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THESIS

USING LESSON STUDY TO UNDERSTAND HOW ELEMENTARY
SCIENCE TEACHERS TRANSLATE SOCIAL CONSTRUCTIVIST
LEARNING THEORY INTO PRACTICE

APISATA JUNTARAPRASERT

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This interpretive case study examines three elementary teachers' understandings and practices with respect to Social Constructivist Learning Theory. The study took place in the context of a Lesson Study professional development experience consisting of a two-day workshop, curriculum planning and practice in the classroom. Throughout the teacher professional development experience, written reactions to Social Constructivist Learning Theory vignettes, individual interviews, classroom observations, and teachers' lesson plans and focus group discussions provided the sources of data.

The analysis illustrates some of the dynamics and promise of teacher change spurred by the teacher professional development experience. Teachers' understanding and practice gradually changed from traditional teaching to practices more consistent with Social Constructivism, although there was not a complete shift. The three case teachers showed that their understandings of Social Constructivist Learning Theory influenced their translation into practice in terms of science lesson plans and pedagogical strategies. In terms of change and growth, opportunities for collaboration and reflection in the professional development experience supported teachers in constructing their own knowledge and translating their understandings of Social Constructivist Learning Theory into practice. All teachers not only perceived many advantages of teaching science in relation to Social Constructivist Learning Theory but also recognized many challenges of teaching science based on this epistemology.

The implications of this study suggest that the incorporation of reflection and collaboration in school-based professional development can encourage positive changes in knowledge, practice and attitude towards teaching science. Additionally, when provided the opportunity, teachers can become curriculum makers rather than technicians which has significant value in terms of making decisions concerning the design of classroom environments. Since teachers in this study did not fully develop their understandings of Social Constructivist Learning Theory, the relationship between teachers' epistemological beliefs and their practice should be considered for future research.

Student's signature

Thesis Advisor's signature

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CHAPTER I

INTRODUCTION

This chapter discusses key main topics including: background of the study, rationale of the study, purposes of the study, and research questions along with a brief overview of the theoretical framework and methodology. Next, the context of the study and brief description of procedures of the study are discussed. Finally, data analysis, salient literature, subjectivities/biases, and definition of salient terms are all discussed in this chapter.

Background of the Study

Everyone agrees that an important factor in educational success is the teacher. The quality of teachers is a key to effective educational reform (Jurawatanaton, 2003). His Majesty King Bhumibol Adulyadej of Thailand is one example of a great teacher educator. He recognizes the importance of high quality teachers and provides guidance through his speeches to individuals who assume the responsibility for preparing future educators. In an inspiring speech at Jitlada Palace on 24th July 1970, he emphasized:

...People should respect teachers. Although teachers were poor, they should teach and distribute knowledge. When teachers intended to teach, they would receive the respect from their students and teaching and learning process would also be easier. Teachers should behave themselves as real teachers. In teacher training, it needed to emphasize them to do their duty as teachers. Students would respect them. If teachers abandoned their duty because they disappointed in some event, students would not respect them and the teachers could not teach. Every teacher could maintain their holiness as a teacher and transfer these holy attributes to teacher trainees as much as possible in order to make this country as Thai country and help people to be complete humans.

That meant having knowledge and ethics in order to make Thai society stable... (Office of the National Education Commission [ONEC], 2003)

Every Thai government from past to present has also been concerned about the quality of teachers and teacher education as reflected in educational policies. Now The National Education B.E. 2542 (A.D.1999) and Amendments B.E. 2545 (A.D. 2002) provide principles and challenging guidelines for education reform and teacher professional development aimed at preparing all Thai people for a learning society (ONEC, 2002). The teaching-learning vision states in Chapter 4 (section 22-30) of the National Education Act that learners are capable of learning and self-development at their own pace to the best of their potential. Moreover, Chapter 7 (section 52-57) stresses the value of professional development as a key component of educational reform in Thailand. This National Education Act affects all teachers in every field, including science. According to the reforms reflected in the National Education Act (ONEC, 2002), science is considered by many to be a global culture for our knowledge-based societies; it is necessary for everyone to be equipped with sufficient knowledge of its everyday applications. The National Science Curriculum Standards (The Institute for Promotion of Teaching Science and Technology [IPST], 2001) is a current reform document aimed at improving scientific literacy for all. It emphasizes the importance of understanding nature and creative technological products and also describes the importance of using our scientific knowledge reasonably, creatively, responsibly and ethically. The National Science Curriculum Standards articulate a vision of science learning as follows:

...Learning of science should be a developmental process so that the learner acquires proper knowledge, process and attitude. Every learner should be stimulated and encouraged to be interested in and enthusiastic about learning science... (IPST, 2001: 3)

From the above, we can see that science learning and teaching are intricately connected and complex activities. There is little doubt that to teach in ways consistent with the National Science Curriculum Standards, teachers must have a solid mastery

of subject matter (Fennema and Franke, 1992). Science teaching involves complex endeavors of applying prior knowledge to the creation of new knowledge needed to solve educational problems within specific situations. The role of the teacher in our present world is one of the providing or creating learning environments that encourage positive social interaction, active engagement and self motivation. Teachers also need to understand how students learn and differ in their approaches to learning. This vision stands in stark contrast to traditional views of teaching as a static set of fixed techniques or strategies. To teach science as portrayed by the Thai standards, teachers should understand cognitive and developmental processes and use this knowledge to design meaningful classroom learning environments.

Teachers today are under growing pressure to perform, deepen their knowledge and improve skills over the course of their careers. Teacher education is an important vehicle for education reform. Historically, teacher professional development has been a part of Thai education for many years. More than twenty years ago, many organizations concerned with teacher professional development searched for ways to produce high quality teachers with skills appropriate for the Thai context (ONEC, 1999b). However, these organizations did not fully recognize this vision. Far too often ideas about effective professional development were imported from other countries and did not always fit well within the Thai educational system (Gray, 1999).

Today, teacher professional development in Thailand faces many challenges. Almost all teacher professional development experiences emphasize theory at the exclusion of practice (ONEC, 2000). Typically, teachers attend short workshops to learn content and pedagogical knowledge, and they are supposed to “magically” transfer their experiences into meaningful classroom practice. This professional development scenario is not unique to Thailand; the situation is similar in many places around the world (Korthagen and Kessels, 1999)

His Majesty King Bhumibol Adulyadej, recognized as a wise teacher, reflected on the relationship between theory and practice and offered the following educational advice:

...Theories were not enough to make a person work efficiently. The clever person who had only theories just ordered other people to work. He would not have the credit and other people would not believe in him because they would have a suspicion and were not sure that he/she could do it. All successes occurred from starting to do something... (ONEC, 2003)

This speech reflects the idea that theory is necessary because it is the framework for thinking and doing. However, knowledge from theories does not always translate directly into practice. Knowledge from theory and knowledge from practice are not the same, even though they have a close relationship. Therefore, the person who has theoretical knowledge should seek to apply it in practice. By translating theories into practice, a dialectical relationship is created which can support the development of theoretical knowledge more completely.

