Factors that Promote a Co-Teaching Model for a Successful Professional Development Strategy for Thai In-service Science Teachers.

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Abstract

What do teachers (pre-service teachers as well as in-service teachers) need to know in order to be able to implement processes proficiently in their classrooms? Pedagogical Content Knowledge [PCK] is referred to a specific category of knowledge for teaching science that is a conceptualized blend of content knowledge into pedagogical knowledge. Applying this knowledge context to enable science teachers to transform particular content knowledge into a form that is understandable for a diverse group of students. The study is a part of professional development [PD] using a Co-Teaching Model [CTM] as PD. The main research purpose is to enhance elementary science teachers' pedagogical content knowledge through CTM. In addition, the researcher aims to develop the effective characteristics of co-teaching model supporting science teachers' changes to their PCK. Three volunteer science teachers in Grades 4-6 at the same school participated in this study for 1 year. This research will present what factors that constrained or supported the development of Thai elementary science teachers' PCK. Data sources throughout the research project consisted of classroom observations, individual interviews, questionnaires

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and document analysis. Inductive analysis was used to analyze the data into more general outcomes which were presented in three case studies and a cross-case analysis. The results show that the three case study participants have developed their PCK. Their performances in developing PCK, as assessed by the design of their inquiry-based lesson plans and as observed in their classroom practices, shifted from teacher-centered to student-centered teaching and learning practices. Moreover, this research study also presents the successful CTM that has to be based on teachers' personal characteristics, interpersonal skills, sharing accountability for outcomes and resources. Additional, a school climate is also important to influence co-teachers spending time to work collaboratively. Further, this study did not focus on the role of administrator; therefore, further research is needed to understand how school and district administrators can promote effective PD program for elementary.

Keywords: Pedagogical Content Knowledge, Inquiry Approach, A Co-Teaching Model, Professional Development.

Introduction

Teachers' knowledge influences what they know, what they think, and how they act in the classroom. Planning and teaching any subject is a highly complex cognitive activity in which the teacher must apply knowledge from multiple domains. Development of PCK leads teachers to have conceptual change and use effective teaching strategies and representation for science concept. PCK is an important tool to identify what it means to be a good teacher and it represents teachers' understanding of difficult concept that students feel uncomfortable to learn, the selection of appropriate instructional materials, and pedagogy.

According to research by Pruet Siribanpitak (2004), many teachers do not have qualifications that match the subjects they teach, and out-of-field teaching adds to the difficulties in critical subjects. Teachers have difficulties in implementing constructivist-based teaching and learning approaches. These approaches are seen to be radically new for the majority of science teachers and they are suspicious of their effectiveness. Particularly, there are a number of studies documenting the problems of in-service elementary science teaching (ONEC, 2001; Yutakom and Chaiso, 1999). Thai elementary school teachers often do not have enough knowledge necessary to create a constructivist classroom. Moreover, most in-service science teachers did not graduate in science (Thongkrai, 2000; ONEC, 2001) and professional development programs cannot fill the teachers' needs. Science, mathematics, and technology teachers typically receive training conducted by the Institute for the Promotion of the Teaching of Science and Technology [IPST] which provides intensive in-service training for science, mathematics, and technology teachers. The type of professional development in science education in Thailand is mostly an authoritative top-down system of supervision regulated from outside the schools. Although IPST deals with conducting the teacher professional development to push the educational reform of a student-centered approach, the traditional forms of professional development persist. Teachers are usually subjected to the "one-shot workshop", that the IPST developed, or a university developed, using topics from disconnected classes (Lewis, 2002).Teachers learn from teaching-by-telling "experts" instead of constructing their own knowledge (Loucks-Horsley, 1995). This is not truly personal professional development. Teachers do not learn how to implement with their real classrooms. They just learn only theory and cannot bring the theory into their practises. Therefore, an improved strategy in PD is required and the

co-teaching model could be considered a means to correspond with the goals of professional development. The co-teaching model is one of the strategies for professionally developing teachers who engage in co-teaching activities with skilled colleagues who are more aware of their own practices and what their students are thinking, feeling, and learning (Loucks-Horsley, 1995)..

