

ORIGINAL ARTICLES

Exploring of Experienced Science Teachers' Pedagogical Content Knowledge: the case of Teaching Global Warming

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ABSTRACT

This inquiry was designed to examine the pedagogical content knowledge (PCK) of teachers primary science when delivering a topic like global warming. This investigation was conducted within an interpretive paradigm using a case study approach and qualitative method of data collection. The participants were fifteen science teachers from fifteen primary schools, Udonthani province, Thailand. This study used Content Representation (CoRe) design as a framework to illustrate aspects of the teachers' PCK. Questionnaires, document analysis and an interview were used in data collection. The results of this study indicated that the current teaching practice lacked sophisticated PCK. Issues were related to the transmission knowledge, pedagogical rationale and student understanding. Furthermore, their resultant CoRe showed that teachers also have misunderstandings about child-centred learning, strategies of teaching, assessment, and students' understanding of global warming. On the other hand, the teachers demonstrated an understanding of the purposes and the socio-cultural role that influenced science teaching and learning, concluding that there is a need for professional development support for teachers to enhance their understanding about teaching and student learning.

Key words: Content Representation, Pedagogical Content Knowledge, Global Warming, Primary Science Teachers

Introduction

Pedagogical content knowledge is the knowledge base for teaching, which has attracted considerable attention since Shulman (1986; 1987) posited that PCK is defined as the unique knowledge a teacher has which is the amalgam of content knowledge and pedagogical knowledge in ways that lead to enhanced student understanding. He also helped clarify the nature of a teachers' PCK, which comprises two components: (1) knowledge about strategies for teaching, which is created to represent the natural phenomenon, and he calls "representations" i.e., instructional strategies illustration, analogies and demonstrations that teachers use to make subject matter understandable to their students; and (2) knowledge of students' "learning difficulties" i.e., students' misconceptions, naïve ideas gained through interpretation of prior learning and experiences or preconceived ideas about a topic. Moreover, PCK is not a single entity that is the same for all teachers of given subject area; it is a particular with individual idiosyncrasies and important differences that influenced by the teaching context, content and experience (Loughran, Berry, & Mulhall, 2006), so assessment and development teachers' PCK are presumably approaches which depend on perspective of research paradigm.

There are several ways that use capturing and portraying science teachers' PCK [e.g. multi method evaluation (Baxter & Lederman, 1994), story-line method (Drechsler & Van Driel, 2008), lesson preparation method (Kapyła, Heikkinen, & Asunta, 2009), using PCK rubric score (Jang, 2010)]. An interesting approach is content representation (CoRe) that was devised by Loughran (2001). CoRe is tool that attempt to portray, holistic overviews of teachers' PCK and it was developed by engaging small groups of expert science teacher in activities about what they consider to be the "big ideas" associated with teaching a given topic for a particular grade level based on their experience of teaching science topic. The research of resultant CoRe elucidate science teachers can use it for planning lesson and assessing their knowledge of teaching specific content to particular student; it is representation of teachers' PCK (Hume & Berry, 2010; Loughran *et al.*, 2001; Nilsson & Loughran, 2011). Furthermore, CoRe is not academic theory, but more so as a means of viewing, understanding and enhancing their professional knowledge of teaching (Bertram & Loughran, 2011).

This inquiry made understanding within five components of science teachers' PCK (Magnusson, Krajcik, & Borko, 1999). These components included:

- Knowledge of goals for science teaching;
- Knowledge of the science curriculum;
- Knowledge of students' understanding of specific science topics;
- Knowledge of assessment in science; and
- Knowledge of strategies for teaching science topics.

Thailand has been experiencing the consequences of global warming (McDonald-Gibson, 2007; COP-17) and so far so good, Thailand has confronted with the natural disasters, such as the tsunami in the south, heavy rain and flooding in Bangkok, landslide in the north and the drought in the north-east, which these situations affect to human beings, habitats, economic, plants and animals involves. It also involves to the people in the countries at late (Thai Meteorological Department, 2010). This problem has had the case from global warming. Many experts believe that humans are imperiling the ecology of the earth by enhancing the nature greenhouse effect, which may result in global warming (James *et al.*, 2000) so that, to make people aware to take care the earth, we have to create when they are children; the teacher is creator. The development of PCK should begin teacher, who will construct sustainable understanding to their students.

