EXISTING NATURE OF SCIENCE TEACHING OF A THAI IN-SERVICE BIOLOGY TEACHER

Wimol Sumranwanich, Sitthipon Art-in, Panee Maneechom, Chokchai Yuenyong
Khon Kaen University – Thailand

Abstract. The paper aimed to investigate the existing nature of science (NOS) teaching in Thailand biology classroom. Participants included Thai in-service biology teacher classrooms in Udontani province, Thailand. Methodology regarded interpretive paradigm. Tools of interpretation included 2 months of classroom observation, interviewing, and questionnaire of NOS. The findings will clarify each case of classroom about (1) teachers' understanding of NOS, and (2) what aspects of NOS were presented and how they enhanced students' to understand NOS in biology learning. The paper has implication for professional development on NOS teaching in Thailand.

Keywords: nature of science, biology, professional development

Introduction

The nature of science (NOS) is a complicated concept. It is difficult for experts to define as it is forstudents to learn. NOS involves a wide variety of topics related to the history, philosophy, andsociology 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, thereis 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; Smithet 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 ahuman endeavor and investigations are conducted within the context of particular theoreticalframeworks; (d) partly the product of inference, imagination, and creativity; (e) socially and culturallyembedded (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 attitudetoward teaching NOS, Chen (2006) drawn the consensus of NOS from previous research (e.g.,Kourany, 1998; Good et al., 2000; Schwartz & Lederman, 2002) for developing the questionnaireabout 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.

The science curriculum in Thailand always sees the importance of the study of the nature of science. In the secondary curriculum of 1978, some topics related to the nature of science were incorporated, but the term 'the nature of science' was not used until the science content domain in the foundation curriculum of 2001 and the core curriculum of 2008 placed the nature of science and technology as the 8th content domain. This covers learning processes in which knowledge inquiry processes, problem solving processes, the nature and limitation of science, attitudes, moral, ethics, and values have been incorporated (OBEC, 2008). The following purposes related to the nature of science have also been addedfor learners(IPST, 2002):(i) to understand the scope, nature, and limitation of science; (ii) to develop learning processes and imagination, ability in problem solving and management, communication skills, and decision making capacity; (iii) tobe aware of relationships between science, technology, human beings, and their environment that brings impact on one another; (iv)to possess scientific attitudes, ethics, moral, and values in creative use of science and technology.

Thailand sees the importance of the nature of science both in the sense of the teacher and the student, just like science education in other countries. The problem arising from scientific curriculum improvement and the setting of new science teachers' standard, however, is teachers' lacking of continual professional support. This results in lack of understanding for instruction of the nature of science, and at the end an impact on students' learning. This is reflected by the Trends in International Mathematics and Science Study (TIMSS, an International Association for the Evaluation of Education Achievement (IEA)), whichassessed teachers' instruction and students' achievements in 59 countries and 8 states in 2007. It was found that Thai science teachers still teach by explaining. They still do not plan instructions that integrate the nature of science, and hence Thai students' average achievement is lower than the average of international students and even lower in tendency, even though Thailand came the second in the world in scheduling more science classes at school (Yuenyong & Narjaikaew, 2009).

From the importance and problem of the nature of science, the researcherssawthat teachers are very important in building understanding of the nature of science in students. It became interesting to study the nature of science as perceived by science teachers.Broaden view of NOS teaching refers to the teaching of science by integrating the NOS in. Teachers' teaching of the NOS can be varied in the range from using implicit approach to didactic approach and to explicit approach. The implicit approaches for teaching the NOS in this research refer to anyinstructional approaches for science including learning by doing science and practical workwhich do not incorporate some activities or discussions to make a connec-

tion betweenscience-subject content and concepts of the NOS nor explicitly point out and reflectconcepts of the NOS that are conveyed during practical work.The didactic approaches for teaching the NOS in this research refer to anyinstructional approaches for science including the way of integrating the NOS. However, thisdiscussion is separated from the activities that students have been engaged in. The lessonsare identified as concentrating on teaching science content and making a simple didacticexplanation of certain aspects of the NOS.The explicit approaches for teaching the NOS in this research refer to anyinstructional approaches for science including learning by doing science and practical workwhich incorporate some activities or discussions to make a connection between sciencesubjectcontent and concepts of the NOS or explicitly point out and reflect concepts of theNOS that are conveyed during practical work (Meesri, 2007).