This study will examine how science teachers develop and use learning theory in their planning and instruction. The study will explore how teachers reconstruct their knowledge and practice of learning theory by using the Lesson Study model. For teachers, teacher educators, university researchers and educational administrators, this study may offer an alternative model of professional development for pre- and in-service teachers.

Rationale for the Study

The rationale for the study is drawn from research embedded in several related areas. Assumptions surrounding the ideas of professional development in science education will be discussed followed by an explanation of the role of Social Constructivist Learning Theory in science education. After that notions of translating theory into practice and ideas about bridging theory and practice through professional

development are articulated, as part of the rationale for this study. This section further delineates the significance of Lesson Study as a model for professional development, and an explanation for the focus on properties of matter through professional development.

Professional Development in Science Education

Science has a rapidly changing knowledge base and expanding relevance to societal issues. Effective science teachers will need ongoing opportunities to build their understandings and abilities. With respect to the National Science Education Standards (National Research Council, 1996), the continuous process of teacher professional development should stretch from pre-service experiences in undergraduate years to the end of a professional career. Moreover, science teachers must have opportunities to develop understandings of how students with diverse interests, abilities, and experiences make sense of scientific ideas.

At the elementary level, young children have a natural curiosity about their surroundings- a desire to explore and investigate, see inside things, find out how things work and find answers to their questions. Science in the elementary school should nurture and extend this curiosity, so that students continue to question, explore and investigate, with increasing levels of insight and skill. An elementary science program should engage students in a process of inquiry and problem solving in which students develop both knowledge and skills. Therefore, effective elementary science teachers should construct knowledge about the nature of elementary science learning in order to create effective science learning environments.

Learning Theory in Science Education

New research in science education raises important questions about the design of learning environments- questions that suggest the value of rethinking what is taught, how it is taught, and how it is assessed (Bransford, Brown, and Cocking 1999). To provide or create learning environments that encourage positive social

interaction and active engagement, effective science classrooms for the twenty-first century need to promote richer conceptions of learning. Learning theory provides no simple recipe for designing effective learning environments, but it constrains the design of ineffective ones. By understanding learning theories, teachers will learn how to support and guide all students towards success. One learning theory that is particularly relevant to professional development in science education is Social Constructivism.

Social Constructivist Learning Theory

At present, science learners are increasingly viewed as active participants in the learning process, who construct meaning through experience. According to Driver and Oldham (1986), learning science involves the active construction of meaning by the student and is not something that is imparted by the teacher. Learning science is also believed to involve more than the individual making sense of his/her personal experiences (Wilson, 2000). Though knowledge is personally constructed, the constructed knowledge is socially mediated as a result of experiences and interaction with others in that social context. These ideas are consistent with Social Constructivism, an epistemology and theory of learning which emphasizes the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding (McMahon, 1997; Derry, 1999).

Translating Theory into Practice

Thailand's Ministry of Education recognizes that teachers are a key factor in the nation's educational development. Professional development processes for in-service teachers in Thailand are usually organized by national and local organizations that act as central agencies. Teacher professional development programs involve high expenditure of money and usually require teachers to be absent from school. They take place in very short periods of time and therefore, lack continuity in terms of monitoring and evaluation. Most of the professional development programs also consist of a collection of separated courses in which theory is presented without many

connections to practice. When teachers return to their schools, they do not bring the knowledge which they learned to the classroom because they do not know how to use or apply it in their practical situations (ONEC, 2005). Teachers may learn a lot of methods and strategies for many types of situations from professional development experiences but typically do not know how to apply these to specific situations occurring in everyday teaching (Korthagen and Kessels, 1999). Basically, this form of professional development remains the status quo, even though many studies in the national context have shown its failure to strongly influence the practice of graduates of teacher education programs. Loughran, Berry, and Mulhall (2006) emphasize that the links between theory and practice, for many teachers, are often tacit, complex and interwoven calling for new ways of understanding teacher knowledge.

Bridging Theory and Practice through Professional Development

Many reports in both Thai and foreign contexts have pointed out that teachers are the most influential factor in educational reform (Duffee and Aikenhead, 1992; Manajuti, 1999; ONEC, 2001). Teachers have been placed at the center of current reform and are seen as key facilitators because they are responsible for the teaching-learning process (Prawat, 1992). According to Loucks-Horsley *et al.* (1998), students' competences will not improve unless teachers' performances improve. In order for this to occur, teachers should reflect the quality and standard of highly respected professionals. Teacher professional development is recognized as an important activity for improving the quality of teachers in ways which can ultimately improve science education for students. Many research studies support the value of collaboration (Lieberman, 1995; Loucks-Horsley *et al.*, 1998; Posnanski, 2002) and reflection (Stone, 1994; Posnanski, 2002) in teacher professional development. New developments in teacher education, such as the current emphasis on school based professional development programs, offer a new approach to the problem of bridging theory and practice. In this context, reflection and collaboration are central concepts in teacher education. Through reflection teachers can analyse and evaluate their own teaching.

Lesson Study as a Model for Professional Development

In the last decade, there has been increasing concern about teacher professional development as a vehicle for translating theory into practice. With respect to in-service teacher professional development, a number of new approaches have been proposed or are being implemented across our nation. One approach that has garnered interest is the Lesson Study Approach where teachers learn about teaching by jointly developing and examining actual classroom lessons (Lewis and Tsuchida, 1997; Yoshida, 1999; Fernandez, 2002; Fernandez *et al.*, 2003). In this approach, teachers' learning can be more directly connected and designed to address the challenges they will face in the classroom, in particular the need to possess a deep understanding of science (Ball, 2000; Putnam and Borko, 2000). Lessons are natural units of teaching that teachers think about on a daily basis. Thus, when teachers come together to work on lessons it is a task that they find natural and can easily sustain (Hiebert, Gallimore, and Stigler, 2002). Moreover, the Lesson Study process requires teachers to discuss their observations of lessons taught in real time, with actual students, and on the tail of extensive reflection. Thus Lesson Study is one model of professional development that has the potential to serve as a context for studying how teachers translate theories into practice.