This research attempt to find the answers of research questions that how do primary science teachers taught a topic like global warming by demonstration all aspects of PCK, and what are problems, threats and requirements for science learning and teaching. The research findings will be reflected in management of administrators teachers (who have taught at the Office of The Basic of Education Commission), educators, and staff, who involved in the institute production of teachers. They will be enhanced and developed the curriculum, teaching process and assessment of pre-service and in-service teachers, who taught in primary and secondary school. Furthermore, the faculty should help to introduce teaching approaches to pre-service and in-service teachers. Everybody should involve in promoting sustainable students' understanding of protection in global warming and they shall be practicing and willingness in society. So, this research aims to examine primary school science teachers' teaching practice on global warming in all aspects of PCK, and to explore the current views of problems, threats, strength, weakness, and possible opportunities of professional development.

Aim Of The Study:

The aim of this research was to examine teaching practice a topic like global warming of experience science teachers and captured their PCK of global warming. Also, this research has to explore the current views of problems and threats, strength and weakness and possible opportunities, which were external factors for development teachers' PCK. The purpose of research did not intend to identify possible common patterns across the PCK development of teachers (Verloop, *et al.*, 2001) and the research did not identified the content and structure of teachers' PCK of a specific a topic in some science issue (Henze, *et al.*, 2007, 2008) as well as research did not explore the PCK development in terms of relations between teachers' PCK different components (Magnusson *et al.*, 1999). In contrast, this inquiry would like to capture and describe in detail the PCK development of each individual participant for teaching a topic in global warming (Loughran, *et al.*, 2004, 2006). Furthermore, the expectation of this research focus on the advantages and disadvantages of teaching issue. If it has gap issue which involves in classroom, the experience science teachers will take to improve their teaching practice, which offers more students' understanding. The following research question is given below:

- How do primary science teacher teach a topic like global warming

Context Of The Study:

There are many external and internal factors, which have influences to this research. One of factors is context around an experience primary science teacher. This section will describe context of the studying in terms of purpose research, area, teachers' tasks and students' ability. Firstly, this inquiry was examining and capturing teaching practice of experience primary science teachers in a topic like global warming. They were captured by CoRe tool which was a new instrumentation for their examining. Secondly, these teachers have taught the students for more than 15 years and they have gotten training about teaching approach from the Institute for the Promotion of Teaching Science and Technology (IPST) for two times, after Thailand has gotten first education reform in 1999. They taught in primary school, which was a rural area and far from the city. Thirdly, every teacher have gotten many tasks from the past to presents, such as financial personnel, management staff, inventory staff and the bodyguard in school, which these tasks, they have spend more time for made it. Finally, the students were taught by these teachers, who did not enough to taught, and also the students came from poor family. Their parents went to work in different provinces then abandon they stayed with their grandfather or relatives. These students have many different ability of learning.

Methodological Approach:

This investigation was conducted within an interpretive paradigm using a case study approach (Cohen, Manion, & Morrison, 2011; Yin, 2009) and qualitative methods of data collection. This report was result in first phase of project of development teachers' PCK. The topic of global warming was selected by the most ideas of participants, who were introduced to attend the project of development teaching, learning science and preparing lesson plan for experience and inexperience science teachers of Udon Thani Primary Education Service Area Office 1. This project started from April to September, 2011. The research has participated workshop, seminar, to staff and following interviews the experience science teachers by CoRe tool. The resultant CoRe will be used to plan for development teachers' PCK in the future.

Participants and Instrumentation:

The participants were 15 primary science teachers who were collected by maximal variation sampling. They have been teaching general science at Udon Thani Primary Education Service Area Office 1. Also, they graduated bachelor degree and have been teaching science over 15 years. Moreover, the topic like global warming was the most participants, who were introduced to attend the project of development teaching, learning science and preparing lesson plan for experience and inexperience science teachers of Udon Thani Primary Education Service Area Office 1.

The CoRe is provided for primary science teachers who will teach a topic like global warming. It looks like a blank template in table format (see Appendix B) across the top row, are the 'Big Ideas', which are meant to represent the major ideas and concepts which are within the particular science content area. Down the left hand column are the CoRe's questions/prompts, which are to be answered for each 'Big Idea'. The questions include:

- What do you intend the students to learn about this idea?
- Why it is important for students to know this?
- What else do you know about this idea (that you do not intend students to know yet)?
- What are the difficulties/limitations connected with teaching this idea?
- What is your knowledge about students' thinking, which influences your teaching of this idea?
- Are there any other factors that influence your teaching of these ideas?
- What are your teaching procedures (and particular reasons for using these to engage with this idea)?
- Specific ways for ascertaining students' understanding or confusion around this idea (Include likely range of responses).