Several studies have reported results of attempts to teach about the nature of science to teachers (Abd-El-Khalick et al., 1998;Bell et al., 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 socio-scientific 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.Several studies have reported results of attempts to teach about the nature of science to teachers (Abd-El-Khalick et al., 1998; Bell et al., 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 socio-scientific 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.

Methodology

Methodology regarded interpretive paradigm. Research method was applied as an interpretation for Teachers' understanding of the nature of science and NOS on their biology teaching.

Participants: Punnee (a pseudonym)

Punee graduated with a bachelor's of science in biology and a graduate diploma in teaching profession from KhonKaen University. She also finished her Master degree in science education from KhonKaen University. She had been teaching for 4 years at Penpittayakhom School, Udonthani. Penpittayakhom Schoolis a large-sized secondary co-education school offering secondary programs from Grade 7 – 12. In 2012, there were a total of 1,799 students and 48 classes, with 80 teachers and staff members. Ten teachers were responsible for teaching and learning in the science domain.

Punnee had a 4-year teaching experiencein biology science. Not only teaching, but also she is responsible for the school finance.She had never been trained in science instruction management under the basic education curriculum of 2008. She liked designing science lessons because she graduated in this field and also holds a graduate diploma. She is interested in science subject and assessed herself in instruction at a moderate level. She reported that her students regularly came to her classes and enjoyed them. Her students were satisfied with the lessons. If there is training on science instruction, the topic Punnee is mostly interested to participate is the instruction innovations of all contents in biology. She was assisted in science lesson planning by her colleagues at the school and exchanged knowledge, contents and activities with them. School administrators also saw the importanceof science teaching and emphasized excellence in science and mathematics.

Research instruments

(A) A semi-structured interview form for the biology teacher understands of thenature of science. Questions were designed in the interview including two parts: (a) part1 – interviewing for baseline data comprising 10 questions; (b) part2 – interviewing for teacher's understanding of the nature of science which comprises 4 questions covering 4 components of the nature of science

(B) An observation record form for the teacher's instruction and summarization of the instruction on the nature of science.

Data collection

(1) The school's baseline data was collected including science instruction, number of students and educational personnel, and general information of the teacher and students under study.

(2) The researcher familiarized herself with the teacher and observed her lessons in the first semester of academic year 2012 in order to lessen the impact from data collection such as from the attitude of the subject. For the said purposes, the researcher observed the class without taking any notes.

(3) Around eight to ten lessons of each teacher teaching on the nature of sciences were observed. The researchers recorded the instructional processes, teacher's behaviors, students' behaviors, and made conclusion of each lesson on the nature of science.

(4) Before teaching of the lessons, the researchers interviewed and recorded how participating teachers' understanding of the nature of science.

Data analysis

(1) Schools' baseline data was compiled and written in a descriptive form to reflect the holistic view of the school.

(2) The data obtained from survey on each of participating teachers' lessons on the nature of science was interpreted how they focus on teaching biology related to nature of science. Their existing ideas about teaching for nature of science in their biology will be categorized into the Deficient Nature of Science Approach, the Implicit Nature of Science Approach, the Didactic Nature of Science Approach, and the Explicit Nature of Science Approach.

(3) The recorded interview on teachers' understanding of the nature of science was transcribed. And, teachers' responding was interpreted to examine their understanding of NOS for four components. These included (i) science knowledge requires evidences; (ii) science knowledge is changeable; (iii) science knowledge is inquired by different interpretation and observation; and (iv)creativity and imagination. Their understanding of NOS will be reported in three levels including good understanding, unclear understanding, and understanding with discrepancies.

(4) Analysis of teachers' understanding of NOS was considered as peer debriefing.

Findings

Case of in-service teacher Punnee understanding of the nature of science and NOS onher biology teaching was explained as below.

MsPunnee's lessons of the nature of science were on the topics of ecological system and environment and natural resources. The observed facts in the ecological system comprised global warming and its relationships with ecology, El Nino and La Nina, global warming and energy transfer in the ecological system, global warming and relationship with ecosystem, global warming and greenhouse effect. For the units on the environment and natural resources, the contents included the changes of the environment and natural resources. Altogether MsPunnee designed these topics in 8 periods and applied three approaches, namely: the Deficient Nature of Science Approach, the Implicit Nature of Science Approach, and the Didactic Nature of Science Approach. The Didactic Nature of Science Approach was applied mostly in 4 periods, followed by the Implicit Nature of Science Approach in 2 periods, and the Deficient Nature of Science Approach in 2 periods, as shown in Table 1.

