IJASRM International Journal of Advanced Scientific Research and Management, Vol.3 Issue 1, Jan 2018
www.ijasrm.com
ISSN 2455-6378

Developing Pre-Service Science Teachers' Pedagogical Content Knowledge through the activities of training program: Understanding & Practice

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Abstract

A training program was developed to enhance pre-service science teachers' pedagogical content knowledge (PCK) in order to enable the pre-service science teachers to understand science curriculum, knowledge of assessment in science, knowledge of students' understanding of science, instructional strategies and orientations towards science teaching, which is conceptualized as PCK (Magnusson et al., 1999). In this study, the knowledge of PCK and its practices of three participants who were pre-service science teachers were examined. The participants demonstrated their understanding of PCK through the process of the training program by discussing and writing content representations (Loughran et al., 2004), preparing the lesson plans, micro-teaching and reflection, and actual teaching in the real classroom, respectively. The teaching performances of the participants were collected by classroom observations, and in-depth interview. The results showed that the pre-service science teachers progressively developed knowledge components of PCK. Micro-teaching was the key activities for developing PCK. However, the pre-service science teachers were found with certain difficulties teaching in their classroom. They required greater ability to design appropriate instructional strategies and assessment activities for teaching. Blending between content and pedagogy was also a matter of great concern.

Keywords: *Pedagogical Content Knowledge (PCK), Pre-service science teachers, Training program, Teacher professional development, micro-teaching*

1. Introduction

The Thai National Education Act B.E. 1999 seeks to improve the quality and relevance of education throughout Thai education system. Teachers are considered as the most important and essential component in the teaching and learning process occurred in classroom; as a result, they are widely accepted as the heart of learning reform (ONEC, 1999).

Pedagogical content knowledge (PCK)

Pedagogical content knowledge (PCK) was originally introduced by Shulman (1987) to enclose a category of teachers' professional knowledge determined to each individual teacher. PCK is defined as "the blending of content and pedagogy into an understanding of how particular

topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learning, and presented for instruction…" (p. 8) and "the particular form of content knowledge that embodies the aspects most germane to its teach ability" (p.9).

PCK is also referred to "...knowledge of the transformation of several types of knowledge for teaching (including subject matter knowledge), and that as such it represents a unique domain of teacher knowledge" (Magnusson, Krajcik and Borko, 1999: 95). Magnusson et al. (1999) conceptualized pedagogical content knowledge for science teaching, consisting of five components: orientations towards science teaching, knowledge of curriculum, knowledge of curriculum, knowledge of assessment, knowledge of students' understanding of science, and knowledge of instructional strategies. This study examines the development of three pre-service science teacher's pedagogical content knowledge (PCK) through the role modeling of training program. The research objective is expressed through the research question: What are the understandings and practices of pre-service science teacher's PCK?

2. Methodology

This study is conducted regarding the interpretive paradigm. The interpretive research seeks to describe and interpret human behavior. (Marriam, 1998; Cohen et al., 2000). This study constitutes a report of case-study method used to monitor how the training program influenced the development of PCK of pre-service science teachers.

2.1 Participant

The participants in this study were three pre-service science teachers who were teaching at a secondary school level. The participant were studying in the fifth-year science education program, majoring in Science at the Faculty of Education at a Northeastern University (pseudonym).To ensure the participants' confidentiality, pseudonyms were given to each participant as Miss Anya, Miss Napa, Miss Sunisa,.

2.2 Methods of Inquiry

The extent and nature of PCK based on the framework developed by Magnusson et al. (1999) model was used in this study. Accordingly, the participants demonstrated their PCK through the process of training program by writing a content representations (CoRes), preparing the lesson plans, micro-teaching, and actual teaching in the classroom. To assess all pre-service science teachers' PCK practices including their views, actions, and reasons in the specific context, the classroom observation, semi-structured interview, and written reflection were employed.

Moreover, this study employed a multiple case research design. The data analysis methods began with within-case analysis and followed by cross-case analysis. Triangulation was also used to describe how that the researcher constructed explanation by using more than one or multiple sources of data.

3. Results and Discussions

The pre-service science teachers' understanding and practice of PCK were analyzed with the five components: orientations toward science teaching; knowledge of curriculum; knowledge of students' understanding of science; knowledge of instructional strategies; knowledge of assessment.

