationship between philosophy of science and science; the evolution of philosophy ideas about the nature of science and the relationship between science, technology, society and environment". The course 232110 provided the explicit NOS instruction through discussion and written work following engagement in hands-on activities based on inquiry cycle (5Es). The explicit NOS instruction in this course consists of 8 lesson plan (16 hours). The 1st – 7th lesson plan provided learning activities based on inquiry cycle (5Es). These activities include how heat transfer, the rock classifying, how we know the sound wave, how physics knowledge tell you about music and constructing music instruments, friction force and every life activities, amazing with static electric, and material and matter in everyday life. The science activities based on inquiry cycle (5Es) allowed students to learn science based on inquiry cycle (5Es) with reflected the learning activity they done to clarify the issues related to the nature of science. The 8th lesson plan provided activity of puzzling box. Five sides of the puzzling box have the alphabet and number as showed in the Figure 1. Only one side has nothing. Undergraduate students, therefore, have to find what should be for that side from conceptualization in class. The 8th lesson plan, the activity of puzzling box allowed student teachers to come explicitly up with the nature of science. After the course, participants completed the questionnaire that adapted from Chen (2006a)'s View on Science and Education (VOSE) Questionnaire in order to examine preservice teachers' concept of NOS and attitudes toward teaching.

Figure 1: Puzzling Box



View on Science and Education (VOSE) Questionnaire

Chen (2006a) developed the view on science and education (VOSE) questionnaire. The VOSE focus on the seven aspects of NOS as mentioned earlier. These aspects include (1) tentativeness of scientific knowledge; (2) nature of observation; (3) scientific methods; (4) hypotheses, laws, and theories; (5) imagination; (6) validation of scientific knowledge; and (7) objectivity and subjectivity in science. Evaluating both pre-/in-service teachers' conceptions about NOS and their corresponding teaching attitudes is essential for NOS instruction to succeed. VOSE assesses both the subjects' conceptions of NOS and attitudes toward teaching NOS. The VOSE questionnaire is therefore designed to assess both. In sum, VOSE contains three parts: views on what NOS is (actual), views on what NOS ought to be (ought), and views on science education closely linked to NOS. Each question of VOSE is followed by several items that represent different philosophical positions. Participants are instructed to read all items of a question before ranking each on five-point scale.

Quality of the instruments (VOSE). The VOSE yields reliable results because the items originated from the respondents' viewpoints instead of experts' presumptions of reasonable responses. The test-retest reliability also is high – correlation coefficient, 0.82. the Cronbach's alphas of all issues of NOS in VOSE ranged from 0.34 to 0.81 (see the table in Chen (2006a)) and were used to verify the appropriateness of discarding some items in the pilot test, but not a main criterion for reliability. For validity, the content and interpretation of the items were validated by two panels of experts, each consisting of six experts (Chen, 2006b)

Data collection and analysis

Preservice teachers drawing key aspect of the NOS will be interpreted from their discussion, written examination about NOS, journal writing and teacher reflection to reflect the hands-on activities based on inquiry cycle (5Es) of the explicit NOS instruction in the course 232110. Preservice teachers' concept of NOS and attitudes toward teaching was examined through adapted version VOSE after the invention. The frequencies and mean rate of choices in each item of adapted version VOSE will be computed to indicate their philosophical positions in concepts of NOS and attitudes toward teaching. The theoretical framework for categories of philosophical positions in the NOS issues and attitude toward teaching NOS was provided in the Table 1 and 2' s Chen (2006a); respectively.

FINDINGS AND DISCUSSION

The explicit NOS instruction in the course 232110 allowed the 1st year undergraduate students to draw the key aspect of the NOS through discussion and written work following engagement in hands-on activities based on inquiry cycle (5Es). Their discussion and reflection about teaching and learning from science activities indicated that they had chance to talk about scientific inquiry, scientific worldview, and scientific enterprise. The outcome of examination about NOS indicated that they held concept about NOS. These will be discussed as below.

