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Examining Thai biology teachers' understanding of the nature of science: Where there are various ethnic groups of the Mekhong sub-region people

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Abstract

This research aimed at examining Thai biology teachers' understanding of the nature of science (NoS). Participants included 118 biology teachers from 51 schools in Nakhon Phanom and Mukdahan provinces, Thailand, where there are various ethnic groups of the Mekhong sub-region people. Research methodology utilised an interpretive paradigm. Teachers' understanding of NoS was interpreted through an open-ended questionnaire about NoS that was adapted from Lederman et al. views of NoS questionnaire form-C and interviews. The results of this study shows that more than 50% of the participants had shown uninformed, ambiguous I and ambiguous II views in the questionnaire and interviews. The paper discuss the NoS understanding of teachers' in order to after this improving their understanding of NoS and preparing them for teaching.

Keywords :Biology teacher, nature of science (NoS), understanding, VNOS-C, teaching.

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1. Introduction

Nature of science (NoS) has also been used to explain what science is, how it works, and how it relates to society. No consensus exists as to what is the accepted definition of NoS; the meaning of the term is neither universal nor consistent (Lederman, 1992). Teachers understanding about NoS arrive to be essential but not sufficient for translating into science teaching, such as pressure to cover content (Duschl & Wright, 1989). In addition, confusion between NoS and science process with lacking of knowledge relate to pedagogical approaches and lacking of subject matter knowledge (Abd-El-Khalick, Bell & Lederman, 1998; Schwartz & Lederman, 2002).

In both international, and Thailand science study goals, the purpose is to assist students to develop understandings the NoS. For example, in the United States of America, the importance of studying the NoS was initially prioritised in 1907 by embedding in a study a model focusing on scientific method and processes. Until 1920, the study objective of the NoS was presented in educational goals, and then in 1960, the study of the NoS incorporated the importance of scientific inquiry. From 1989, the American association for the advancement of science (AAAS) clearly specified the understanding of the NoS as an important component of scientific literacy.

The understanding the NoS is emphasises in the standards for science teachers internationally. In Thailand, the Institute for the promotion of teaching science and technology (IPST) is an organisation specifying science and technology teachers' standards. The Institute emphasises the need for teachers to understand the NoS and technology in accordance with the curriculum, understanding of science concepts, understanding inquiry and problem solving, including applying knowledge to construct learning experiences, that are more meaningful to students. In the science teachers' standards, IPST identified that the NoS is explainable; that provable science knowledge can be obtained from scientific processes for inquiry of human knowledge; that science knowledge can change once new evidence appears; existing information is interpreted in different ways and that science is something all people can participate in wherever they are in the world.

Furthermore, the understanding of the NoS also have some impacts on attitude of students on science and science study (Clough & Olson, 2004). Effective learning management of the NoS requires several related factors, such as Pedagogical Content Knowledge, belief and understanding in the NoS (Lederman, 2006).

2. Nature of science in Thailand

In Thailand, NoS was originally prioritised in the curriculum by defining an objective that allows students to develop scientific process skills and to understand the scope and constraints of science. In the present educational curriculum (2008), the study of the NoS was further prioritised as an objective that indicated science instructional management in academic institutes shall have a significant goal to understand the scope of NoS and the constraints of science. The eighth learning standard is one in which student apply scientific processes and understanding of inquiry for knowledge exploration, problem solving, provide explanations for natural phenomena and understand the inter-relationships between science, technology, society and environment.

Based on the study of teachers' understanding and learning management of the NoS, it was found that even some teachers have strong understandings of NoS but this did not lead to classroom learning management and resulting in understanding of students in science content (Lederman, 1999). Many science teachers still emphasise on the content rather than processes, lack scientific discussion, spend too much time on activities although one of the key points of learning management is indicating the NoS to make students access scientist work and more understand science knowledge content (Lederman & Lederman, 2004). Abd-El-Khalick et al. (1998) studied planning teaching and operations of preservice teachers and found that planning teaching, and science content of these teachers was not based on aspects of the NoS. These aspects were often ignored and importance of the NoS was

less than presenting science content. Lederman (1999) also studied new and experienced teachers' teaching operations and found that both groups of teachers rarely taught about the NoS in their classrooms. The experienced teachers contended that the content of the NoS is difficult and not suitable for secondary school students; the new teachers did not want to teach different from other more experienced teachers.