Focusing on the Properties of Matter through Professional Development

Properties of matter is an important topic that appears in the Basic Education Curriculum in Thailand. It is present in strand 3 Properties of Matter (ONEC, 1999a). Many researchers claim that it is a foundational domain concept in science (Ryan and Charly, 1990), particularly in chemistry, in relation to the science of matter and its transformation (Martin, 2001). Moreover, in both Thai and foreign contexts research suggests that students and teachers do not have a sufficient understanding of matter (Ryan and Charly, 1990; Stavy, 1990; Kruger, Palacio, and Summers, 1992; Haidar, 1997; Nakhleh and Samarapungavan, 1999; Johnson, 2000; Valanides, 2000; Kikas and Eve, 2001; Martin, 2001; Krnel, Glazer, and Watson, 2003; Sanguansin, 2005). This is especially important with respect to teachers, as researchers have shown that

science teachers' knowledge of the subject matter either enhances or limits students' learning (Anderson and Mitchner, 1994; McDiarmind and Anderson, 1989 cited in Haidar, 1997).

Properties of matter is also a topic that relates to students' daily lives. During the early years, children's natural curiosity leads them to explore the world by observing and manipulating common objects. To facilitate effective science learning about properties of matter, teachers need to provide opportunities to continue children's explorations in focused settings with other students using simple tools, such as magnifying and measuring devices.

Teachers in Thailand are expected to undergo professional development experience based on the National Education Act of 1999 (ONEC, 2002) and the National Science Curriculum Standards (IPST, 2001). Research suggests that traditional professional development programs have not been effectively enhanced teacher learning (Korthagen and Kessels, 1999). Consequently, the Lesson Study model has gained in popularity as a vehicle for enabling teachers to collaborate and learn in real situations. Several studies suggest that it is an effective model to promote science teacher learning (Chokshi and Fernandez, 2005). Furthermore, Lesson study, is a new model of professional development in Thailand. Therefore, this study will be situated within the context of a professional development model premised on the belief that Lesson Study can enhance teachers' understanding and is appropriate for the Thai context.

This study is intended to fill the gap in literature regarding the theory/ practice relationship that is found in science education research on professional development. There exists little research that deeply investigates how in-service science teachers translate learning theories into practice at the elementary school level in Thailand.

Purpose of the Study

The purpose of this study is to explore how Thai elementary teachers translate understandings of Social Constructivist Learning Theory into practice using the Lesson Study Approach. This study aims to explore teachers' knowledge of Social Constructivist Learning Theory through a collaborative process of Lesson Study. In particular, it investigates how elementary teachers design their lesson plans in relation to a specific learning theory. This study focuses on collaboration of teachers in designing, teaching and revising science lesson plans. This study also examines how the Lesson Study Approach affects Thai elementary teachers' understanding of Social Constructivist Learning Theory.

Research Questions

This study examines the Lesson Study experience of elementary in-service teachers with respect to the theory/practice relationship in science teaching and learning. Specific research questions are posed in light of this purpose.

1. How do Thai elementary teachers' understandings of Social Constructivist Learning Theory compare and change at different points of the Lesson Study process?
2. How do Thai elementary teachers translate understandings of Social Constructivist Learning Theory into practice using the Lesson Study Approach?
 - 2.1 What relationships exist between the teachers' conceptions of Social Constructivist Learning Theory and their design of lesson plans?
 - 2.2 How do teachers teach their lessons plans based on Social Constructivist Learning Theory?
 - 2.3 What pedagogical strategies do teachers infer through their understanding of Social Constructivist Learning Theory?

3. How do Thai elementary teachers collaborate in the Lesson Study approach to understand Social Constructivist Learning Theory as it applies to their science instruction?

4. How do Thai elementary teachers perceive the benefits and challenges of applying Social Constructivist Learning Theory in their science instruction?

Theoretical Framework of the Study

The theoretical framework of this study draws on assumptions surrounding teacher knowledge and belief, curriculum development, learning theories, issues of theory into practice, and reflective practice. The theoretical framework will be discussed in depth in Chapter II. A brief overview of the components of this framework provides a perspective for this study below.

Teacher Knowledge and Belief

Research suggests that teachers' belief, knowledge, and past experiences significantly affect classroom practices (Borko and Putnam, 1995; Senk, Beckmann, and Thompson, 1997). Definitions of knowledge and belief and distinctions between these definitions have impacted what researchers have looked for and value in attempts to describe a knowledge base that influences teachers' teaching. Some researchers distinguish between teacher belief and knowledge, suggesting that beliefs are affective while knowledge is cognitive (Abelson, 1979; Nespor, 1987; Ernest, 1989). Other researchers suggest that it is impossible to distinguish between knowledge and belief. Kagan (1992) viewed teacher belief as a form of situated knowledge that is found in context, content and in person. The taxonomy of the knowledge base for teaching proposed by Shulman and his colleagues also does not distinguish between teacher belief and knowledge (Wilson, Shulman, and Richert, 1987). In this study, the researcher will define a belief as a form of knowledge called personal knowledge: a teacher's tacit, often unconsciously-held assumptions about students, classroom, learning, and the academic material to be taught.

Social Constructivist Learning Theory

The learning theory that is relevant to this study is Social Constructivism. Social Constructivist epistemology posits that knowledge is transferred, interpreted, and modified through social and cultural interactions (Vygotsky, 1986). Therefore, human cognition is considered to include not only individual but also social processes. In addition, it is believed that individual and social processes cannot be distinguished and separated. In this study, the researcher will investigate how teachers translate Social Constructivist Learning Theory into their science planning and classroom teaching.

Conceptions of Curriculum

Empowering teachers and professionalizing teaching are common themes in discussions of teacher involvement in curriculum development (Sizer, 1992; Paris, 1993; Giroux, 1994). Several theorists conclude that curriculum and teacher are one in the same. According to Van Manen (1977) and Nias (1987), curriculum is the way that teachers' beliefs transform academic objectives into actual classroom instruction. Johnston (1988) also supports the notion that curriculum change is the context for teachers' belief. According to Walker's model (1971), curriculum development includes three elements: a curriculum platform, its design, and the curriculum deliberation process associated with them. In this study, the researcher investigates the deliberation process as teachers' converse during Lesson Study.

The Link between Theory and Practice in Science Education

Many studies show that traditional paradigms for teacher education do not function well in terms of creating transfer from theory to practice (Korthagen *et al.*, 2001). Many notions and educational concepts developed during teacher education "wash out" during use in the classroom. It is argued that educational reform efforts in the past have often been unsuccessful because they failed to take teachers' existing knowledge, belief, and attitudes into account (Van Driel, Beijaard, and Verloop,

2001). Previous studies have found few teachers who exhibited evidence of intentional application of theory to the instructional planning process (Harste, 1985; Richardson and Hamilton, 1988); teachers appear to use learning theories in instructional planning only as an afterthought. This study tries to decrease the gap between theory and practice in professional development programs.