1. Undergraduate students' discussion and reflection

Undergraduate students' discussion and reflection about teaching and learning from science activities indicated that they had chance to talk about scientific inquiry, scientific worldview, and scientific enterprise. The reflection from participating science activities based on inquiry cycle (5Es) and the puzzling box may reflect how they talk about each aspect of NOS.

1.1 Reflection from participating in science activities

Undergraduate students' discussion and reflection from participating in science activities suggested that they recognized some aspects of NOS, particular scientific inquiry. They had chance to talk about scientific inquiry, collecting data, and drawing conclusion in their group.

The science activities about "how we know the sound wave", and "how physics knowledge tells you about music and constructing music instruments" supported students to apply their scientific skills and developing the idea of scientific worldview. They talked that they could explain the variables related to constructing sound from those music instruments. However, they had difficulty to explain how the straw could be made different sound quality or tone like 'do', 'rae', and 'me'. Through their explanation, lecturers enhanced them to consider the aspect of scientific worldview.

The science activity of classifying the rock seemed to very enhance students to recognize the aspect of scientific inquiry in NOS. The science process skills were deeply discussed during this activity. In their data collecting, the eureka technique was recognize as tool to extend their sense. The history of eureka also was discussed in aspect of drawing

hypothesis require not only the logic but also imagination or creativity.
Students' reflection also recognized the nature of working in group where his or her idea was challenged by group process. They mentioned that it was very hard for a idea to be accepted in classroom. This reflection has been picked up for pointing to aspect of the scientific enterprise during the puzzling box.

1.2 Reflection from puzzling box

The puzzling box allowed students to predict and explain what the number and alphabet should be for the empty side of the puzzling box. It could be observed that they were inquiring or developing the knowledge for explaining the phenomena. Through their developing their knowledge, they tried to find the reasonable pattern, laws, or theories for the number and alphabet of that empty side. The numbers is interpreted as sign of that side; or represent the number of alphabets for that side, or series of the relationship among six sides. The meaning of alphabet was interpreted. Some of them were interpreted as flowers, or boy or girl names. It is indicated that they were drawing their hypothesis with the logic and imagination. After they drew the group hypothesis, each group was challenged their hypothesis from other group during each presenting their idea. Through share the ideas among groups, the classroom came up with the viable knowledge or theory for the puzzling box. The conclusion session following then, lecturer raise the issues of each group method of investigation, group logic or imagination, drawing group conclusion, and drawing the viable theory of puzzling box in order to present the NOS as knowledge of the way science works is requisite for scientific literacy. It focuses on three principal subjects including scientific worldview (SW), scientific methods of inquiry (SI), and the nature of the scientific enterprise (SE).

The reflection about the Puzzling box also was asked in the final examination of the 232110 course. The question of "Do you think that the Puzzling box activity remind you about the issues of NOS whether or not? Please give me your ideas behind" was asked in the examination with aimed to examine participants understanding about NOS from the explicit NOS activity – the Puzzling box. Participants' explanation about the relationship between the Puzzling box and NOS were interpreted into categories about SW, SI, and SE as showed in the Table 2. It indicated that the Puzzling box activities allowed participants to consider all issues of NOS. The "scientific inquiry" was the simplest issue of NOS to be recognized. Nearly all participants were reminded the NOS issue of scientific inquiry from the Puzzling box. It seemed that the "scientific inquiry" and scientific enterprise were the participants' feature issue of NOS from the Puzzling box. There were approximately 58 percents of participants who mentioned about SI and SE. However, in order to represent the NOS, all three issues (i.e. SW, SI, and SE) should be mentioned. Approximately 29 percents of students mentioned to the three aspects about NOS that were reminded from the puzzling box activity.