The study reported in this research is aimed at identifying how a PCK-based science co-teaching model impacts on the development of in-service elementary science teachers' PCK, and how they develop their PCK during a co-teaching model. The researcher views educational environments such as classrooms, CTM, and schools as a complex world. The elementary science teachers in these educational environments are persons who construct their own knowledge and interpret the meaning of the social world to develop their PCK. The researcher thus believes that an interpretive methodology can provide appropriate directions to conduct the research in order to reach the answers to the research questions. Interpretivism is therefore employed as a framework to find out the meaning of how elementary in-service teachers learn and construct their own PCK in specific contexts. This research framework can help the researcher to capture the complexities and contextual factors in natural settings that impact the development of elementary science teachers' PCK.

Research Methodology

Grounded Theory as the Research Methodology

This PCK Study is based on the interpretive research framework and conducted using grounded theory as its research methodology. The primary goal of grounded theory is to generate theory inductively from data. The data analysis focused on assessing how elementary science

teachers develop their pedagogical content knowledge through the co-teaching model. Case study research is focused to understand developing teachers' PCK. The researcher analyzed documents and underlying knowledge of participants in speaking and writing. Data from multiple sources such as teachers' journals and interviews; field notes and videotapes from observations and card sorting were analyzed by the process of open coding to get the transcripts from the first interview, observation, reflection and card sorting, developing initial categories of the participant's pedagogical content knowledge and their practice by inquiry. In developing categories, the researcher used a constant comparative method of analyzing multiple sources of data served to triangulate the data in order to increase trustworthiness of the research findings and assertions made. Data from teachers' journals and interviews, field notes and videotapes from classroom observations, videotaped transcriptions from group discussions, semi- structured interviews, and card sorting when using the CTM will be transcribed and developed to core categories of developing pedagogical content knowledge.

Research Question

1. What factors constrain or support the elementary science teachers' implementation of the Co-Teaching Model [CTM]?

Context of the Study

Since research in educational field gradually change to focus more on qualitative way, the purpose of the research also move to interest in how to understand small group of people or research sample in deeply explanation. When the researches focused on a small group, they can obtain greater information and develop an in–depth understanding to their situations. In addition, the generalization is not the major goal of educational research.

This study was conducted in a elementary school governed by the Office of the Basic Education Commission. The school is located in Nontaburi province in suburban area of Bangkok Metropolitan. The school has two semesters per year; the first semester ran from May to September and the second semester ran from November to March. The school breaks each academic year for the month of October. The three case studies were teachers at Wattanawan School. The school enrolls students from kindergarten to grade 6. However, the study focused only on science elementary teachers who taught at upper elementary level which involved students in the 4^{th} – 6^{th} grades. Therefore, the participants in this study were three elementary science teachers who were teaching at the upper elementary level (Level Standard 2, grades 4-6) in public schools under Office of the Basic Education Commission. They were purposive sampling selected from thirty-three teachers who completed questionnaires during the second semester of the 2009 academic year. The three science teachers also were interviewed voluntarily and in how they had worked their school situations. To protect their privacy they were given pseudonyms, Ms. Malai, Ms. Napaporn, and Mr. Sirod. In the first semester of the 2009 academic year, these elementary science teachers were provided with the co-teaching model, which was developed to become the PCK based co-teaching model of this research. In order to develop the teachers' understandings and practices of PCK through CTM, multiple data sources have been used during the research process.

School Background

Wattanawan School was a public elementary school located in Nontaburi province. This school is situated in the suburb with a lower and middle class of families. The school was established in 1950. To date, this school had 4 buildings, one outdoor sport field, a science laboratory, an ICT room, a language room, a botanical garden, a green house and a library.