3.1 The case of Anya

Orientations toward science teaching

Anya thought that teacher should be the supporter for enhancing of student learning. Teacher's roles as facilitator, it's providing students with activities to shift them from their alternative conceptions to scientific conceptions. She mentioned that: "In my view, teacher should be the supporter for enhancing of student learning. They should provide students with activities to shift them from their alternative conceptions to scientific conceptions. Teacher's roles as facilitator to finding out what the students are thinking; helping students clarify and reflect on their own ideas; challenging students' ideas; helping students change their ideas; helping students find answers for themselves" (Journal writing of Anya)

Knowledge of curriculum

Anya noted her feelings during classroom discussion, saying that:
I've learned the meaning of education technical terms from the curriculum framework. After discussion, I better understood about learning science that should cover all three domains; scientific knowledge, science process skills, and attitudes. (Journal writing of Anya)

Additionally, Anya thought that she now understood and recognizes the goals of teaching and

learning science in the Science Curriculum Framework. In her view, she thought that learning science should cover all three domains; scientific knowledge, science process skills, and attitudes.

Knowledge of students' understanding of science

Anya's aware of student prior knowledge and learning styles was related to her own incomplete science concept and understanding. She was concerned with ways to ask students' content-specific understanding and provide variations of activities that met student ability and learning style. She reflected that:

"In my view, knowing of student prior knowledge is very importance. I used many questions for helping students to clarify their ideas and relate them to the lesson." (Journal writing of Anya)

Anya considers the importance of student prior knowledge and learning. She came to understand more about the importance of prerequisite concepts for leaning specific science concepts, and student's learning ability and learning style. Her understanding of these issues came from reading and discussing student prior knowledge in the class of the training program.

Knowledge of instructional strategies

After participating in the program, Anya had a better understanding of teaching strategies and sequences based on constructivist views. Her broadened ideas, student prior knowledge, hands-on and mind-on activities were keys of constructivist-based teaching strategies.

"For me, I have had better understanding of constructivist-based teaching strategies. …the activities should base on the science content and context of learning… such as student conception and learning, … before student do the activities, teacher should ask the questions for knowing student prior knowledge." (Journal writing of Anya)

Knowledge of assessment

Anya thought that to assess student learning, there should not be only one assessment method. Rather, a variety of assessment methods should be employed, and those should cover dimensions of scientific literacy.

Anya's assessment method was suitable. She employed a variety of assessment methods to assess student understanding of the concept. She emphasized and assessed all three domains. (Anya's field note)

Additionally, in her view, assessment methods should not only consist of a concept test at the end of the class. Rather student learning could be assessed throughout teaching and learning activities.

3.2 The case of Napa

Orientations toward science teaching

As the progressed, Napa broadened her views of teaching and learning of science. Napa's beliefs about learning appeared to center around constructivist views. Napa believed that students hold prior knowledge, and she thought that teachers need to change their role from lecturer to learning organizer and facilitator. In this role, she felt the teacher should prepare material and encourage students to learning themselves.

"At first, I did not aware student prior knowledge. After I participated in the program, I think student prior knowledge is very important. We should survey student prior knowledge before teaching.Teachers should change their behavior from lecturer to learning facilitator."

Knowledge of curriculum

Napa noted her feelings during classroom discussion, saying that: "I've learned more of the meaning of education technical terms from the science curriculum. Actually, I already learned all of these but I'm not clear. Some terms I have a few understanding. After discussion, I better understood the terms". Napa developed understanding of technical terms, educational goals, learning standard, student learning, and teachers' roles proposed in the science curriculum.

Knowledge of students' understanding of science

As the program progressed, Napa developed her knowledge of her students' prior conceptions and learning. Napa felt that she better understood these students' prior conceptions after her learning in the training program. She also thought that she forgot some concepts she already learned. This program helps her to realize about student prior knowledge and learning. She explicitly reflected that

:

"Now, I realized that students' prior conceptions are very important. When student answer their ideas, teacher should probe what the students really meant by their answers so that we can link their prior knowledge with the lesson…and

before teaching we make sure we cleared the concepts. In the program, I wrote content representations, its make me clear about this concept and the way to teach."

Knowledge of instructional strategies

As the program progressed, Napa's pedagogical sequences relied on 5E strategy involved delivering content through five step of inquiry; Engagement by asking the question, Exploration by laboratory activities, Explanation, Elaboration and Evaluation.

After her microteaching, Napa thought that her understanding of how to plan and sequence the activities had improved. Napa was asked to improve the lesson plan for teaching the same content. Napa reflected on this lesson planning and teaching: "This period, I have better understanding in lesson planning. I know where I should start and how I should prepare instructional media for my students". Napa had learned many constructivist-based teaching strategies. Her second teaching experience was more consistent with constructivist views in which students' prior knowledge was emphasized.

Knowledge of assessment

Napa developed her understanding of assessment. She used a variety of assessment methods such as worksheets, assignments, classroom observation, student journal writing, concept mapping, concept survey and interview. She commented on this in her journal: "In this period, I have learned methods for probing students' science conceptions such as student worksheet, assignment, classroom observation, student journal writing, concept mapping, concept survey and interview. I will try these methods and then I think I would know which methods are most useful."