Table 1. Punnee's ecology lessons on the nature of science

Approaches of lessons on the nature of science	Frequency (period)	Scientific contents
The Deficient Nature of Science Approach	2	– Global warming and energy transfer in the ecological system – Global warming and relationship with ecosystem
The Implicit Nature of Science Approach	2	Environmental and natural resources problems
The Didactic Nature of Science Approach	4	1. Global warming and relationship with ecosystem 2. El Nino and La Nina 3. Global warming and greenhouse effect 4.Changes of the environment and natural resources

The Deficient Nature of Science Approach applied by MsPunnee mostly involved students studying the handout and do the activity on the worksheet. For example, in the global warming and transfer of energy in ecosystem, students were divided into groups and studied the roles and functions of living things in the food supply chain. Then students were asked to do activity sheet 2 and discussed in front of the class.

For the topic of global warming and relationship with ecosystem, students formed into groups and chose their interesting topic to search information, draw

diagrams and present in front of the class. The topics provided were water cycle, carbon cycle, nitrogen cycle, phosphorus cycle, and sulfur cycle. Then the teacher and students concluded the knowledge obtained and presented in concept mapping.

In the Implicit Nature of Science Approach, MsPunnee relied on lesson planning. For the content of the environment and natural resources, students were asked to plan what to do for their interesting community problem.They explored and compiled information and knowledge they required as agreed in the past period. Then the teacher let them discuss, exchange ideas, and plan the operation on the chosen problem and presented to the teacher. Here is an example of what MsPunnee said to her student, in which one component of the nature of science was related:

1) Creativity and imagination influence scientific knowledge inquiry. MsPunnee used the Implicit Nature of Science Approach by having students watch a video on "Stop global warming with sufficiency life" in the introduction part. She said, *"After watching "Stop global warming with sufficiency life", what will you do to lessen global warming?"* Students had to use imagination to find the answer based on the video. They used scientific knowledge which is derived from observing the nature and created imagination and creativity to explain.

(From MsPunnee's lesson, Period 7, December 24, 2012
02.30 – 05.40, Penpittayakhom School)

MsPunnee's Didactic Nature of Science Approach mostly involved brainstorming and discussion of the topic to study. For example, in global warming and ecosystem, students were divided into small groups; they brainstormed and discussed the statement, "A survey of marine resource researchers showed a decrease of marine population, destruction of coral reefs, and some endangered marine species." Each group posed questions that would add to the explanation of this statement. The questions were then discussed for the answers. Students then summarized their answers in concept mappingto explain how global warming affects ecosystem. Finally, the whole class discussed the effects of global warming on coral reefs and ecosystem. Here is what MsPunnee said that was related to two components of the nature of science:

1) For the component of different observation and deduction in scientific knowledge investigation, MsPunnee applied the Didactic Nature of Science Approach as shown in her greeting and conversation, "*Hi students. Today we will study the topic of global warming and its relationship with ecosystem. I'd like you to brainstorm on the effects of the present global warming on our earth."* MsPunnee used this instruction to make students use their senses to observe the present day global warming and its effects, since this can be perceived through our sense.

(From MsPunnee's lesson, Period 1, December 3, 2012
01.20 – 05.45, Penpittayakhom School)

2) For the component of the use of evidence for scientific knowledge, MsPunneeused the Didactic Nature of Science Approach. She asked students to study information of different types of ecosystem and posed some problems for them to show their opinions. She said, *"A survey of marine resource researchers showed a decrease of marine population, damage of coral reefs, and some endangered marine species."*

(From MsPunnee's lesson, Period 1, December 3, 2012
10.30 – 12.00, Penpittayakhom School)

For the topic of El Nino and La Nina, students watched a video showing the phenomena, studied the handout and media already researched. Students then discussed together and made conclusion of the knowledge of El Nino and La Nina and their relationships with ecosystem. Then students presented this in front of the class. The teacher and students discussed the content of the video and the effects of El Nino and La Nina on ecosystems. Students finally summarized their knowledge of this topic. Here is an example of MsPunnee's statement related to one component of the nature of science:

1) For the role of creativity and imagination on scientific knowledge inquiry, MsPunnee used the Didactic Nature of Science Approach by letting students watch a video on El Nino and La Nina and discuss the impact on ecosystem. She asked, *"1) What were food chain and food web in ecosystem in the past like? 2) How do El Nino and El Nina affect food chain and food web in our ecosystem?"*This step required students to use their imagination to find the answers which were based on the content of the video. Students had to use their scientific knowledge derived from observation of nature, imagination and creativity to explain scientifically.