The school also has received tremendous support from the Office of Basic Education Commission for scientific materials and equipments. In 2009, the number of students attending in this school was approximately 1,200. There were 430 students in the higher primary school level: 4 classes of each Grade 4, 5 and 6. The class sizes ranged between 35-40 students. In this year, Wattanawan hired 80 government teachers under the support of the office of basic education commission. According to the school record of students' achievement in Science, the average grade was 2.5-3 in the 2007 academic year. The vision of this school is community participation, emphasizing on self-discipline, environmental conservation, technology and English as a knowledge tool. The schools objectives are focusing on learning and morality, contributing to Thai community, understanding and applying advanced technology, and being good member of society.

In Wattanawan School, students came from lower or middle class families. Their parents were workers, merchants, or agriculturists. Most students did live in the vicinity of the school communities. They stay with their families who had old family in that area. With respect to teaching and learning science, the higher primary level students learned science 3 periods per a week (one hour/period). Therefore, they studied science 120 hours a year. In the 2009 academic year, science subject in the school was taught based on the National Science Curriculum Standards [NSCS] (DCID, 2002).

Research Participants

Purposeful sampling is brought to find the research sample as selection strategy. This sampling method is based on the criteria that the researcher would like to learn and find the answer for research questions. From the questionnaire, the last section of the questionnaire contained a brief description about this research and teachers were asked to participate

in this larger study of PCK based co-teaching model (Chatmaneerungcharoen, S. et, al., 2008). There were 33 questionnaires returned (73.33%) to the researcher. Once the teacher indicated yes, they were screened based upon their responses to what would be their motivation for being part of the large study group. Twenty teachers (60.61%) indicated their willingness to participate in the study. In the end three criteria were used for choosing the participants and they were as follows:

a) Teachers who were teaching Science subject in the upper elementary levels in the same school. They were science teachers in Grades 4, 5 and 6.

b) The teachers were teaching Science in both semesters and could participate in both phase of the study.

c) They showed a willingness to contribute to the profession by being open to classroom observations by the researcher, participate in follow-up interviews and be able to attend meeting of the PCK based co-teaching model.

Subsequently, the researcher visited teachers in school and had conversations with the school administrators regarding the study plan. The following section and Table 1 describes the teachers' education backgrounds and their situations.

Table 1 Teacher's Background

	Teacher's Background		
Name	Malai	Napaporn	Sirod
Gender/Age	Female/50	Female/53	Male/38
School of teaching		Wat-ta-na-wan school**	
Level of teaching	Grade 4th	Grade 5th	Grade 6th
Science Teaching Period (Week)	12 Hours (4 Classes per Semester)		
Teaching experience	28 years	32 years	15 years
Science teaching experience	3 years	11 years	1 years 11 months
Education background	Bachelor's degree in Education (Social Study) Master Degree in Educational Administration	Bachelor's degree in Education (Physical Education)	Bachelor's degree in Education (Agricultural Education)

* Pseudonym of the teachers

** The school was public school which was funded by the government. Students did not pay for any fees while they studied in the schools.

Teachers' Background

Case Study I: Ms. Malai

Ms. Malai, who was 50 years of age at the time of the study, had a Bachelor's degree of Social education. She had been teaching Social

subject for 24 years. Since 2006, she has been teaching in Science subject for 3 years. There were 35 students per classroom. She taught in Science subject for 12 hours to 15 hours a week. In addition to teaching in classroom, she had the reasonability to do school accounting and consulter for 4 th grade students. She had responsibility of teaching science in Grade 4 and she volunteered to do even though she did not have strong background in Science. It is for reason that she attended several workshops and took CTM related to the area of Science during school holidays.

The workshops and CTM covered theoretical knowledge related to Science for grade 4 as well as provided her with opportunities for practical field experiences. During 5 years, the following is a list of some of the Promotion of Teaching Science and Technology, IPST; the Department of Education, Faculty of Education, Kasetsart University; and Educational Districts. The many workshops she attended covered topics such as: making teaching and learning material, making teaching and learning assessment, designing lesson plan, using teaching strategies and knowledge directly related to the field of Science. Even though she attended many workshops, she still cannot be confident to teach science.