This inquiry has used these questions to interview 15 primary science teachers. The main issue of question is teaching practice of global warming.

Data Collection:

The data collection consisted of an open-ended questionnaire, a semi-structured interview and collecting documents, which these to investigate teaching practice and the teachers' PCK of "global warming". This data collection is exploring the fundamental data, which will use an approach for developing experience science teachers' PCK. The data collections are detailed below.

Questionnaires, the open-ended questionnaires, which were developed in all aspects of PCK. The questionnaires consist of two sections. The purpose of using the open-ended questionnaire was to explore the current views of problems and threats, strength and weakness and possible opportunities, which was external factors for development the teachers' PCK. The questionnaire was validated by content experts and piloted with a cohort of 30 primary science teachers similar to the participants. There are two sections of questionnaires (Appendix A). The first section consists of the teachers' background information (e.g. name, sex, age, graduate education, science experience, teacher science year, etc.). The second section was concerned with the teachers' understanding about the problems, threats, strength, weakness and desiring of development their PCK. Open-ended questionnaires were sent to participants for two weeks and return to sender.

Interviews were conducted with all 15 primary science teachers; semi-structured interview was conducted in the first semester from May to July, 2011.

The purpose of interview was to examine teaching practice a topic like global warming of experience science teachers and capture their PCK of global warming. The interview questions base on the CoRe tool. The initial interview schedule was tested on six experience science teachers (not among the fifteen participants in this study). As a result of this pilot study, some interview questions were rephrased more than two times or rephrased new question in Thai language to promote teachers' understanding. The final interview was one on one

interview. This interview took place within one month after the questionnaire. The duration of the interview varied from 15 to 30 minutes depending on how much time the participants want to have.

Collecting document was also method, which used collect data. The main questions of inquiry were: "What evidence, which was invented, when, is and what effect on students learning?" The research had collected documents after interview finished. There are many documents, which were collected by research, such as lesson plan, students' task, and painting about global warming, science projects, the picture of activities of science learning, the exercise and test. The duration of the collecting documents varied from 30 to 50 min depending on how much time the participants want to have.

Analysis:

This study used a qualitative method design, qualitative techniques. There are three way of data analysis, which depend on research design and data collection. Firstly, the qualitative data was collected by open-ended questionnaires, which was analyzed by frequency. Secondly, The qualitative data was collected by semi-structure interviews, which is using the question from CoRe as well as it was analyzed by combination of documentary interpretation (Erickson 1986) and constant comparative method (Glaser & Strauss 1987). Finally, the data was collected by collecting documents. The research used content analysis which is also used to make meaning of teachers representation of teaching practice. By this analysis, the research can employ multiple approach of evidence looking an issue from each primary science teachers and used triangulation method to analyze the data.

Results And Discussion

The results are presented in two sections: 1) Teachers' teaching practice of global warming in all aspects of PCK and, 2) The problems, threats and requirement of development teachers' PCK for science teaching.

Teachers' teaching practice of global warming in all aspects of PCK can be separate two categories.

Firstly, the primary science teachers have understanding about the goals of teaching global warming and the context of socio-cultural, because they determine purposes clearly before teaching, such as the case, process, consequences, reduction and the ways to stop global warming. So their reflection is as follows:

"To promoting students' knowledge and understanding of global warming and they have known the case of global warming, as well as the effect that occurs on anyone, how do we will protect global warming" (Eh, interviews).

Global warming is complicated, because there are a number of involved parties with a variety of needs, values and interests. So teaching global warming, the teacher should set the purpose about positive attitude toward the environment as well as create awareness and willingness to make personal sacrifices and environmentally responsible behavior. The teachers also related learning environment to context of socio-cultural views, which involves learning and teaching. They have understanding about the parents and people in community, who determine their role for reducing and increasing global warming,

"When the students study finished, they did not take to use in everyday life, or they have no role in community, more simplify, they finished learn but they cat not utilizations. If we ask them that who is actor in community? Maybe we got the answer, which are parents. If father take to make charcoal, his son will make charcoal too; father tell his son that "the son, you can try burn rice straw. When the son heard, he need to burn because his father orders" (Wit, interview).

Secondly, the primary science teachers have misunderstandings and indistinctness about knowledge of curriculum, students' conception in specific science topic, teaching strategies, and assessment. The teachers do not understand the curriculum, because they cannot take the perspective of curriculum development and child-centred learning which were applied in teaching global warming.

