Enhancing Thai Teachers’ Understanding and Instruction of the Nature of Science

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Abstract

This study examined the effects of PD program on Thai teachers’ views and their NOS’s instruction. The program consisted of 2 phases to developing teachers’ understanding and teachers’ instruction by using Explicit Teaching Approach. Participants were 15 teachers. The methods consisted of workshops and lesson plan models. The researcher tracked the changes in the pre- and post- views by using the VNOS-C and interviews. To evaluate teachers’ understanding of the NOS, their views were collected and analyzed to find how their understanding has changed and how they addressed NOS in their lesson plans. It was found that after the teachers attended the program, their NOS’s understanding and instruction had improved. This result indicates that teachers’ understanding and instruction was enhanced by attended the PD program.© 2013 Published by Elsevier Ltd.

Keywords: nature of science; professional development program; explicit teaching of NOS; Thai teacher.

1. Introduction

Understanding of the Nature of Science is a prerequisite of science literacy. It is also one of the major goals of science instruction. We cannot have science literacy without understanding the nature of Science. (Lederman, 1992; AAAS, 1994; McComas and Olson, 1998; NSTA, 1998; Haidar, 1999; Han et al., 1999; Akerson, Abd-El-Khalick, and Lederman, 2000; IPST, 2003). Understanding of the Nature of Science also enhances teachers’ changing views of learning and teaching of Science. Teachers who have a contemporary view of the Nature of Science would be most likely to make more use of inquiry - based or constructivist teaching (Lederman, 1998; McComas et al., 1998). In elementary school science education, there is an assumption that students should begin to learn about what science is and what scientists do and think at this level, because young students already have potential to study these things (Etheredge and Rudnitsky, 2003; Harlen, 1996; Skamp, 2004). Thus, elementary school teachers should not avoid conveying the appropriate concepts of the Nature of Science to their primary school students even at the elementary school level.

In Thailand, the Institute for Promoting Science and Technology Teaching (IPST), which has responsibility for developing science standards documents and promoting teachers in teaching Science, has appreciated the
importance of understanding the Nature of Science for a long time (ONEC, 2001). The understanding of the Nature of Science is recommended as an objective of learning Science for basic education. In the reformed national standards for teaching Science (2008), the content strand for the Nature of Science and Technology and its intended learning outcomes has been explicitly stated. IPST also has tried to promote teaching approaches which convey understanding of the Nature of Science such as the inquiry oriented and problem-solving instructional approaches (IPST, 2003). In order to develop teachers’ understanding and teaching of the Nature of Science, it is important to emphasize developing teachers’ understanding both of Nature of Science’ concepts and instruction. This means teachers should have adequate understandings or conceptions of various aspects of the Nature of Science, as well as the knowledge of how to teach those aspects of the Nature of Science effectively (Abd-El-Khalick and Lederman, 2000; Akerson and Abd-El-Khalick, 2003). A program for teacher professional development on the Nature of Science conceptions and instructions should be constructed based on the perspective of social constructivism. The design of activities within the teacher professional development program emphasized two specific aspects: developing teachers’ understanding of the Nature of Science concepts and developing teachers’ teaching methods for the nature of science by using Explicit Teaching Approach (Abd-El-Khalick, Bell, and Lederman, 1998; Clough, 1998; Bell, Lederman and Abd-El-Khalick, 2000; Schwartz and Lederman, 2002).

2. The nature of science

Typically, NOS refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge (Lederman, 1992). These characterizations nevertheless remain fairly general, and philosophers of science, historians of science, sociologists of science, and science educators are quick to disagree on a specific definition for NOS. Such disagreement, however, should not be surprising given the multifaceted and complex nature of the human endeavour we call science. Moreover, similar to scientific knowledge, conceptions of NOS are tentative and dynamic: These conceptions have changed throughout the development of science and systematic thinking about its nature and workings (Abd-El-Khalick & Lederman, 1998). In addition, from an analysis of eight international science standard documents, those authors summarized a consensus view of the NOS. Some aspects of the NOS include: (1) Scientific knowledge is tentative; (2) no single scientific method exists, but there are shared characteristics of scientific approaches to science, such as scientific explanations being supported by empirical evidence, and are testable against the natural world; (3) creativity and imaginative play the role in the development of scientific knowledge; (4) Laws and theories serve different roles in science; (5) there is a relationship between observations and inferences; (6) although science strives for objectivity, there is always an element of subjectivity in the development of scientific knowledge; and (7) Scientific ideas are affected by their social and historical milieu (McComas et al., 1998).