An example of this uncertainty appeared in a class presentation where students had categorized groups of nutrients in their favourite food. Students were randomly selected to present their task in front of class.

Students: My mom always cooks fried vegetables with tofu so I should get vitamins from vegetables.
Malai: Is it only vitamins in your food? How about tofu?
Students: Sorry, I do not know.
Malai: Tofu contains lots Carbohydrate that is used for body growth
Students: My dad tells me that if I eat tofu every meal, I might be tall
Students: In your reading sheet, tofu was high in protein?

Malai: OK, please wait let me check.
(Narration: The teacher walked to her deck and started to read her textbook.)

Malai: From reading sheets, OK, tofu has essential protein because it was made from soy.
(Malai's Classroom Observation 3#: August, 2009)

Case II: Ms. Napaporn

Ms. Napaporn was 53 years old; she graduated with a degree of physical education. She had 11 years teaching experience in science subject. In previous years she taught science in the lower primary levels. For the past ten year, she had been teaching in 5th grade in Science subjects. There were 40 students per classroom. She taught in science subject for 12 hours to 24 hours a week. She taught this subject area even though it is not her area of expertise. In addition to teaching in classroom, the teacher has many responsibilities to do such as student's consulter for 5th grade students, laboratory teacher, activity teacher, scout teacher and the head of the Science department. In 5 years, teacher A has been attended with many workshops provided by educational institutions and her school. These workshops focus on curriculum, lesson plan, instructional media, teaching method, and learning and teaching assessment. She also participated to create school curriculum including selecting manual books.

Case III: Mr. Sirod

Mr. Sirod was 38 years in-service elementary teacher. He graduated from Bachelor of Arts major in Agricultural education. In 10 years previous he taught Agricultural subject in the lower primary levels. For 1 year and 11 months, he has been teaching in grade 6 for Science subject. There were 40 students per classroom. He had to teach in science subject for 12 hours per week. He taught this subject area even though it is not his

area of expertise. More than teaching in classroom, the teacher had many responsibilities to do such as consulter section for 6th grade students, laboratory section, audiovisual section and students' activities section in this school. In 5 years, he has been attended with many workshops provided by educational institutions and his school. These workshops and CTM covered theoretical knowledge related to curriculum, lesson plan, instructional media, teaching method, science content, and learning and teaching assessment. For school curriculum, he only selected books that are taught following the school curriculum.

Professional Development Design

The professional development program employed in this study encompassed a period of time of 1 year. CTM team participated in one –to-one and central meeting and worked through CTM stages.

CTM I: Exploration

The first phase of the research design is aimed at investigating how elementary science teachers understand PCK and how to construct a co-teaching model. This phase involved with designing the CTM model took place during the 2009 academic years. The first research question is: what is the prior understanding of elementary science teachers' pedagogical content knowledge? And the second question is: what are the characteristics of a co-teaching model designed to facilitate Thai elementary science teachers' development of pedagogical content knowledge? To answer these questions, the researcher reviewed documents that described the expectations of teacher professional knowledge from standards in Thailand. The researcher analyzed the level of expectations of the Standards for teaching profession (4th) of teachers' council of Thailand (1999) and National plan for reforming in teacher education and development of educational personnel (ONEC, 1995). Moreover, the model was developed

by considering information from the preliminary data of a pilot study, a literature review of teaching and learning science based on constructivism and the inquiry approach, science education in Thailand, professional development strategies, and the co-teaching model. The process of developing co-teaching and the details of this model are described in chapter 4. Interpretive multiple cross case studies were used as the research design to study the impact of the co-teaching model on the development of teachers' PCK. The multiple case study design provided the opportunity to observe the growth of each science elementary teacher's PCK from the beginning to the end of research. Grounded theory was employed to generate theory from research data.