"Time of teaching not enough because there are the contents of global warming in every subject, such as English, social science" (Bol, interview). "All learning activities were provided by the teachers, but the student did not involve doing activities" (Kol, interview).

The teachers may have misunderstandings about knowledge and belief of students' conception in specific science topic, because they have examined students' conception like assessment of global warming, which were examined by multiple choices achievement test. They described the ways of examining students' understanding of global warming in the following:

"Testing by science achievement test of learning and learning behavior observation" (Rat, interview).

"There are many documents, which have shown that the students had pre-test and post-test by multiple choices achievement test, such as tests and paper of answer" (Researcher, documentation).

In examining students' thinking intend to make explicit the students' alternative conception of global warming. If students have misconceptions, we will solve some problems that designed lesson plan, teachers draw on their knowledge about commonly held ideas about the topic that students bring to class (the importance

of which is highlighted by the "alternative conceptions" literature mentioned earlier) and also the usual responses (including level of interest) of students to specific teaching and learning situations. However, in assessment, the teachers need to constantly monitor the progress of students' understanding, so they can determine the effectiveness of their teaching of the topic and plan future lessons. While summative assessment is usually explicit, teachers' formative assessment is often unacknowledged and implicit, and probably more specific to the topic being studied (Loughran, *et al.*, 2006). Also, the teachers may change test from achievement test to true or false question for examining students' understanding, for example is as follows (Taber & Taylor, 2009):

- Animals such as cows produce gases that add to global warming;
- The Greenhouse Effect can be seen from space; and
- If we can keep rubbish out of rivers it will help reduce global warming.

The result about knowledge and belief of teaching strategies focus on formal and model of teaching approaches, such as inquiry process (5Es e.g. engagement, exploration, explanation, elaboration, and evaluation), and experimental methods. The teachers' view base on dilemma between constructivist and positivist as following:

"I taught by using inquiry process and experiment methods which were showed in step to step" (Dow, Bol, Wat, and Sum; interview).

The problems, threats and requirement of development teachers' PCK for science teaching; There are many factors that influenced the development of teachers' PCK for science teaching.

Firstly, the primary science teachers have been confronted with the problems and threats of science teaching global warming. For example, 53% of teachers lacked the equipment for experiment; 33.33 % of teachers lacked instruction media for using science teaching; 20 % of teachers lacked the experiment process skill. According to these teachers concentrated the media and the equipment, which were enhanced students' understanding. The following ideas of these teachers, it has showed that they also have weakness about strategies of teaching approach and specific science content representing. Teaching might to depend on media, equipments, and materials. More simply, the teacher needs to consider the tools of teaching and representing a particular content for example, teaching biology, the teacher should understand the materials for that instruction, the alternative text software, programs, visual materials, single-concept films, laboratory demonstrations, or "invitations to enquiry" (Shulman, 1986). Today, these mean Information and Communication technologies [ICT] and technological pedagogical content knowledge [TPCK], with the continual increase of computers in schools and the numerous applications of ICT, the construct of PCK needs to be extended to account for the need to study and understand teacher cognition about the educational uses of computers (Angeli & Valanides, 2008).

Secondly, primary science teachers have strength in science teaching. For instance, 40% of teachers have supported the students' experimental by themselves. 13.33% of teachers would like to self-leaning and desire to find new system in real-life. There were some teachers, who had awareness to improve their teaching by themselves and see the importance of the nature of science, which was shown below:

"Science is a term of phenomenal studies in day life. We should investigate and understand how natural world works

I always looking for new thing which came from scientists' work" (Ek, open-ended questionnaires).

Teaching this subject matter knowledge, maybe teachers used PCK for teaching the nature of science (NOS) too, because knowing what to assess and how to asses were an important part of PCK, which related to view of NOS for students' understanding. For example, teachers' comments about the difficulty of assessing students' views of NOS point out their difficulty in knowing *what* to assess. This is significant, because teachers' ability to assess their students' views of NOS can limit the degree to which they can evaluate their own effectiveness. Without this source of feedback, it would be unlikely that they would be able to make continued improvement in their abilities to teach NOS (Hanuscin, Lee, & Akerson, 2010).