Reflection is an important part of cognitive development in adults. However, many in-service teachers do not have an occasion to reflect on the what, how, and why of teaching. Furthermore, many professional development programs do not encourage much reflection. Kruse (1997) suggests that reflection is simply a dialectic process of thought and action. Most definitions and conceptions of reflection stem from the concepts derived by Dewey (1933), Van Manen (1977), or Schon (1983, 1987). However, the majority of research about reflection involves studies in the realm of theory. Very little research on reflection has been examined in practice; such research is still in its infancy (Tsangaridou and Siedentop, 1995).

In this study, reflective practice is a process whereby professionals solve problems and construct professional knowledge using an underlying structure. Reflection involves a conversation with a unique and uncertain situation (Schon, 1983). Therefore, the process of collaboratively planning lessons and using them in the classroom not only includes the thought processes that teachers engage in prior to and during teaching, but also includes the thought processes or reflections that they engage in during and after planning interactions. In this study, reflection can also be conceptualized as a process leading to evaluation and eventual routines to guide teacher thinking. Reflection occurs both during and after teaching and feeds back into the planning of future lessons. The Lesson Study approach that will be used in this study parallels this reflective cycle, as it involves categories of planning, acting (teaching) and reflecting. According to many research studies, to know teaching means to know the teacher cognitively. However, studies on teacher cognition have sought to understand what teachers think, with little consideration given to how they were actually behaving (Beattie, 1995). The current study will be conducted in the authentic school setting in order to better understand teaching and teachers and how

their thoughts translate to their intent and actions. The purpose of this study is to examine science teachers' understanding of social constructivist learning theory. Specifically, the study focuses on three experienced elementary science teachers and investigates how they translate their understanding of learning theory into practice.

Methodological Framework of the Study

Methodology

The purpose of this section is to describe and justify the methodology and methods that will be used in the development and implementation of this study. In order to investigate the research questions of interest, interpretive research methodology will be used to understand teachers' thinking and actions as perceived by them. Interpretive methodology is directly aligned with the research questions in that the questions seek to understand the reality created by teachers at different points through the Lesson Study process. Interpretive research was chosen because it approaches inquiry with "the view that reality is constructed by individual teachers in interaction with their social world. It examines how people interpret their experiences, how they construct their worlds, [and] what meaning they attribute to their experiences." (Merriam and Simpson, 2000: 98)

Interpretive research methodology allows the researcher to understand the social ecology that occurs in the classroom and schools between teacher and students, or among teachers and other teachers in the educational milieu. Interpretive research tends to emphasize how the teachers being studied to see the world through their eyes. In this study, all research questions were aimed at developing greater understanding of how Thai elementary science teachers make sense of, and give meaning to Social Constructivist Learning Theory and translate it into practice.

This study enabled teachers to reflect on their own work by examining their understanding of learning theory and corresponding actions that occurred when they participated in a Lesson Study professional development experience. What was

learned from these questions will contribute to an interpretation of the phenomenon of teacher collaboration and teachers' classroom practice. It facilitated an interpretation of teachers' experiences through specific, detailed descriptions. The data which were collected from written reactions to vignettes, individual interviews, classroom observations, focus group discussions, and lesson plans were analyzed and interpreted in light of the theoretical framework of the study. Because the researcher was the instrument for both data collection and data analysis in interpretive research, the conclusions were verified with respondents for accuracy of interpretation to minimize researcher bias and subjectivity.

Methods/ Data Sources

In order to investigate the research questions, an interpretive methodology guided by case study methods was used. Primary data sources included: anecdotal notes of classroom observation, focus group discussions, individual interviews, lesson plans, and written reactions to learning theory vignettes. The data collected in relation to each research question was illustrated in the following matrix and is discussed in depth in Chapter III of this study.

Table 1.1 The matrix for research questions and data collection

Research Questions	Data Source				
	Anecdotal Notes of Classroom Observation	Focus Group Discussions	Individual Interviews	Lesson Plans	Written Reactions to Learning Theory Vignettes
1. How do Thai elementary teachers' understandings of Social Constructivist Learning Theory compare and change at different points of the Lesson Study process?		√	√	√	√
2. How do Thai elementary teachers translate understandings of Social Constructivist Learning Theory into practice using the Lesson Study Approach?					
2.1 What relationships exist between the teachers' conceptions of Social Constructivist Learning Theory and their design of lesson plans?		√	√	√	√
2.2 How do teachers teach their lessons plans based on Social Constructivist Learning Theory?	√		√		
2.3 What pedagogical strategies do teachers infer through their understanding of Social Constructivist Learning Theory?			√	√	
3. How do Thai elementary teachers collaborate in the Lesson Study approach to understand Social Constructivist Learning Theory as it applies to their science instruction?		√			
4. How do Thai elementary teachers perceive the benefits and challenges of applying Social Constructivist Learning Theory in their science instruction?			√		

Context of the Study

This study was conducted during second semester of 2007. In the second educational area in Nonthaburi province, there are ten large elementary schools in the same local government. All of these schools have a student population of more than four hundred and more than 30 teachers. Students and teachers live in the community where schools were located, with the school generally the center of the community. Every elementary school in this province had a library and laboratory room. However, some schools lacked up to date scientific equipment and instruments. There were 102,545 elementary students currently enrolled in schools in the second educational area of Nonthaburi province. Most of the students and teachers attending these schools practiced the Buddhist religion. In the academic year 2006 (basic education curriculum), the average science score of grade 6 students in this educational area was 2.89 out of a total possible score of 4.00. Science, along with mathematics and foreign language, were subjects that students in this educational district found difficult.

The school in this study was a large suburban elementary school in Pakkret district. Students who attended this school mostly came from low socioeconomic families whose parents were migratory workers moving from rural provinces. The majority of students were Buddhist. The rest of the student population was comprised of Christian and Muslim. The teaching period started at 8.30 a.m. and finished at 3.30 p.m. This school was elementary and middle school, providing education for K-9 students with 570 students and 32 teachers.

Teachers in the large schools of Nonthaburi Province are very diverse. The teachers range in age from 25-55 years old. Their teaching experiences vary from 5-30 years. At most schools, there are 3-6 teachers who teach science in the elementary level. Almost all teachers not only teach science but also other subjects such as mathematics and Thai language. Most of them do not hold a degree in science.

In both site and participant selection, purposeful sampling was used. Purposeful sampling leads to “selecting information-rich cases for study in-depth (Patton, 2002). Of the full time science teachers from the ten large schools in the second educational area of Nonthaburi province, three teachers were selected for in-depth participation in this study. One teacher at each grade level (one, five and six) was selected for participation in the research process. The first selection criterion was that participants should have experience teaching the topic of properties of matter. A second criterion was that participants should voluntarily agree to invest their time as a participant in this study. The third criterion was that the three participants must teach in the same school in order to collaborate in the Lesson Study group. In addition to the above criteria, the researcher was cognizant of the diversity of participants, taking into account age, education and teaching experience. The three teacher participants, together with the researcher constituted the Lesson Study group.