(From MsPunnee's lesson, Period 2, December 7, 2012
01.30 – 17.40, Penpittayakhom School)

The content of global warming and greenhouse effect was taught by dividing students into groups and teacher and students discussed global warming first. Then students discussed within their group to find solution to the condition as part of the ecosystem. Students then presented their work by putting on posters and giving a talk on the school's loudspeaker. Here are some examples of MsPunnee's questions which were related to 2 components of the nature of science:

1) Scientific knowledge relies on evidence. MsPunnee used the Didactic Nature of Science Approach as she introduced her lessons by revising the knowledge from the first period on global warming and the world ecosystem from the statement, *"The destruction of coral reefs leads to decrease of marine creatures. Today, I want you to think and answer these questions: 1) How important are the coral reefs? 2)*

What benefits do marine animals obtain from the coral reefs? 3) Why are marine creatures decreased when coral reefs are destroyed?"

(From MsPunnee's lesson, Period 5, December 17, 2012
02.10 – 10.20, Penpittayakhom School)

2)Scientific knowledge is derived from different observation and deduction. In this respect, MsPunnee applied the Didactic Nature of Science Approach as can be seen in her explanation during the class discussion on global warming, *"Global warming happens from the increase of carbon dioxide in the atmosphere. Carbon dioxide has a property of heat retaining. This is too great until it covers the atmosphere. When the sun reaches the earth it cannot reflect back. Heat is retained in the atmosphere making the temperatures higher. The impact of global warming is the high temperatures that are not suitable for living things."*

(From MsPunnee's lesson, Period 5, December 17, 2012
25.30 – 40.40, Penpittayakhom School)

For the content of the changes of the environment and natural resources, students were divided into small groups of 4-5 and considered conditions and problems of the environment the teacher proposed. They participated in the discussion on the teacher's topic. Then the teacher selected some students to present their discussion. Students were next asked to pose a social related issue on "Is our school and community affected by any environmental problem? What is it and how?" The teacher asked students to brainstorm and say if they want any information related to their interesting environmental issue that affects the school or community. Then students planned together how to tackle the problem. Here are the examples of teacher's instruction related to 2 components of the nature of science:

1) Creativity and imagination influence scientific knowledge inquiry. MsPunnee used the Didactic Nature of Science Approach. In the introduction, she asked, *"What kind of world do you want to live in? Give some examples. Say why you want to live in that world?"* At this stage, students used their imagination to find the answer. They used their scientific knowledge derived from observation of the nature and then built imagination and creativity to explain it scientifically.

(From MsPunnee's lesson, Period 6, December 21, 2012
03.20 – 05.00, Penpittayakhom School)

Students answered, *"I want to live in the world where the air is clean, with no vehicle exhausts, and it is not hot. If our body receives good and clean air, good environment, we will be healthy, our brain will be fresh and able to learn and memorize better."*

(Group 3, December 21, 2012
7.00 – 7.40, Penpittayakhom School)

2) Scientific knowledge is derived from different observation and deduction. In this respect, MsPunnee applied theDidactic Nature of Science Approachby asking another question that continued from the above, *"And how is the world condition today?"*

(From MsPunnee's lesson, Period 6, December 21, 2012
10.30 – 12.24, Penpittayakhom School)

Students answered, *"Today our world is warmer. There is a lot of pollution and a lot of environmental problems such as water pollution, air pollution, deteriorated soil, and forests are destroyed."*

(Group1,December 21, 2012
13.27 – 15.08, Penpittayakhom School)

MsPunnee did not use the Explicit Nature of Science Approach. Therefore, the teacher should improve her teaching and learning by incorporating activities related to the nature of science and allow students to reflect their understanding by posing discussion questions clearly related to principles of the nature of science. As such, the teacher would be able to apply the Explicit Nature of Science Approach.