CTM II- CTM IV

The second phase of this study aimed to examine how the in-service teachers developed their PCK during the CTM. It is a follow-up phase to explore the effects of a CTM on the development of in-service teachers' PCK and to investigate the factors constraining or supporting PCK development. A multiple case study design was used to study the development of in-service teachers' PCK and constraints or supports of their PCK development while engaging with the CTM. To answer these research questions, the data collection methods used in phase II were classroom observation, semi-structured interview, and document review.

CTM I: Exploration (July-September 2009),
CTM II: Preparation (October-November 2009),
CTM III: Co-Planning (December 2009), and
CTM IV: Co-Teaching and –Evaluating (January-February 2010).
A diagram of the CTM is provided in Figure 1

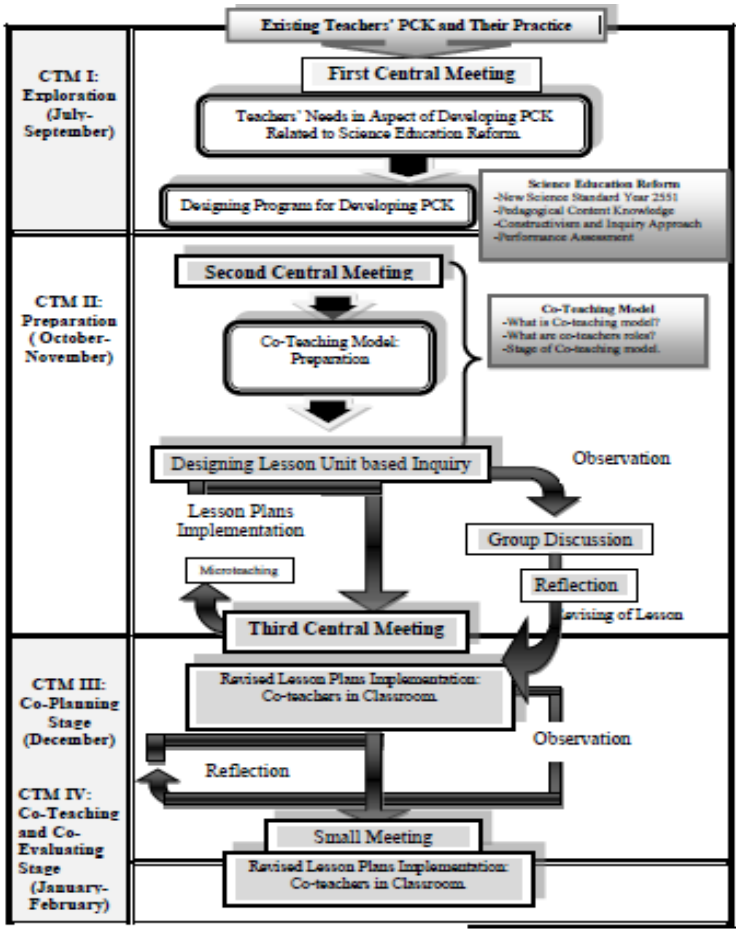

Figure 1 A Co-Teaching Model [CTM] Procedures

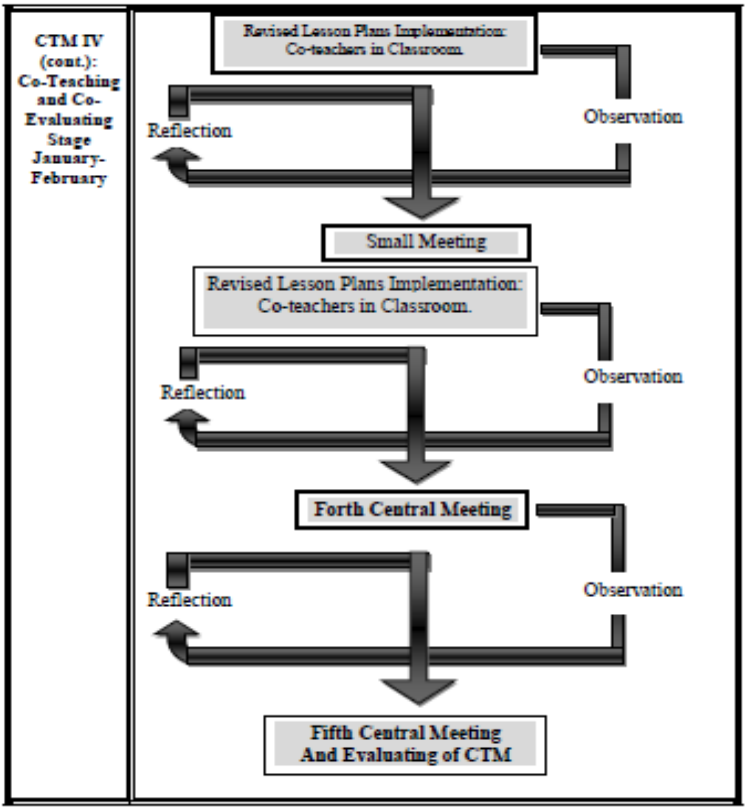

Figure 1 (Continued.)

Research Data Analysis

In the data analysis methods, the researcher attempted to find out patterns of growth or development by comparing the in-service teachers' understandings and practices of PCK through CTM, The approach to analysis involved an inductive process: categorical aggregation and a search for correspondence and patterns. Because 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 used to describe the idea that the researcher tried to construct an explanation by using more than one or multiple source of data.

In developing categories, the researcher used a constant comparative method of analyzing multiple sources of data served to triangulate the data in order to increase trustworthiness of the research findings and assertions made. Data from teachers' journals and interviews, field notes and videotapes from classroom observations, videotaped transcriptions from group discussions, semi- structured interviews, and card sorting when using the CTM will be transcribed and developed to core categories of developing pedagogical content knowledge.

Research Results and Conclusion

Elementary Science Teachers' PCK Development throughout the PCK-based CTM

Malai's initial PCK knowledge base was limited. She had not learned about the science curriculum, so her prior knowledge of curriculum was weak. Even though her understanding and practices about teaching and learning science were contemporary constructivist, her knowledge of student learning and teaching strategies was based on positivist understandings. As the CTM progressed, Malai's PCK knowledge base gradually broadened through