The participants in this study consisted of three elementary science teachers; Duangjai, Somsri and Palita (pseudonym). Teachers in this group had never participated in the Lesson Study process before. Most of them did not have prior experience with research and had not previously participate in research. Each teacher received a small stipend, and funds for instructional materials. The three teachers’ background and instructional experience is described in detail in the following sections.

Duangjai

At the time of the study, Duangjai, was an elementary teacher with 16 years of teaching experience; she had taught at three different schools. Duangjai held a bachelor’s degree in Thai Language Teaching. Duangjai’s class met for 60 minutes on an alternating block schedule. Sixty students in grade 1 were enrolled in Duangjai’s science classes. She was also working on Master’s in Curriculum and instruction during the year of this study.

Somsri

Somsri, who had 27 years of teaching experience, taught science and social science at the elementary level. Somsri obtained a bachelor's degree in home economic teaching. She had attended many in-service teacher professional development programs throughout her teaching career, but none had a focus on science teaching and learning.

Palita

Palita was an experienced teacher with 32 years of experience and certification of specially skillful position in the education system. Palita held a bachelor's degree in social science teaching. Her class met 60 minutes on an alternating block schedule. She was responsible for teaching science in grades 6-9.

The school in this study follows the scope and sequence of science based on the National Science Curriculum Standards of the elementary level education (IPST, 2001). In this study, properties of matter were found in strand 3, which were composed of two standards; standard Sc 3.1 and standard Sc 3.2 of the National Science Curriculum Standards. The content includes five topics:

1. Properties of matter & materials
2. Classification of matter & materials
3. The change of matter
4. Separation of matter
5. Utilization of matter & materials

Procedures of the Study

This study used case study method with a goal of collecting enough data to understand how the group functions and to investigate how teachers participate in a unique method of teacher learning and curriculum development. Specially, the

researcher was interested in how the teachers used Social Constructivist Learning Theory in their lesson plans and applied it to teaching about the properties of matter. This study centered around the Lesson Study Model, wherein a collaborative group of teachers followed a recursive cycle of articulating a clear lesson plan, observing the teaching of this lesson, and discussing and revising the plan.

The study was divided into three phases: Phase I: Workshop; Phase II: Teacher collaborative lesson planning and Phase III: Teacher practice in the classroom. Phase I and Phase II occurred in October, 2007 during four days of the school break. Phase III occurred in second semester academic year between November, 2007 and February, 2008.

Phase I

This phase involved two days of activities designed to facilitate teacher learning about Social Constructivist Learning Theory and its application to practice. Initial meetings and activities focused on developing an understanding of Social Constructivist Learning Theory. During this phase, the researcher provided an introduction about the objectives and modeled activities that reflected the application of Social Constructivist Learning Theory to science instruction. These activities used concrete examples that reflected different tenants of Social Constructivist Learning Theory. The essence of phase I was allowing teachers to experience and learn as students while developing understandings of Social Constructivist Learning Theory. Throughout this phase, teachers discussed and reflected on what they were experiencing and considered how they might develop pedagogical techniques and hands-on and minds-on activities that were consistent with Social Constructivist Learning Theory.

Phase II

Teachers met for collaborate planning during Lesson Study. Accordingly, their works started with coming together to plan lessons for a total of two lessons for each

teacher over a period of two days. Because all of the teachers were new to Lesson Study, this phase also briefly introduced the Lesson Study approach and how it could be used to examine and improve practice.

Phase III

Phase III continued the Lesson Study process with an emphasis on teaching, observing and discussing lesson plans. Each teacher implemented two lessons (running from November, 2007 to February, 2008). In the Lesson Study cycle, one of the group members would teach a lesson that was collaboratively planned in phase II and the others would observe and provide feedback during a follow-up debriefing meeting. During the follow-up meeting, the teacher would revise the plan for the lesson. Shortly after this, the teacher would teach a new version of the lesson to another class. Finally, the teachers would meet again to discuss the entire process of working on this lesson. During the Lesson Study process, teachers would brainstorm creative solutions for improving their practice by discussing and revising the lesson plan together. This Lesson Study cycle was repeated two times. A total of six lessons (two for each teacher) was collaboratively planned, implemented, revised and taught a second time.

Data Analysis

Data analysis enabled the research to establish how teachers make sense of Social Constructivist Learning Theory, plan and implement lessons based on it in their classrooms. It was designed to help the researcher constantly reduce the data to manageable proportion without losing its essence (Coffey and Atkinson, 1996). All data analysis sought to better understand and verify inconsistencies between what participants said and what they did. Data analysis was conducted throughout the study rather than being relegated to a later period after data collection had been completed (Guba and Lincoln, 1994). The researcher analyzed the data by using an iterative process of reading the transcripts of classroom observations, focus group discussions, individual interviews, lesson plans, and written reactions to vignettes.

Data analysis focused on describing what goes on during the Lesson Study process and coding, categorizing, interpreting, and then checking categories and interpretations by rereading and by collecting more data. The specific details of the data analysis are described in Chapter III.

Review of Literature

Literature that is salient to this study is reviewed in depth in Chapter II. This review of literature started with a critique of what research says about students and pre- and in-service teachers' alternative conceptions regarding properties of matters. Research was discussed in relation to the four alternative major concepts of matter: conservation of matter, composition and structure of matter, physical properties and change and chemical properties and change. Following that, the review of literature synthesized what is known from studies of professional development of science teachers. A number of studies that shed light on the influence of pre-service and in-service professional development programs on teachers' construction of knowledge were examined. In addition, the literature review also examined and synthesized studies of reflection and the critical role it plays in developing professional knowledge. This section concludes with a discussion of Lesson Study as an approach to professional development. In this method, teachers work collaboratively in planning and revising lessons based on their reflection.

Definition of Salient Terms

This study uses several terms which may have multiple definitions and meanings to the reader. The terms are defined to facilitate understanding and interpretation of the results of this study. The following terms are used within the context of this study:

Professional development program means the variety of experiences which are systematically conducted as an ongoing process over a sustained period of time to

enable teachers to construct and apply knowledge, understanding, and skills to meet the changing needs and strengths of students.

Lesson Study means an instructional improvement experience involving a cycle in which teachers work together in learning, planning, teaching, observing, reflecting and revising lessons that are designed to enhance student learning of specific science concepts and content.

Reflection means deliberate, thinking about or contemplation to analyze any act from a past experience or event and the impact it has had through interactions with others in order to better understand and improve an aspect of practice.

Pre-service teacher means an undergraduate student whose academic program requires four years or more of education to gain basic knowledge for entry into a teacher career.

In-service teacher means a teacher who teaches science at the elementary level in a public school. He/she receives a salary from the national budget.

Elementary school means a public school for the first seven to twelve years of a child's formal education. This school has a 1-6 grade configuration.