Conclusion

The research findings show the necessity to emphasize the nature of science in parallel with instruction and scientific ideas in training science teachers so that students would have accurate understanding of the nature of science. Participating teachers could not use the Explicit Nature of Science Approach. Many research suggested that to teach NOS effectively, teachers must make aspects of NOS an explicit part of the classroom discourse. Rather than utilizing didactic means, teachers should provide learners with opportunities to reflect upon and explain their ideas about NOS, discuss the strengths and limitations of those ideas, and assess the consistency of their ideas with those of others (Abd-El-Khalick et al., 1998; Bell & Lederman, 1998; Bell et al., 2000).

Relevant organizations should train education students to be able to design their instruction that clearly reflect the nature of science before they train or work in teaching profession. The relationships between understanding of the nature of science and in-service teacher instruction based on observation in classrooms using the semi-structured interview and their lesson plansshown that their lesson did not incorporate the learning of nature of science in class. Thus, knowledge and understanding of the nature of science did not affect the lessons (Lederman,1999(. The factors influencing students' understanding of the nature of science were inquiryteaching approaches and students' perception.The research results show the importance of the use of the nature of science in science teachers' instruction. Relevant organizations should develop

science teachers to be able to provide instructions based on the Explicit Nature of Science Approach.

REFERENCES

Abd-El-Khalick, F., Bell, R.L. & Lederman, N.G. (1998). The nature of science and instructional practice: making the unnatural natural. *Science Education*, *82*, 417 – 436.

Bell, R.L., Lederman, N.G.&Abd-El-Khalick, F. (2000). Developing and acting upon one's conception of the nature of science: a follow-up study. *J. Res. Sci. Teaching*, *37*, 563 – 581.

Chen, S. (2006). Development of an instrument to assess views on nature of science and attitudes toward teaching science.*Science Education*, *90*, 803 – 819.

Good, R., Lederman, N., Gess-Newsome, J., McComas,W.& Cummins, C. (2000). Nature of science: implications for research, assessment, and teacher education. *A symposium and paper presented at the annual international meeting of the Association for the Education of Teachers in Science*, Akron, OH.

Institute for the Promotion of Teaching Science and Technology (IPST) (2002). *The manual of content of science learning.* Bangkok, Thailand: Curusaphaladphoa

Khishfe, R.&Abd-El-Khalick, F. (2002).Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science.*J. Res. Sci. Teaching*, *39*, 551 – 578.

King, B.B. (1991). Beginning teachers' knowledge of and attitudes toward history andphilosophy of science.*Science Education*, *75*, 135 – 141.

Kourany, J.A. (1998). *Scientific knowledge: basic issues in the philosophy of science*. Belmont: Wadsworth.

Lederman, N.G. (1999). Teachers' understanding of the nature of science: factors that facilitate or impede the relationship. *J. Res. Sci. Teaching*, *36*, 916 – 929.

Lederman, N. &Abd-El-Khalick, F. (1998).Avoiding de-natured science: activities that promote understandings of the nature of science (pp. 82 – 126). In: McComas, W.F. (Ed.). *The nature of science in science education: rationales and strategies.*Dordrecht: Kluwer.

Meesri, S. (2007). *A development of professional development program for enhancing teachers'understanding of the nature of science and its implementation in the classroom – PhD thesis.* Bangkok: Srinakharinwirot University.

Pomeroy, D. (1993). Implications of teachers' beliefs about the nature of science: comparison of the beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education*, *77*, 261 – 278.

Schwartz, R.S. & Lederman, N.G. (2002). "It's the nature of the beast": the influence of knowledge and intentions on learning and teaching nature of science. *J. Res. Sci. Teaching, 39*, 205 – 236.

Smith, M.U., Lederman, N.G., Bell, R.L., McComas, W.F. & Clough, M.P. (1997). How great is the disagreement about nature of science: a response to Alters. *J. Res. Sci. Teaching*, *34*, 1101 – 1104.

Yuenyong, C. & Narjaikaew, P. (2009). Scientific literacy and Thailand science education. *Inter. J. Environ. & Sci. Educ.*, *4*, 335 – 349.

✉ **Dr. Chokchai Yuenyong (corresponding author)**
Science Education Program
Faculty of Education
Khon Kaen University, Thailand
E-mail: ychok@kku.ac.th