3.3 The case of Sunisa

Orientations toward science teaching

Sunisa mentioned that students could learn science directly from real situations, such as reading books and discussion with their peers. They did not need to do experiments relying only on scientific method. Rather, teachers might let students do experiments and make conclusions about the results which would lead those understanding scientific concepts. They could learn scientific concepts and then verify the concepts by doing an experiment.

Knowledge of curriculum

Sunisa and the other pre-service science teachers were asked to share the ideas about school-based science curriculum. Sunisa noted that the school developed its own curriculum and this was aligned with the basic education curriculum and covered eight learning strands. This understanding was evidenced in her reflective journal: "After discussion class, I realized that what the important factor in science curriculum is. How school developed its own curriculum and how to analyze the curriculum to apply in my lesson plan." (Sunisa's journal writing)

Sunisa had progressed in her curriculum knowledge. She had learned that learning science should be relied on learning standards in the Science Curriculum Framework

Knowledge of students' understanding of science

As the program progressed, Sunisa gradually realized the significance of student prior conceptions and learning. This understanding was developed from many activities in the training program. For example, she had a chance to share and discuss student learning aligned with the student alternative conceptions in science and their learning difficulties. She noted that student learning was important in classroom teaching. She was also motivated student to share ideas about prerequisite concepts for learning about Home electrical appliances. Sunisa had opportunities to read articles about student alternative conceptions in science and their learning difficulties, and then discussed these with her peers. In classroom discussion, Sunisa reflected on her understanding: "I thought that teachers should be aware of student ideas and understand student needs. Teacher should know that wthat is the suitable learning style for their student. Teaching and learning should be based on student ability." (Sunisa's field note)

Knowledge of instructional strategies

She noted that she should emphasize on student-centred more than lectures. Student should learn science form activities. Sunisa brought this belief about teaching science to her first lesson plan about electronic circuit (Home electrical appliances). She began the lesson with a discussion with students about electrical appliances in their house, and then informed the student to do activities. The students explained their ideas about activities. Students and

teacher ended the class by their conclusion. Sunisa had developed their better understanding about teaching strategies to become more student-centred from the activity in training program. She had opportunities to learn constructivist-based teaching strategies. During the activities, she was required to reflect on and discuss the constructivist issue. In the discussion, questions and issues including pedagogical sequences were provided in her worksheet. Through the activities, Sunisa learned pedagogical sequences of constructivist-based teaching strategies. Sunisa reflected that: "The important thing of student-centred teaching was the student thinking. Teacher should ask students questions to motivate students thinking, and students had a chance to do activities from their curious and practice science process skills." (Sunisa's journal writing)

Knowledge of assessment

Sunisa had some limited understanding of assessment. For her, conceptual understanding was main purpose of teaching and learning science. As the program progressed, Sunisa's assessment knowledge developed from discussion and reflection on science teacher's teaching. She reflected that there should be a variety of methods used to assess student learning in the classroom such as worksheet, portfolio and field note from observation. She reflected that: "The teacher should use many methods for assessment. There was not only quiz or test. She should use authentic assessment such as worksheet, portfolio and field note from observation." (Sunisa's journal writing)

In this study, it was found that the training program was likely to improve the pre-service teachers' confidence and ability to teach. There was evidence showing that the pre-service teachers constructed their tentative PCK with greater confidence.

6. Conclusions

The training program could be employed to enhance the pre-service science teachers' confidence and useful for their future PCK practices. Discussion, writing CoRes, micro-teaching and reflection were the key activities to develop the pre-service science teachers' PCK implementation. With the PCK approach, the pre-service teachers were provided with opportunities to plan, teach and reflect their particular concept, which in turn, improves their greater PCK performance. Also, the interviews indicated that the pre-service science teachers became aware of their progress in their lesson planning and teaching, and the strengths and weaknesses of their teaching

All pre-service science teachers progressively developed the knowledge of each component of PCK implementation through the training program. The beliefs of the pre-service teachers about the orientations towards science teaching were broadened to be more constructivists in nature, resulting in the expansion of their views of teaching and learning science. As a consequence, the pre-service science teachers realized the role of students, the importance of students' prior knowledge, and students' learning in science classroom. However, the pre-service science teachers were lack of ability to design appropriate instructional strategies and assessment activities for teaching. Blending content and pedagogy was also a matter of great concern.
The implication of this study was that science educators can enhance pre-service science teachers' PCK practice by fostering them with better understandings of the instructional strategies, assessment activities and blending between content and pedagogy in their classroom.

Acknowledgments

The researcher would like to express my deepest thanks to advisor Assistant Professor Dr.Paisan Suwannoi for his meaningful suggestions. I would also like to thanks National Research Council of Thailand (NRCT) for financial support. Finally, I am honestly grateful to Sakon Nakhon Rajabhat University that gave me the opportunity to study a doctoral degree.

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