Table 2 Participants' statements for Linking between Puzzling Box and the NOS

Categories of Participants' view about NOS	Frequency (participants)	Percents
Interpreted as aspects of SI, SW, and SE	19	28.79
Interpreted as aspects of SI and SW	12	18.18
Interpreted as aspects of SI and SE	19	28.79
Interpreted as aspect of SI	14	21.21
Interpreted as aspects of SW	1	1.52
No indication for SI, SW, and SE	1	1.52
Total	66	100.00

Note: SI refers to Scientific Inquiry, SW refers to Scientific Worldview, and SE refers to Scientific Enterprise

2. Preservice Teachers' Concepts of NOS and attitudes toward teaching NOS

Preservice teachers' concepts of NOS and attitudes toward teaching NOS were examined through the VOSE questionnaire. Then, the section will clarify (1) preservice teachers' conceptions of NOS; and (2) preservice teachers' attitudes toward teaching NOS.

2.1 Preservice teachers' conceptions of NOS

This study focus on conceptions of NOS into 7 issues of NOS including tentativeness, nature of observations, theories and laws, use of imagination, validation of scientific knowledge, and subjectivity and objectivity. The VOSE revealed participants' philosophical positions in each NOS issues.

2.1.1 Preservice teachers' philosophical positions in issue of tentativeness. The tentativeness of scientific knowledge could be viewed as changing in at least two forms – Popper, 1975/1998) or revolutionary (Kuhn, 1970). The Table 6 in Appendix revealed that most of preservice teachers perceived tentativeness of scientific knowledge. The majority of preservice teachers (approximately 66 percents) took the position of revolutionary for the issue of tentativeness. There were only approximately 3 percents of participants taking evolutionary position to represent the tentativeness. Interestingly, it indicated that some of participants (approximately 26 percents) seemed to concern on the cumulative of scientific knowledge rather than tentativeness.

2.1.2 Preservice teachers' philosophical positions in nature of observation issue. Observations are theory laden. Therefore, observations may be affected by the observers' anticipation and preconceptions. It indicated that most of preservice teachers positioned theory laden for nature of observation issue. Table 10 in Appendix revealed that the majority of participants selected choice 8A (approximately 47 percents) and 8E (approximately 24 percents). However, it seemed that numbers of participants also took the philosophical position of theory independent for observation issue. There were approximately 12 percents of participants selecting the item 8C and 8D.

2.1.3 Preservice teachers' philosophical positions in issue of scientific method. NOS indicated that there is no universal scientific method. In fact, scientists apply various methods in doing research. Unfortunately, preservice teachers seemed to hold the position of the universal scientific method. Table 11 in the Appendix revealed that the majority of participants selected the items representing position of the universal scientific method. These include items of 9A (approximately 45 percents), 9B (approximately 13 percents), and 9F (approximately 3 percents). However, numbers of participants also took the position of diverse methods (item of 9C; approximately 26 percents) for the NOS issue of scientific method

2.1.4 Preservice teachers' philosophical positions in issue of theories and laws. A law is used to express what has been observed and to predict what has not yet been observed. Theory is defined as an explanation of phenomena and associated laws (Chen, 2006a; McComas, 1996).

Consider the epistemology of theories and laws, broadly perceived that theories and laws were created by scientists to interpret and describe phenomena. Table 7 in the Appendix revealed that majority of preservice teachers selected the 5D (57.9%). This seemed that majority of them perceived that theories were created by scientists. However, the Table 8 showed that there were number of preservice teachers positioning epistemology of laws both in the discovered (6A and 6B; 44.7%) and invented laws (6D and 6E; 47.3%). Few of participants positioned who selected 5C and 6C that indicated that theories and laws were discovered or invented. In fact, most of participants selected the choices where represented the position of invented theories (5D, 5E, and 5F; 65.8%) and laws (6D, and 6E; 47.3%). This could be mentioned that their position about epistemology of theories and laws were in position of the invented theories and laws.

Comparison between theories and laws, they are two different types of knowledge. They both have substantial supporting evidence, and one does not become the other. The Table 9 showed that there were not many preservice teachers positioned that theories and laws could not be compared because of the different types of ideas (7D; 23.7%). Majority of them (63.2%) positioned laws as being more certain (7A and 7B).