Research Bias/ Subjectivities

It is important to clarify the researcher's subjective beliefs with respect to the current study. In order for the reader to better understand the study, this section clarifies the researcher bias and describes how the researcher came to be interested in the subject of Social Constructivism and the Lesson Study approach.

The researcher received a scholarship from the Thai government to study at Kasetsart University which focused on the development of effective science teachers. After graduating with a bachelor's degree in chemistry, she studied for an additional

year to learn about science teaching and learning. In the process, she observed that the teaching styles of faculty of science and faculty of education were quite different. For the most part, the science faculty taught using a lecture style and had students do experiments that followed a prescribed set of directions in order to get one correct, verifiable result. While taking science courses, the researcher learned it to be a good listener, take notes and remember as much as possible. Yet, after passing a test, the researcher frequently felt that she did not really understand the material in meaningful ways.

By contrast, the faculty of education focused on student learning and provided the researcher with experiences designed to understand how students learn. The researcher had a chance to study constructivist philosophy and compare it with the way that she had learned science. She discovered that through learning by doing and interacting with other people to exchange ideas and construct knowledge, she was better able to learn and understand. After taking a test, the researcher felt she was better able to retain a conceptual understanding of material.

However, in the science teacher education program, when the researcher had a teaching experience for one semester (four months), she faced many problems trying to translate the theories learned in school into actual classroom practice. Some theories seemed to be too abstract to make sense of and apply in practice. Therefore, the researcher came to believe that a study was needed to better understand how teachers make sense of constructivist philosophy and apply it in authentic classroom situations.

Overview of the Remainder of the Dissertation

This study will be comprised of six chapters. Chapter I delineates the purpose and rationale of the study along with a brief overview of the theoretical framework and methodology. In addition, this chapter includes a definition of salient terms and explanation of researcher bias. The Theoretical Framework in Chapter II explains the conceptual understandings of (1) teacher knowledge and belief (2) Social

Constructivist Learning Theory (3) conceptions of curriculum (4) the link between theory and practice in science education and (5) a summary illustrating the connections between these four main areas. This chapter also includes an in-depth discussion of relevant literature, including a review of studies concerning alternative conceptions of properties of matter, professional development of science teachers, the role of reflection in professional learning of teachers and Lesson Study as a tool for studying teacher knowledge. Chapter III discusses the overall research methodology and methods that were used to explore the study questions. This chapter included a description of the study, participants, procedures of the study, data sources, data analysis and criteria for ensuring the quality of the research. Chapter IV illustrates the results of the study in relation to the initial four main research questions. Chapter V is discussions and analysis of this research study. The researcher also discusses the conclusions and implications of the finding for teacher professional development, methodology and science teaching in chapter VI.

CHAPTER II

THEORETICAL FRAMEWORK AND REVIEW OF LITERATURE

Introduction

The focus of this chapter is on the specialized knowledge of the theoretical framework and review of the literature for this study. The first part of this chapter highlights research that informs the theoretical framework. This part has been organized into five major areas: (1) Teacher Knowledge and Belief (2) Social Constructivist Learning Theory (3) Curriculum Development (4) the Link between Theory and Practice in Science Education and (5) a Summary illustrating how these four main areas of the theoretical framework are related. The second part of the chapter discusses relevant literature, including a review of studies concerning Students' and Teachers' Alternative Conceptions related to Properties of Matter, Science Teacher Professional Development, the Role of Reflection in Professional Learning of Teachers, and Lesson Study as a Tool for Studying Teacher Knowledge.

Theoretical Framework

In this section, the theoretical framework is described and explained. Initially, conceptions of teacher knowledge and belief are described followed by a discussion of Social Constructivist Learning Theory. After that, conceptions of curriculum are articulated, as used in this study. Finally, theoretical perspectives concerning the link between theory and practice are discussed. This section further delineates the significance of the theoretical framework for understanding teachers' conceptions of Social Constructivist Learning Theory and explores how the knowledge that is constructed is related to the study of learning to teach.

Teacher Knowledge and Belief

Teacher knowledge/belief plays an important role in science teaching and learning process. Effective learning depends upon effective teaching. Effective teaching depends upon teachers who have appropriate and useful knowledge. According to Dill (1990), effective teaching is a product of a complex multivariate equation including knowledge about pedagogy, knowledge about subject matter, and knowledge about the student. Under any circumstances, teachers' knowledge helps learning to occur. To teach all students according to national standards, teachers need to be flexible and understand the subject matter deeply, so they can help students create useful cognitive maps, relate one idea to another, and address alternative conceptions (Darling-Hammond, 1998).

Teaching also involves making an immense number of decisions which depend on teachers' knowledge and belief. Research suggests that teachers' knowledge/belief, and past experiences significantly affect classroom practices (Borko and Putnam, 1995; Senk *et al.*, 1997). Research in education further suggests that what teachers think about and believe prior to teaching shapes what they do in the classroom (Carnahan, 1980; Clark and Peterson, 1986; Clark and Yinger, 1987). Based on a thorough review of the research literature, it appears that teacher behavior is substantially influenced and possibly determined by teachers' thought processes which are a reflection of their knowledge and belief (Stevens and Wenner, 1996).

To understand the complex process of teaching, it is necessary to understand the knowledge teachers build and use "in action" (Schon, 1983). The focus in research in the late 1980's emphasized cognitions or thoughts that underlie a teacher's actions. The research on teacher cognition examined teacher thought processes before, during, and after teaching in an effort to understand the decisions they made, why they made them, what they actually did, and the cognitive processes they employed (Clark and Yinger, 1979, 1987; Twardy and Yerg, 1987; Borko and Livingston, 1989; Griffey and Housner, 1991). Significant research about teacher learning in recent years has shifted from what teachers do to what they know and what informs this knowing

(Cochran-smith and Lytle, 2001). Recent research emphasizes the importance of recognizing and examining the beliefs, values, and images based in an individual's personal history as the starting point of forming a teacher professional identity (Hawkey, 1997). Examination of research dealing with teacher's professional identity shows intersections and collisions occurring within the multiple contexts of the larger social/political culture, within personal biography, within the culture of schools, and within realms of experience with teaching (Sfard and Prusak, 2005).