The NoS seems to be difficult for both teacher and student because it was thought as abstract and no had relevance to daily life discussing instructional management of the NoS in the classroom.

3. Review of the literature

3.1. Science literacy

The first goal for the present science education reform initiative is to prepare and develop a society that is scientifically literate (AAAS, 1989; 1993; NRC, 1996) who will be accountable for personal determination that affects the regional and worldwide community (Bell, Lederman & Abd-El-Khalick, 2000; Smith & Scharmann, 1999).

Designs for scientific literacy expanded the definition of scientific literacy to contain the 'scientific habits of mind and an understanding of the NoS and its impact on individuals and its role in society' (AAAS, 2000).

3.2. Definitions of the NoS

Science educators the word 'NoS' is used to describe the intersection of issues addressed by the philosophy, history, sociology and psychology of science as they apply to and potentially impact science teaching and learning. As such, the NoS is a fundamental domain for guiding science educations in accurately portraying science to students (McComas, Clough & Almazroa, 1998).

Although teaching of NoS has been carried out in other countries, very little classroom based research has been conducted in Thailand. Thai science education stakeholders may have unique views on NoS knowledge and ideas about NoS that are sometimes inconsistent with the NoS knowledge held by science educators in the United States and other countries (Tira, 2009). Because of contextual and cultural differences, it may be naive to assume that Thai science educators, NoS views and understandings are similar to those of science educators in other countries. It is important to investigate and understand the views of Thai science education stakeholders on NoS in order to facilitate the development of a science curriculum that fosters NoS knowledge which is appropriate to Thai environments. The end goal of developing such a curriculum would be to increase the scientific literacy of Thai citizens.

4. Purpose of study

The purpose of this study was to examining Thai biology teachers' understanding of the NoS.

5. Research methods

5.1. Setting

This study was conducted in a suburban/rural high school in Nakhon Phanom and Mukdahan provinces, the northeast, Thailand, where there are various ethnic groups of the Mekhong sub-region people. Their ethnic were Nyaw, Phutai, Seak, Khalerng, So, Kha and Laos. The biology teacher ages were between 24 and 58 years. All the participants spend time teaching the subject of biology average 5 hours per day.

5.2. Participants

Participants in this study, the total number of 118 biology teachers, including 32 males and 86 females from 51 schools in Nakhon Phanom and Mukdahan provinces, Thailand, The participants were biology teachers. However, they come from difference major, e.g., Physics, Chemistry, General Science, Science and Marine Technology and Biochemistry.

5.3. Instrument

To explore Biology teachers' understandings of NoS, we employed an instrument called the views of NoS questionnaire form C (VNOS-C) (Lederman et al., 2002) which contained 10 open-ended questions aligned with the seven target aspects of NoS. Validity of the VNOS-C questionnaire was affirmed in this study by interviewing 12 (10%) of the participants using the recommended semi-structured interview follow-up protocol. A scheme for categorising and scoring participant responses to the VNOS-C and interviews; we therefore assumed that it would also be applicable to Thailand respondents. The VNOS-C consists of 10 items and addresses seven NoS aspects considered in this research: (a) Empirical NoS; (b) Tentative NoS; (c) Distinction between scientific theory and law NoS; (d) Inferential NoS; (e) Creative and Imaginative NoS; (f) Theory-laden NoS and (g) Social and Cultural NoS.