Thirdly, the teachers require improving their PCK by workshop, which focus on training or actually practice (20%). They would like to develop teaching approach (60%). There were different ways of teaching global warming, which were represented base on individual belief, such as "Learning by doing" (Lai), "Intervene integration" (Sum), "Inquiry process" (Dow), "Experiment method" (Jit), and "Using media and computer assistant instruction" (Wit). Following of teaching concept of these teachers, who have been realizing student-centred learning, but all science teachers adhere to formal teaching approach, which were taught step by step. They also would like to enhance teaching approach of student-centred learning.

I would like to investigate new teaching approach and new education technology, which were used to represent in students' understanding. (Wit open-ended questionnaires).

Finally, the teachers have had self- teaching development and they had development of conducting in teaching and learning, such as exploring knowledge by themselves (33.33%), which were showed in detail as follows. "Using technology available for teaching" (Wit), "taking the results of student assessment enhanced yourself teaching" (Lai); participation workshops, which should take part the experts and sophisticates (20%).

Following idea of these teachers, they awake to development their teaching and all teachers look on self-development, which lead to improvement teaching and learning in classroom as well as if teaching will occur effective, another teachers think that, the teacher should got assistance by the experts and sophisticates.

Conclusion And Implications:

This inquiry indicates that in teaching global warming, the teachers have shown evidence of a tentative PCK, and they have developed an understanding of PCK in terms of knowledge of purposes and the socio cultural context which influences learning and teaching global warming. Attribution of the role of the community has affected students' practice about the reduction and reducing global warming. On the other hand, there are other issues that teachers have expressed in their teaching, which imply that they did not clearly understand the ambiguous nature of PCK. The problematic issues have been organized in descending order from most to least, such as knowledge of students' conception in content of global warming, teaching strategies, assessment, and curriculum. When each individual was considered, we could separate two groups. First, Ek, Lai, Sang, Sue, Reun, and Wit, who articulated an adequate PCK. Another group, See, Tian, Jit, Dow, Bon, Vat, Sum, and Kol, whose articulated ideas for teaching global warming did not indicate an advanced level of PCK. They had misunderstood students' understanding of global warming, and their teaching strategies adhered to a formal or stepped teaching approach. Although, they gave weight to student centered learning, they articulated their role in an indistinct way for conducting student centered learning.

There are a range of problems and threats for quality science teaching as explored through PCK. The first issue is the lack of instructional media, equipment for scientific experiments, and scientific process skills for using media and equipment. Also, the method and teaching approaches, which were the procedures and guidelines to make students aware of the importance of global warming and activities to reduce global warming. Consequently, teacher professional development should use PCK for teaching the nature of science.

However, to enhance the quality of teachers' group teaching; there are the opportunities and the strengths in order to improve their teaching. The development focus on professionalism of teaching practice, understanding the context of global warming, will encourage students to learn in meaningful ways. These things will happen, if all stakeholders participate in workshops which focus on action oriented activities and to utilize the good material. This result derives from solving problems within their own educational context, where they have to teach, meanwhile they should receive support and assistance from outside experts and educators, who will be involved in critical discussion and reflection activities in their teaching. This will enable them to achieve a view essential for improving the quality of teaching and lead to a variety of ways to create and develop a new knowledge, which benefits to society.

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Appendi a. The open-ended questionnaires

Section one.

1. What is your name?
2. Where is the school, which did you teach?
3. What is graduate degree?
4. How long have you been experience science teaching?
5. How many subjects did you teach?
6. What do you have others tasks, which are except of teaching?

Section two

1. What do you have problems and threats of teaching in science?
2. What approach do you want to development the pedagogical content knowledge?
3. How do you think your approach for development your PCK, which make better?
4. How do you have teaching approach, which lead to best student learning in science?
5. What do you think your strengths of teaching in science? Why?
6. What do you think your weaknesses of teaching in science? Why?

APPENDIX B. A CoRe TEMPLATE

Year level for which this CoRe is designed.....	Important Science ideas/concepts			
	Big idea "A"	Big idea "B"	Big idea "C"	Big idea "D"
Content Area.....				
What do you intend the students to learn about this idea?				

Why it is important for students to know this?				
What else do you know about this idea (that you do not intend students to know yet) ?				
What are the difficulties/limitations connected with teaching this ideas?				
What is your knowledge about students' thinking, which influences your teaching of this ideas?				
Are there any other factors that influence your teaching of these ideas?				
What are your teaching procedures (and particular reasons for using these to engage with this idea) ?				
Specific ways for ascertaining students' understanding or confusion around this idea (Include likely range of responses).				

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