Teaching is a very complex process that is influenced by many kinds of teacher knowledge (Leinhardt, 1986; Leinhardt and Greeno, 1986; Wilson *et al.*, 1987; Carpenter *et al.*, 1989; Ball, 1991; Leinhardt *et al.*, 1991; Even, 1993; Even and Tirosh, 1995; Carpenter and Franke, 1996; Fernandez, 1997; Geddis and Wood, 1997; Ma, 1999). For over two decades, research studies in education have focused on teachers' knowledge. Many researchers have studied what teachers should know and have tried to characterize teacher knowledge to ascertain what is needed to teach effectively (Elbaz, 1983; Shulman, 1987; Yeany, 1991). From the perspective of teacher knowledge, the effective teaching of elementary science depends on the adequacy of teachers' understanding both of scientific knowledge and of the ways in which this knowledge can be taught successfully to student. It is argued that, in order to do this, teachers must have sound science subject knowledge and an appropriate understanding of theories of learning (Traianou, 2006)

Definitions of knowledge and belief and distinctions between these definitions have impacted what researchers, in recent years, have looked for and value in attempts to describe a knowledge base that influences teachers' teaching. Some researchers distinguish teachers' belief from teacher knowledge stating that beliefs are affective rather than cognitive as is the case with knowledge (Abelson, 1979; Nespor, 1987; Ernest, 1989). Other researchers suggest that it is impossible to distinguish between knowledge and belief. Kagan (1992) viewed teachers' belief as a form of situated knowledge that is found in context, content and in person. Within this perspective, the concept of practical knowledge refers to an integrated set of

knowledge, conceptions, beliefs, and values teachers develop in the context of the teaching situation.

In this study, the researcher will define a belief as a form of knowledge called practical knowledge: teacher's tacit, often unconsciously-held assumptions about students, classroom, learning, and the academic material to be taught. In the past decade, interest in teachers' practical knowledge (Carter, 1990) or craft knowledge (Grimmett and MacKinnon, 1992) has increased. Practical knowledge consists of teachers' knowledge and beliefs about their own teaching practice, and is mainly the result of their teaching experience. Teachers' practical knowledge is conceptualized as action oriented and person-bound. As it is constructed by teachers in the context of their work, practical knowledge integrates experiential knowledge, formal knowledge, and personal beliefs.

Many studies on specific aspects of science teachers' practical knowledge have focused on views about teacher development. Some of these studies have focused on the effects of in-service or pre-service programs on teachers' views of teaching and learning science (Constable and Long, 1991; Porla-An Ariza and Garcõa GoÃmez, 1992; Hand and Treagust, 1994). From the perspective of practical knowledge, studies focusing on the actual implementation of constructivist approaches in classroom practice are particularly interesting. These studies have revealed that although teachers may express beliefs about the teaching and learning of science consistent with constructivist ideas, their actual classroom behavior may be more or less "traditional" (Briscoe, 1991; Johnston, 1991; Mellado, 1998). However, some studies reported changes in both teachers' beliefs and their classroom practice in the direction of constructivist ideas. These changes seemed to take place under conditions of sufficient time, resources, and on-going professional support (Glasson and Lalik, 1993; Tobin, 1993; Appleton and Asoko, 1996; Radford, 1998). For example, Adams and Krockover (1999) reported positive outcomes in a 3-year case study of a beginning secondary biology teacher, in which a specific observation rubric was used to stimulate a constructivist teaching style.

Teachers fulfill many roles. In order to carry out their roles, teachers draw on their own conceptions, or personal theories about how learning is fostered in a classroom. Calderhead (1996) asserted that the assumptions teachers have about their students and how their students learn is likely to direct how they approach teaching tasks and how they interact with their students. Therefore, as Schunk (2000) asserts, how teachers understand and interpret learning theories can have a direct impact on instructional practices and students' learning. The next section highlights Social Constructivism; a learning theory that rose to prominence in the 1990's and continues to impact research and practice in science education in the current decade.

Social Constructivist Learning Theory

According to Schunk (2000), effective teaching requires teachers to develop theoretical perspectives in order to determine implications for instructional approaches in the classroom. Theories provide a framework that can be used in making educational decisions. In order to help teachers construct such theories, opportunities need to be created to enable them to become familiar with emerging knowledge bases of particular theories. Abell (2000) emphasizes that teachers must understand science concepts, principles and the nature of science; how students learn, and science curriculum, instruction and assessment. Learning theory is an important aspect of the knowledge that teachers should develop to understand how students learn. Many researchers attempt to explain learning by creating theories such as behavioral or cognitive theories. This study is aligned with Social Constructivism, a theory that falls under the umbrella term of sociocultural theories of education that assume that human cognition is formed by social and cultural contexts as well as by individual characteristics.

Understanding how learners construct knowledge is always an important issue in science education. Many so-called fads in education turn out to have a firm, research supported foundation in constructivist learning theory (Colburn, 2000). Constructivism is a theory about "knowing" and "learning" (Bettencourt, 1993; Bodner, 1996; Fosnot, 1996) which asserts that knowledge cannot be directly

transmitted but must be actively constructed by learners. Colburn (2000) discussed constructivism as both a philosophy and a learning theory and recommended a series of specific activities that promote constructivist teaching in the classroom. Although there are still many criticisms about constructivism (Phillips, 1995; Gil-P´erez *et al.*, 2002; Matthews, 2002), its perspectives on learning have undoubtedly profound influences in contemporary science education (Staver, 1998; Niaz *et al.*, 2003). Consequently, researchers have recommended many teaching strategies or models which are based upon the assertions of constructivism to promote students' science learning. Both sociology and psychology have undergone a transformation from views of constructivism centered on the personal, subjective nature of knowledge construction to views centered on its social, intersubjective nature (Mehan, 1981). These newer views are generally called "Social Constructivism". The emphasis is on the process of knowledge construction by the social group and the intersubjectivity established through the interactions of the group. According to Shepardson (1999), learning science requires, in part, that children participate in a speech community or engage in social interactions with a more knowledgeable individual (teacher or peer) or more knowledgeable resource (such as a science textbook, magazine, or CD-ROM).

The perspective of Social Constructivism is that individuals construct what they learn and understand through interactions with teachers, peers, parents and situations in the development and refinement of skills and knowledge. Cobb and Bauersfeld (1995) in their research found that the strategies of interaction that the children and the teacher developed influenced students' learning significantly. In essence, Social Constructivism is actually a variety of cognitive constructivism that emphasizes the collaborative nature of many learning.

Several studies have been conducted which claim to show purported benefits of the use of techniques compatible with Social Constructivist theory in science classroom teaching. For example, Lumpe and Staver (1995) used the Social Constructivist perspective to develop students' conceptual understanding about photosynthesis in a biology classroom. The results of their study indicated that

students felt comfortable in working with their peers and gained a better understanding of the concepts. Lidar, Lundqvist, and Ostman (2006) studied how teaching activities interplayed with the “how” and the “what” of students’ learning. The results of their study revealed that the interaction between grade 7 students and the teacher is of central importance for what students learn. Venville (2004) investigated the process of conceptual change from both ontological and social perspectives when Year 1 (5- and 6-year-old) students who were learning about living things. He found that children with nonscientific theories of living things were able to benefit from instruction based on tenets of Social Constructivism. Roth *et al.* (1999) observed 24 students and their experienced teacher in an Australian suburban high school and found that participants interacted little, which prevented them from recognizing that they experienced different life worlds. He and his colleagues suggest that when socio-linguistic interactions do not occur, learning is inhibited. These studies suggest that teaching strategies based on Social Constructivist perspectives can provide support for student learning about science and an avenue for addressing their alternative conceptions.