5.4. Data collection and analysis

The data were collected from sources: open-ended questionnaire and semi-structured interview. Multiple data sources were collected and included classroom observations, open-ended questionnaires, semi-structured and structured interviews and instructional plans and materials. In addition, students in each of the teachers' classrooms were interviewed with respect to their understanding of the NoS. All the questionnaires and interview transcripts were analysed to participants' understanding of NoS. Using analytical induction, multiple data sources were analysed independently and together to triangulate data while constructing teacher profiles.

6. Findings

The results are presented biology teachers' understanding of NoS. When the participants showed uninformed, ambiguous I, ambiguous II or informed views inconsistently according to the contexts, these views were categorised as partially informed views. In particular, more than 50% of the participants had shown uninformed, ambiguous I and ambiguous II views in the questionnaire and interviews. The biology teachers' current understanding of the NoS from the VNOS-C questionnaire and semi structured interviews.

The first phase focused on biology teachers' definitions of science and their views of NoS. The open-ended VNOS-C questionnaires, semi-structured interviews were used to investigate these factors. The VNOS-C was administered to the target group and 12 biology teachers (10%) were selected for follow up semi-structured individual interviews. During these interviews, participants were provided with their questionnaires and asked to explain and justify their answers. Follow-up questions were used to probe interviewees' responses in depth and pursue their lines of thinking. Interviews, which were 45–60 minutes long, were audio taped and transcribed verbatim for analysis. Table 1 summarises the results from the seven aspects of NoS from the VNOS questionnaire and the semi structured interviews. These aspects included empirical, observations and inferential, tentative, theory-laden, creative and imaginative, distinction between scientific theories and laws, Social and cultural and responses categorised the target aspects of the NoS into one of the four levels which were uninformed, ambiguous I, ambiguous II and informed. Following the Table 1 elaborated on the quality of the responses.

Table 1. Each items shows the number of participants' understandings of the aspects of NoS (*n* = 118)

Items	Aspects of NoS	Biology teachers' understandings of the aspects of NoS (%)			
		Uninformed	Ambiguous I	Ambiguous II	Informed
I 1	EMP	29.7	55.09	13.56	1.69
I 2	EMP	17	57.63	16.10	9.32
I 3	EMP	89	5.09	2.54	3.39
I 4	TEN, OBT, CRI and DTL	27.1	54.24	15.25	3.39
I 5	DTL	34	56.78	8.47	0.85
I 6	TEN and DTL	21.2	63.56	8.47	6.78
I 7	OBT	41.5	51.70	1.69	5.08
I 8	CRI	13.6	75.42	10.17	0.85
I 9	THL	71.2	19.49	7.63	1.69
I 10	SOC	38	15.25	29.66	16.95

Empirical (EMP), Inferential (INF), Tentative (TEN), Theory-laden (THL), Creative and imaginative (CRI), Distinction between scientific theories and laws (DTL) and Social and cultural (SOC).

This section discusses the profiles of biology teachers' initial views. Each response may be categorised into more than one aspect since the respondents can choose more than one answer. However, to make the discussion easier, biology teachers' views for each aspect are presented separately.

6.1. Empirical

Item 1: What, in your view, is science? What makes science (or a scientific discipline, such as physics and biology) different from other disciplines of inquiry (e.g., religion and philosophy)?

First, at the uninformed level, 35 biology teachers (29.7%) of the teachers did not clearly define science in detail. They held a vague general idea that science could be anything with numbers and evidence to present the validity of the data. For example:

Science demonstrated concrete can be obtained by using the principle of cause and effect.

)*Bio P 32,VNOS-C#1*(

Second, at ambiguous I level, 65 biology teachers (55%) of the teachers defined science as 'knowledge' about the natural world, discovery of the truth, cause and effect relationships, development of technology and explanations expressed in numbers. An example of a response at this level was

Science is knowledge which can be proved .It is knowledge of truth and natural phenomena—not supernatural phenomena .Also, it is about the applications of technology)*Bio P 51, VNOS-C#1*(

Third, at ambiguous II level, 16 biology teachers (13.6%) of the teachers thought science was about the natural world itself, what things are, and how things work.