learning activities in the CTM. Malai was provided with many opportunities to broaden her understanding and practices about the nature, teaching and learning science. Malai was provided interesting ideas from her CTM members through sharing, reflecting, and discussion during her co-planning, co-teaching, and co-evaluating. Through these activities, Malai's understanding and practice of PCK supporting teaching and learning science based on constructivism shifted to more constructivist

understandings specifically, in the nature of scientific knowledge. She provided an extensive reflection on her learning in her written reflective.

...I've learned what the National Education Act is, and the content in each chapter. I've learned that the development of the basic education curriculum is based on the Act. Participating in analysis of the national requirements revised my prior understanding about students' construction of knowledge. I have a better understanding of science curriculum; especially strand 1, 2, and 8. These strands relate to general science content. When I plan my lesson, I understand how to interpret curriculum and link to my lesson. Now, I use science curriculum not only for science content, I also realize about the goals for teaching and learning science described. So, I implement my understanding of the national framework to reflect on the classroom teaching. From CTM meeting, we discussed about how to bring the national requirement into classroom practice? I have learned many things from that sharing. I plan my lessons related to curriculum goals as well

(Malai's Reflective Journal # 11: December, 2009)

Additionally, making observations of the co-teacher's practice and discussing about students' prior knowledge and learner's learning enhanced Malai's awareness of the importance of students' prior knowledge and individual differences in learning. She learned that the students held different science conceptions. When she brought her PCK into teaching practice, Malai's microteaching with her co-teacher showed her development in understanding and practice of PCK for constructivist teaching and learning gradually. She had learned that science teaching should be flexible and meet student grade levels and their learning style. Specifically, Malai noted that;

...Communication between teacher and students are very important. If students can feel that teacher understand them, the students will be comfortable to express their thinking and actions. The students will tell teacher what concepts they understand or what concepts they still are confused and need more suggestions by the teacher.