2.1 Professional development program

Fullan (1994) argues that the professional development is “the sum total of formal and informal learning pursued and experienced by the teacher in a compelling learning environment under conditions of complexity and dynamic change”. Day (1999) also, through a more descriptive interpretation of professional development, defines the term as “the process by which, alone and with others, teachers review, renew and extend their commitment as change agents to the moral purposes of teaching; and by which they acquire and develop critically the knowledge, skills, planning and practice with children, young people and colleagues through each phase of their teaching lives”. Bredeson (2002) perceives the notion of professional development through three interdependent concepts: learning, engagement and improved practice, and defines professional development as “learning opportunities that engage educators’ creative and reflective capacities in ways that strengthen their practice”.

2.1.1. Explicit teaching of NOS

This approach advocates that to improve teachers’ understanding of the NOS, the NOS should be considered as a cognitive learning outcome and should be taught explicitly rather than expected to be naturally development during the regular science activities (Khishfe and Abd-El-Khalick, 2002). It’s refers that teachers’ acquisition of knowledge
of some of the aspects of the NOS should be highlighted during their activities. Khishfe and Abd-El-Khalick (2002) explained the important qualifications regarding the conceptualization of an explicit and reflective approach. It cannot be overemphasized that this approach should not be confused with didactic teaching. The explicit and reflective approach does not solely invoke elements from history and the philosophy of science or exclude science-based inquiry activities.

2.1.1. Thai teacher

Thailand is divided into 76 provinces, which are gathered into six regions, that is North, North-East, Central, East, West and South. Basic education in Thailand includes 12 years of study. According to the Basic Education Curriculum (Ministry of Education, 2008), basic education in Thailand are divided into nine grades: Elementary school (Grades 1-6), Secondary school (Grades 7-9). According to Section 43 of the Teacher and Educational Personnel Act (Secretariat of the Cabinet of Thailand, 2003), teaching in Thailand is presently regarded as a highly-qualified profession, which requires a Teacher Professional License. However, most of Thai elementary school’s teachers didn’t have degree in science. Most importantly, they lack an understanding about the Nature of Science’s concepts and instruction to addressed the Nature of Science’s concepts in their classroom. (ONEC, 2001; Promkatkeaw et al., 2007; Buaraphan, 2009)

3. METHODS

The investigation present study was interpretive in nature (Strauss & Corbin, 1990) and focused on the meanings that participants ascribed to the emphasized their understanding about NOS’s concepts and instruction of the Nature of Science and their teaching practice of the classroom.

Instrument

The Views of Nature of Science form C [VNOS –C] and interviews was used to explore pre- and post-views of teachers’ understanding about NOS’s concepts and instruction of the NOS and their teaching practice of the classroom, before and after they attended the professional development program. It consists of 10 items open-ended questionnaire. In addition, their lessons plan was used to explore. Specifically, the researcher inquired into

1. How do elementary school teachers change their views about the NOS after they attended the professional development program?
2. How do teachers generally address the NOS in their teaching?

Data Collection and Instruments

A combination of the pre- and post-views of an open-ended questionnaire (VNOS –C), semi-structured interviews, teachers’ reflection about how to addressed the NOS’s concepts into their lessons plan, classroom observations and lesson plan instructional were used to investigate the enhancing of teachers’ understanding about the NOS’s concepts and their teaching methods. This study is designed for collecting and analyzing data in order to describe and generate theoretical explanations for answering the aimed of study from 15 Thai elementary school teachers from Khon Kaen Elementary Educational Service Area Office 3, under the Office of the Basic Commission, in the Northeast region of Thailand. All of participants in this study were grade 6 science teachers.

Data Analysis

The pre- and post-views of an open-ended questionnaire (VNOS –C) and corresponding interview transcripts of the 15 interviewed participants were analyzed and compared the enhancing of teachers’ understanding about the NOS’s concepts. Moreover, the lessons plan which constructed and addressed NOS’s concepts into these lessons plan were analyzed. This analysis indicated that the profiles of participants’ NOS views [after they attended the professional development program] as derived from the pre- and post-views of an open-ended questionnaire (VNOS –C) were faithful to show that the participants’ views were enhanced.