For example:

Science is nature .Science can be categorised as biological and physical science .It is about respectively) *Bio P 64, VNOS-C#1*(

Finally, at the informed level only two teachers (1.7%) defined science as a process of finding knowledge about the natural world. One of the responses suggested that

Science was about truth which results from conducting an experiment, performing an observation, drawing a conclusion, and forming a theory) *Bio P 42, VNOS-C#1*(

According to the Benchmarks for Science Literacy (AAAS, 1993), although science disciplines are different in some ways, they are not separated by immutable boundaries. Science disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are a part of the same scientific enterprise. Although each discipline provides a conceptual structure for organising and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some sub-disciplines spin off to become new disciplines in their own right (AAAS, 1993).

In the follow-up interviews, a sample of teachers further clarified their view of science and what makes science different from other disciplines of inquiry one interviewee stated that Science is about seeking for the truth, and explaining it logically. For example, if I want to study the composition of new species of a plant; I need to follow a procedure, that is, setting up a hypothesis based on what I want to know. Then, I carry out an experiment in order to answer the question Finally, I compare the results with the hypothesis. If the experiment is repeated several times and still end up with the same results, then I can form a theory out of it. This is the scientific process (Bio P 50, Interviews)

7. Discussion and conclusions

The conclusions and discussions of this study are organised into phase regarding to research questions.

This first phase starts with a conclusion and discussions about the current understanding of the NoS of biology teachers in Thailand was explored.

The first research was investigation about teachers' understanding of the NoS. The NoS in this research consists of seven aspects in other words: (1) empirical; (2) observations and inferential; (3) tentative, (4) theory-laden; (5) creative and imaginative; (6) distinction between scientific theories and laws and (7) social and cultural. One hundred and eighteen teacher participants had a variety of understandings of the NoS. They had insufficient understanding in many aspects.

1) Empirical; first, at the uninformed level, 53 biology teachers (45.2%) of the teachers did not clearly define an experiment in detail. They described the focus on scientific theory. Second, at ambiguous I level, 46 biology teachers (39.2%) of the teachers described that an experiment involves collection of data and other information. However, they did not describe a clear for experiment. Third, at ambiguous II level, 13 biology teachers (10.7%) explained about an experiment to relate with using the scientific process. Finally, at the informed level, six biology teachers (4.8%) did clearly define an experiment in detail and they explained variables in experiment detail.
2) Observations and inferential; first, at the uninformed level, 49 biology teachers (41.5%) Many teachers say I do not know and they explained point of science knowledge about a species as a group of organisms. Second, at ambiguous I level, 61 biology teachers (51.7%) of the teachers indicated the scientists were certain about concept of a species because they used a variety of observational evidence. Third, at ambiguous II level, two biology teachers (1.7%) of two teachers mentioned that scientists were not certain about the characterisation of what a species was. However, they had not clearly explained. Finally, at the informed level, six biology teachers (5.1%) of the teachers indicated scientists were not certain about the characterisation of what a species was. And, the participants explained a clear understanding that.