(Malai's Reflective Journal#18: February, 2010)

Like Napaporn and Sirod, they had developed their PCK when the CTM progressed. After Napaporn attended the CTM, she began to conceptualize that in addition to helping students learn to justify and evaluate their data and conclusions, communication was the best way to train students to listen and respect alternative thoughts. With regard to Napaporn's instructional practice, the findings showed that in CTM I, Napaporn's practice partially agreed with her understanding of student's communication. In prior practice, students communicated only their data. They did not share their conclusions. However, after she was engaged in CTM II-IV, Napaporn's teaching practice was aligned with her understanding. In her instructional practice, students had chances to share both data and conclusions with others, as illustrated in an excerpt below.

Napaporn: Now I want you to select a representative of your group. Then the representative will write data from the experiment on the blackboard. Which group would like to be volunteered?

Students: My group would like to be the volunteer

Napaporn: O.K. So, group three will present their data as the first group. Every group please sends your member to write your own data and conclusion on blackboard.

Students: (Students fill up the blackboard with their data.)

Napaporn: (Napaporn writes five questions on another board.)

Napaporn: Students, look at the questions on the board. Students, work in groups to answer these questions. (Napaporn reads the questions out loud.) Students, consult with friends in the group. Talk with your friends and look at your data. Try to answer the questions. I'll ask each group to share the answers . . .

Napaporn: Ok, group three; please come to present your data and conclusion. In addition, please tell the answers for five questions.

(Napaporn's classroom observation #5: January, 2009)

Sirod's PCK knowledge base gradually broadened through learning activities in the CTM. Sirod's understanding of science curriculum was influenced by analyzing and discussing the science curriculum framework and from the reflection with the CTM team about school-based science curriculum. He learned that the students held different science conceptions. He provided an extensive reflection on his learning in his written reflective.

.... After I participated in the analysis of the national requirements I revised my prior understanding about students' construction of knowledge. I have a better understanding of science curriculum. When I plan my lesson, I understand how to interpret curriculum and link to my lesson. Now, I use science curriculum not only for science content, I also realize about the goals for teaching and learning science described. Consequently, I conduct my understanding of the national framework to reflect the classroom teaching.

(Sirod's Reflective Journal # 11: December, 2009)

As co-teaching is an increasingly popular teaching approach that provides support to students in diverse inclusive classroom, it is a new strategy in Thai educational context. Many teachers are taking the plunge

and entering this professional partnership by trial and error. The result from cross case analysis revealed that the success of co-teaching rested upon six supporting factors.

The Factors that Constrain or Support the Thai Elementary Science Teachers' Understandings and Practices of PCK through CTM.

The first factor was that both partners can blend their instructional expertise and interpersonal skills. These were the main factors that helped the co-teachers success with their co-teaching. As the characteristics of co-teaching that were mentioned in previous topics, if the co-teachers could display parity and mutual respect, agree on specific mutual goals, and share accountability for outcomes and resources, they would have successful teaching. Particularly, these components were more likely to occur within a school climate that emphasized collaborative relationships therefore the second factor was that the school principal should be one of the CTM team and understand the process of co-teaching very well. Furthermore, as in any relationship, co-teachers grew and became more comfortable with each other, the students, and their responsibilities over time. The relationship among Malai, Napaporn and Sirod was identified in three stages when they began to participate in CTM. The three teachers in the beginning stage were hesitant to make independent decisions due to their unfamiliarity with each other, and their interpersonal relationship appeared somewhat awkward. After they had worked together for three weeks, they changed their relationships to the compromising stage that was more comfortable with each other and their instructional responsibilities, and often they used the "my turn, your turn" approach. At the end, the teachers experienced a high level of comfort with each other and the curriculum, their instruction was blended and fluid as in the collaborative