Next, to discern that the elementary teachers who were participants had enhance their understanding of concepts and instruction of the NOS, researcher reviewed the pre- and post- of their VNOS-C responses and associated interviews. Researcher had previous experience coding the VNOS-C surveys and separately coded the
responses as traditional, mixed, or contemporary and compared analyses. There were very few discrepancies and any that arose were resolved through discussion, further consultation of the data, and consensus.

To describe an instruction that participants used at each classroom, researcher reviewed lesson plans and field notes of classroom observations being carried out in each classroom. Researcher looked for an instruction of the NOS ‘concepts being emphasized in each classroom. Researcher looked at lesson plans to discern whether there were NOS objectives, NOS’ teaching as well as NOS assessments planned and reviewed videotapes to listen to conversations among teachers regarding teaching of NOS conceptions.

RESULTS AND DISCUSSION

Teachers’ Responses to the Open-Ended Questionnaire

The View of Nature of Science form C [VNOS-C] is an open-ended form. Fifteen teachers responded to this questionnaire at beginning and after the program. The findings were organized into the Changes in the NOS views.

Changes in elementary teachers’ views about NOS’s concepts

In their protest responses and interviews, all articulated, to some degree, the meaning of most of the aspects. Four out of seven aspects of the NOS those teachers initially held were misconceptions: Law and Theories; creativity and imagination; Sociocultural Embeddendless; and subjectivity. At the end of the professional development program, all teachers seem to improve their views about the NOS.

At the completion of the professional development program, all participants demonstrated abilities to articulate detailed descriptions of all targeted aspects of the NOS. The researcher looked for evidence of change resulted in two main change categories that differ in degree of change.

A change was considered (1) “major” if there was evidence of an overt switch from a misconception/traditional view initially to a view that is in more agreement with that prompted in the program, or (2) “enhancement” if a teacher demonstrated improved understandings over his/her initial profile, thus indicating a shift in the desired direction. The summarizes changes. For each teacher, the NOS test responses and corresponding interview transcript will be reviewed, and a summary profile generated to represent that teachers conceptions. Each aspect will be scored with a “+” to indicate the teacher’s agreement on particular aspect. Score of a “+++” indicates the teacher’s abilities to articulate the meaning of the aspect in his/her own words through supporting examples from professional development program, or a “++++” to indicate the teacher’s abilities to articulate the meaning of the aspect in his/her own words and provide examples different from those presented in professional development program. Additionally, data were examined for reference to connections among aspects. Post program NOS profiles were generated via the same process, utilizing the NOS post test questionnaires and follow-up interviews. A couple paragraphs below are the explanations and examples of teachers’ responses to the open-ended questionnaire and interviews.

Laws/Theories: A majority of teachers indicated that laws and theories are “the scientific knowledge but they are different”, Laws describe phenomena in nature, theories are explanations for natural phenomena. However, ten of participant teachers held traditional views about laws and theories. They thought “laws” in science indicated a “developed theory and static”. In response to the fifth item of the open-ended questionnaire followed by interview, one teacher stated, “Law had develop from theory and impossible to change ” (T4pre). When teachers were asked to describe how scientists determined the relationship between law and theory before they had proof to show the pattern and relationship, no teacher talked about the kind of scientific knowledge to support the relationship of law and theory, just that “Law had develop from theory ”. Another teacher that held traditional view of laws and theories told that “Law can change to be the theory but theory cannot change to be the Law…” (T5 pre)” That could mean this teacher believed that the relationship between Law and theory is the development from law to theory only.

At the end of the program all teachers had appropriate understandings of law and theory. And Teacher 4 changed her view as shown below. Laws and theories are the kind of scientific knowledge. (T4post)

Teachers’ Views Change of NOS’s Aspects Results From The Views Of Nature of Science form C [VNOS-C]