2.1.5 Preservice teachers' philosophical positions in use of imagination issue. Scientists use imagination, along with logic and prior knowledge, to generate new scientific knowledge. Imagination and creativity are often presented together in documents of science education reforms. The Table 5 showed that the majority of preservice teachers (3B; 52.6%, and 3A; 21.1%) viewed scientists' using of imagination.

2.1.6 Preservice teachers' philosophical positions in issue of validation of scientific knowledge. This issue reflects that how a theory is accepted by the science community. The Table 3 revealed that the majority of participants positioned validation of scientific knowledge based on empirical evidence (1H; 47.4% and 1A; 10.5%). However, a theory is not only evaluated based on empirical results but also science community's choosing through the conference. The norm of the paradigm about scientific worldview, therefore, also may influence the science community's judgment of competing theories. Surprisingly, none of participants selected item of 1C and 1F where positioned scientific paradigm as position of validation of scientific knowledge.

2.1.7 Preservice teachers' philosophical positions in issue of objectivity and subjectivity in science. Scientific knowledge was constructed from both in objectivity and subjectivity process of constructing meaning.

Science may be influenced from scientists' beliefs, values, judgment, creativity, opportunity, and psychology which situated by society, culture, and discipline that they are embedded. Subjectivity of scientific knowledge may be reflected in scientists' observations, interpretations, use of imagination, and theory choice. The VOSE allowed us to categorize different NOS positions of subjectivity in science including parsimony, authority, paradigm, personal factors, sociocultural influence, imagination, methodology, and neutral. However, the findings revealed that most of preservice teachers perceived scientific subjectivity in position of paradigm (item 8A – influence of observation), sociocultural influence (item 2A and 2B), neutral (item 1B – different perspectives of two theories' explanation), and imagination (item 3A and 3B – applying imagination in science)

Scientific knowledge is empirically based. Scientists try to be open-minded and apply mechanisms such as peer review and data triangulation to improve objectivity. The VOSE allowed us to categorize different NOS positions of objectivity in science including no influence of socioculture, use no imagination, based on experimental facts, no influence of personal beliefs, methodology, and overall. . However, the findings revealed that most of preservice teachers perceived scientific objectivity in position of methodology (item 9A – universal scientific method), and over all (item 1H – existing one truth about science)

2.2 Preservice teachers' attitudes toward teaching NOS

2.2.1 Preservice teachers' attitudes toward teaching NOS in the issue of tentativeness. The Table 14 revealed that there were number of preservice teachers held attitude toward both teaching the tentativeness of scientific knowledge (12A; 50%) and avoids it (12C; 42.1%).

2.2.2 Preservice teachers' attitude toward teaching NOS in the nature of observations issue. It indicated that they aware of observations as theory laden. The Table 13 showed that the majority of preservice teachers held attitude toward revealing the theory-laden nature of observations (11D; 42.1% and 11E; 47.4%).

2.2.3 Preservice teachers' attitude teaching NOS in issue of scientific methods. It seems that they held attitude toward teaching the universal scientific method (item 10A – F) rather than encouraging different methods (10G –I). The Table 12 showed there were number of them selected the item 10C and 10E.

2.2.4 Preservice teachers' attitude toward teaching NOS in issue of theories and laws. It indicates that they held attitude toward avoid teaching the relationship between theories and laws (item 13C and 13D) rather than teaching relationship (item 13A and 13B). The Table 15 showed that the majority of them (approximately 58%) selected item 13C.

CONCLUSION

The studying undergraduate students' understanding about the nature of science suggested that the explicit NOS instruction in the course 232110 allowed the 1st year undergraduate students had chance to think about NOS from their learning activities. However, it indicated that they had difficulty to conceptualize the overview of NOS. In order to support them to regard the NOS in their teaching, the KKU preservice program have to more emphasize in NOS for the following course of the program. Other courses of the preservice program in KKU, then, could provide contextual instruction in order to give undergraduate students chance to reflect their pedagogy that suite for science content, students, context, and particular nature of science. The reflective NOS instruction, therefore, was provided in the KKU preservice program. Gradually gaining concept in teaching may support them to practice their pedagogical content knowledge and skills during the 5^{th} year of school internship.

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