stage. The third factor then is time for implementing CTM as a crucial factor to support co-teaching. The CTM teacher should have more time to participate and learn among members. Knowing and working time for CTM members was the supporting factor for co-teaching model. The fourth factor was related to the co-teaching stages (co-planning, co-teaching and co-evaluating), reflecting upon and evaluating the co-teaching experience were a significant process that was integrated into CTM. The fifth factor is that the co-teacher should have an opportunity to share his/her idea in CTM meetings. Moreover, the results from the three cases presented that a model for co-teaching reflected these critical components by including each teacher's interpersonal skills, content knowledge, philosophy of teaching, teaching behaviours, and stage in the co-teaching experience. Consequently, co-teachers could integrate these components so that they stay clearly centered on the learning achievement of each student, which was the barometer of success of the co-teaching endeavour. The sixth factor was about co-planning, co-teaching models, differentiation, universal design, and cooperative learning. Co-teachers should be offered the needed resources; and state department personnel, faculty of institutions of higher education, and personnel from school districts to form partnerships. Not only high level people should be involved in the co-teaching model, student perspective was also an important factor that affected the co-teaching classroom. For the six supporting factors that were discussed as above, they could become constraining factors if the professional development program using co-teaching failed to acknowledge or implement them.

In summary, after the CTM experience, the three teachers developed their knowledge of science, pedagogy, and context. There were many things that happened during the CTM. However, CTM experience

suggested that co-teachers should consider ways to share their instructional expertise; sharing their visions for the co-teaching experience; commit to focusing on students' needs; communicating ways in which they would emphasize personal integrity; and scheduling a regular time to reflect on their co-teaching practice.

Implications for Professional Development

The professional development program utilized in this study involved the use of basic elements of co-planning, co-teaching, and co-evaluating to promote the teachers' understandings and practices of PCK for a reformed science classroom. They can implement their knowledge as theory into their actual practice in real classrooms. According to the results of this study, the CTM is productive in affecting changes of the case study teachers' understandings and practice of PCK in the classroom. The crucial components underlining the CTM that are likely to have an impact on the development of the science teachers might be: establishing common goals among program members, empowering teachers' leadership of the professional development program, providing opportunities for teachers to learn in their actual classrooms, giving time and support for teachers to plan, implement, observe, and reflect on their lessons, providing chances for teachers to learn through other teachers who are colleagues, having long-term assistance for continuous learning and practical change, and most importantly building and sustaining a trusting and respectful atmosphere among the teachers and the researcher. In summary the results from this research has discovered an important way for the creation of professional teacher development in science. Professional development should be created by teachers' needs and their problems regarding teaching science in real situations. The professional development program should help elementary science teachers in integrating all elements of knowledge; how

to integrate content knowledge, teaching knowledge, including setting goals for teaching science, methods of teaching science, learners and learning, curriculum and assessment and evaluation. The development of targeted science teacher's knowledge should look to develop long-term collaborative working. The collaborative works in all three stages of the co-teaching model are effective opportunities for exchanging teachers' understanding of each aspect in PCK. The teachers can then apply their understanding into practices properly. Opinions and experiences of individual teachers must be relevant to the needs of the teacher professional development program. In the study, there are three stages of CTM: co-planning, co-teaching, and co-evaluating. The three teachers said the most effective stages that helped them change their understanding and practice of PCK were the co-planning and co-evaluating stages. Future professional development programs regarding the co-teaching model should consider integrating these two stages as major strategies for developing teacher knowledge and their practices. Particularly, in the context of time limit, the co-teaching model should focus on providing the opportunity for teachers to share, reflect, and discuss their understanding and practice of PCK.

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