From the NOS’s aspects such as empirical, tentativeness, subjectivity, law and theories, observation and inference, creativity and imaginative and sociocultural embeddedness;
- Teacher 1: Enhanced all of NOS’s aspects (E) and showed connections among aspects in empirical and observation and inference (C).
- Teacher 2: Enhanced all of NOS’s aspects (E) and showed connections among aspects in tentativeness and creativity and imaginative (C).
- Teacher 3: Enhanced all of NOS’s aspects (E) and showed connections among aspects in subjectivity and observation and inference (C).
- Teacher 4: Enhanced all of NOS’s aspects (E) and can not showed connections among aspects.
- Teacher 5: Enhanced all of NOS’s aspects (E) and showed connections among aspects in empirical (C).
- Teacher 6: Enhanced all of NOS’s aspects (E) and showed connections among aspects in creativity and imaginative and sociocultural embeddedness (C).
- Teacher 7: Enhanced all of NOS’s aspects (E) and showed connections among aspects in subjectivity, observation and inference and sociocultural embeddedness (C).
- Teacher 8: Enhanced all of NOS’s aspects (E) and can not showed connections among aspects.
- Teacher 9: Enhanced all of NOS’s aspects (E) and showed connections among aspects in empirical, tentativeness, observation and inference, creativity and imaginative and sociocultural embeddedness (C).
- Teacher 10: Enhanced all of NOS’s aspects (E) and showed connections among aspects in empirical and tentativeness (C).
- Teacher 11: Enhanced all of NOS’s aspects (E) and showed connections among aspects in subjectivity, observation and inference and sociocultural embeddedness (C).
- Teacher 12: Enhanced all of NOS’s aspects (E) and showed connections among aspects in tentative, observation and inference and sociocultural embeddedness (C).
- Teacher 13: Enhanced all of NOS’s aspects (E) and showed connections among aspects in empirical (C).
- Teacher 14: Enhanced all of NOS’s aspects (E) and can not showed connections among aspects.
- Teacher 15: Enhanced all of NOS’s aspects (E) and showed connections among aspects in tentative, observation and inference and sociocultural embeddedness (C).

Note: M: major change from traditional to contemporary view; E: Enhanced (started out adequate, but gained); C: showed connections among aspects. Final NOS views: + provides a definition or affirmative response; ++ provides a description in own words, examples from program; +++ provides a description in own words and additional supporting examples.

Results of the Teachers’ Teaching of the Nature of Science

To answer how teachers addressed the NOS’s aspects in their teaching, teachers’ lessons plan, teachers’ reflection about how to addressed the NOS’s concepts into their lessons plan, classroom observations and lesson plan instructional were collected to investigate the enhancing of teachers’ understanding about the NOS’s concepts and their teaching method. As an attempt to trace the changes in teaching NOS, fifteen science teachers were devided into 3 groups and each group had assigned five lessons plan which used explicit teaching approach for integrating or addressing some aspects of NOS in their teachings at the end of training program. These will help identify the effectiveness of the professional development program on the instruction of the NOS. A total of 15 lessons plan were presented through 3 groups teaching.

The data indicated that after the teachers attended the program, they also explicitly addressed aspects of the nature of science in their lesson plans which used explicit teaching approach. This result indicates that teacher’s understanding about the nature of science and instruction by using explicit teaching approach was enhanced by attended through the professional development program.

Conclusion

To evaluate the effectiveness of the professional development program, the teachers’ understanding of the NOS and teaching approach were studied. The findings of this study are summarized as follows:

The results of developing the teachers’ understanding of the nature of science

The data were gathered through open-ended questionnaire [VNOS – C] and semi-structure interviews.

The results from study of teachers’ understanding of the NOS indicated that after attending the professional development program, they held more contemporary views of the NOS than before attending the program. Most of the change was considered as “enhancement” of teacher demonstrating improvement on understandings over his/her initial profile, thus indicating a shift in the desired direction. Some change was considered as “major” that there was
evidence of an overt switch from a traditional view initially to a view that is in more agreement with that prompted in the program. In the final views, most teachers can articulate the meaning of the aspect in his/her own words through supporting examples from professional development program. Some teacher can articulate the meaning of the aspect in his/her own words and provide examples different from those presented in professional development program. Other enhancements involved explicitly addressing aspects of the NOS in their lessons plan.

**Discussion**

The results from this study provide insight into teachers’ conceptions of the NOS and those strategies which were effective in enhancing teachers improve their understanding and teaching of NOS. The results indicated that the teachers improved their NOS instruction through their lessons plan which used explicit teaching approach. Through interventions it has proven possible for elementary school teachers to develop informed conceptions of the NOS through an explicit reflective approach (Akerson; Abd-El-Khalick; & Lederman. 2000; Akerson; & Abd-El-Khalick. 2003).

The findings of this study indicated that after the teachers attended the program, their understanding about the nature of science aspects and instruction had improved. They could articulate the meaning of different aspects of the nature of science in their own words and provide examples. Moreover, they also explicitly addressed aspects of the nature of science in their lesson plans. This result indicates that teacher’s understanding about the nature of science and instruction by using explicit teaching approach was enhanced by attended through the professional development program.

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