3) Tentative; first, at the uninformed level, 29 biology teachers (24.2%) of the teachers believe that scientific theories do not change. Second, at ambiguous I level, 69 biology teachers (58.8%) of the teachers indicated that scientific theories change. However, they not explained how scientific theories change. Third, at ambiguous II level, 14 biology teachers (11.9%) of the teachers explained that scientific theories change and they indicated how scientific theories did change. Finally, at the informed level, six biology teachers (5.1%) of the teachers indicated that after scientists have developed a scientific theory did change. They explained a clear understanding of the theories.
4) Theory-laden; first, at the uninformed level, 84 biology teachers (71.2%) of the teachers attributed point to the dinosaur extinction controversy not answers how was these different conclusions possible if scientists in both groups have access to and use the same set of data to derive their conclusions. Second, at ambiguous I level, 23 biology teachers (19.5%) of the teachers explained about different conclusions possible but they not indicated about idea of espect NoS in Theory-laden. Third, at ambiguous II level, nine biology teachers (7.6%) of the teachers used the term data explained that both hypotheses were possible since evidence was limited and not enough to prove that one of the two hypotheses was correct. Finally, at the informed level, two biology teachers (1.7%) of two teachers indicated understanding about idea of espect NoS in Theory-laden.
5) Creative and imaginative; first, at the uninformed level, 16 biology teachers (13.5%) of the teachers indicated that not used imagine and creativity in experiment. Second, at ambiguous I level, 89 biology teachers (75.3%) of the teachers explained scientists used imagination and creativity in experiment science. However, the teachers indicated only in data collection. Third, at ambiguous II level, 12 biology teachers (10.2%) of the teachers indicated scientists used imagination and creativity in experiment science. However, the teachers some explained why scientists used imagination and creativity. Finally, at the informed level, one biology teacher (1%) of one teacher indicated that scientists used imagination and creativity in experiment science. And, the teacher explained why scientists used imagination and creativity.
6) Distinction between scientific theories and laws; first, at the uninformed level, 40 biology teachers (34%) of the teachers believed in a hierarchical relationship between theories and laws. Second, at ambiguous I level, 67 biology teachers (56.7%) of the teachers explain a theory and a law. However, they did not explain about the theories and laws differ. Third, at ambiguous II level, 10 biology teachers (8.5%) of the teachers indicated the theories and laws differ and theory cannot become a law. Finally, at the informed level, one biology teacher (1%) of the teacher explains about a theory and a law and one teacher indicated a clear understanding of the theories and laws differ. A theory was a scientific explanation of an observed phenomenon, unlike laws.
7) Social and cultural; first, at the uninformed level, 45 biology teachers (38%) of the teachers indicated that they believe science is a universal not related to socio-cultural. Second, at ambiguous I level, 18 biology teachers (15.3%) of the teachers explained that they believe that science reflects social and cultural values. However, they not indicated how science and scientific knowledge relate to socio cultural. Third, at ambiguous II level, 35 biology teachers (29.7%) of the teachers indicated they believe that science reflects social and cultural values and they explained how science and scientific knowledge relate to socio cultural. Finally, at the informed level, 20 biology teachers (17%) of the teachers understand about social/cultural influence on science. Which is consistent with in a research, these data are consistent with some prior studies on NoS which also revealed inadequate understandings of this aspects (Akerson & Abd-El-Khalick, 2003; Akerson & Hanuscin, 2007).

This paper used the VNOS-C questionnaire along with semi-structured interview in order to explain the teachers' conceptions of each individual aspects of NoS and classified their conception of each aspects not as either informed or naive, but rather on a spectrum ranging from informed, ambiguous I, ambiguous II and uninformed. Using four categories for classifying the teachers'conceptions of the seven individual aspects of NoS allows more subtle changes in their understanding of these concepts to be observed before and after instructional interventions and further allowed for any relationships

between these aspects to be identified. Similarly, Nader (2009) studied that the data analysis comprised three phases.

The first phase attempted to answer the question of one of the study. The pre-post and delayed VNOS-C questionnaires' responses and the corresponding random sample interview transcripts were separately analysed to establish the questionnaire validity and to generate a pre-post and delayed profiles that categorise participants' NoS conceptions as naive, partially informed, and informed for all the participants. And, Mark (2008) using five categories for classifying the teachers' conceptions of the seven individual aspects of NoS.

In conclusions of phase 1 indicated that teachers lacked understanding all of aspects of NoS. The results of the investigated in the first phase led to find the solution as an effort to promote and encourage teachers' understanding of NoS.

8. Implications and recommendations

In the future research needed to investigate the larger scale study might examine the relative contribution of each approach, as well as looking at interaction effects, to the development of biology teachers' knowledge of NoS.

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