Social Constructivist Theory was initially posited by post-revolutionary Soviet psychologist, Lev Vygotsky (1896-1934). Although a cognitivist, Vygotsky rejected the assumption made by cognitivists such as Piaget that it is possible to separate learning from its social context. Vygotsky’s work focuses on the important role culture and context play in the development of an individual. According to Vygotsky (1978), learning is not simply the assimilation and accommodation of new knowledge by learners; rather it is a process by which learners are integrated into a knowledge community. Vygotsky (1978) noted that every function in the child’s cultural development appears twice: first, on the social level and, later on, on the individual level; first between people (interpsychological) and then inside the child (intrapyschological). Vygotsky emphasizes the importance of culture and social context in learning. His theory is composed of three central tenants: internalization, semiotic mediation and the zone of proximal development (1978, 1981).

Internalization. Internalization is the process which through social activities evolves into internal mental activity. Vygotsky (1981) pointed out that individuals are guided by their own mental processes as they participate in social activities. However, these processes are influenced by social experiences. Mental functions first begin on a social or interpsychological plane and then move to an inner or intrapsychological plane. The transformation of natural forms into higher cultural forms is one from external to the internal. Kim's (2001) example of internalization is described below: Two people, interacting through communication, help to extend each other's understanding of what makes a rainbow.

A: Why is there a rainbow?

B: Because it just rained.

A: But I only see a rainbow when it's sunny.

B: You're right, there must be sun.

A: But you're right too. There must be rain as well.

A and B: So we need sun and rain for a rainbow.

Semiotic Mediation. Vygotsky (1981) makes a distinction between what he terms "lower, natural behavior" and "higher, cultural behavior". Human beings share lower biological forms of mental behavior, such as elementary perception, memory, and attention with animals. The higher forms of human mental functions like logical memory, selective attention, decision-making and comprehension of language are products of mediated activity. Vygotsky labels the mediators of human activities as "psychological tools" or "signs." These tools such as culture, language, and social context are important to human's cognitive development. Through the mediating actions of these tools, natural forms of behavior are transformed into higher, cultural forms, unique to humans. Vygotsky calls this process semiotic mediation.

The Zone of Proximal Development. Vygotsky (1978) distinguishes between three levels of development. The first level of actual development refers to all the functions and activities an individual can perform on his or her own without help from somebody such as a teacher, adult or peer. The second level of potential

development refers to all functions and activities an individual can perform with guidance and assistance of someone else. The final level is described as the Zone of Proximal Development (ZPD), which refers to all functions and activities an individual can perform by independent problem solving through guidance and assistance of someone else. (Figure 2.1)

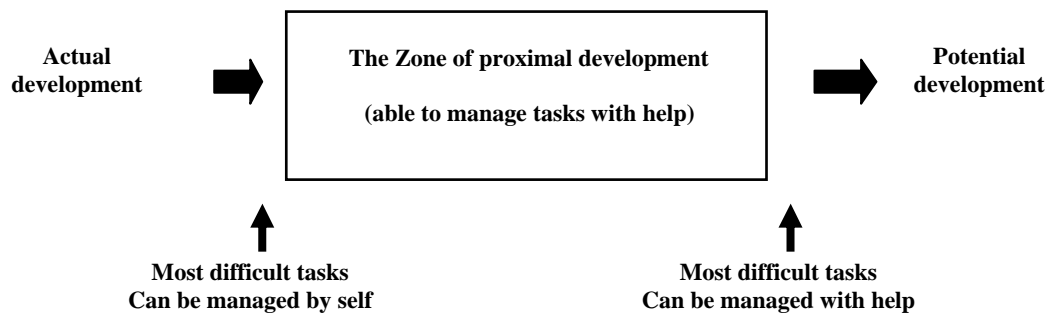


Figure 2.1 Zone of Proximal Development

Source: Williams and Burden (1997)

In the zone of proximal development, a teacher and a learner or an adult and a child work together on a task that the learner or the child cannot perform independently because of the level of difficulty. In other words, the zone of proximal development is that area where children can achieve a goal with the support and guidance of a more knowledgeable other. This approach implies that teachers should focus on activities within this zone, since it is here that learning progress will occur.

Furthermore, Social Constructivism is based on specific assumptions about reality, knowledge, learning and motivation with implications for teaching and learning. These assumptions can be described as:

Reality. Social Constructivism posits that reality is constructed through human activities. Members of a society together invent the properties of the world. For the Social Constructivist, reality cannot be discovered: it does not exist prior to its social invention.

Knowledge. Vygotsky (1978) emphasizes the role of language and culture in cognitive development. Language and culture play essential roles both in human intellectual development and in how humans perceive the world. Humans' linguistic abilities enable them to overcome the natural limitations of their perceptual field by imposing a culturally defined sense and meaning on the world. According to Vygotsky (1978) language and culture are the frameworks through which humans experience, communicate, and understand reality. Therefore, knowledge is also a human product, and is socially and culturally constructed. Individuals create meaning through their interactions with each other and with the environment they live in. Knowledge is not simply constructed, it is co-constructed.

Learning. Social constructivists view learning as a social process. Meaningful learning occurs when individuals are engaged in social activities. Construction of social meanings, therefore, involves intersubjectivity (a shared understanding among individuals whose interaction is based on common interests and assumptions that form the ground for their communication) among individuals. Social meanings and knowledge are shaped and evolve through negotiation within the communication groups. Any personal meanings shaped through these experiences are affected by the intersubjectivity of the community to which people belong.

Motivations. Social Constructivists see motivation as both extrinsic--a reaction to positive and negative reinforcements and intrinsic--based on the learner's internal drive. Because learning is essentially a social phenomenon, learners are partially motivated by rewards provided by the knowledge community. However, because knowledge is actively constructed by the learner, learning also depends to a significant extent on the learner's internal drive to understand and promote the learning process.

Implications for Teaching and Learning. The Social Constructivist perspective has important implications for instruction and curriculum design (Phillips, 1995). This view of learning highlights the significance of the individual learner's prior knowledge in subsequent learning (Ausubel, 1968; Driver and Bell, 1986; Bischoff

and Anderson, 2001). From a Social Constructivist perspective, teachers do not teach in the traditional sense of delivering instruction to a group of students. Rather, they use materials with which learners become involved through manipulation or social interaction.

A Social Constructivist perspective of the teaching and learning process stresses the need for collaboration among learners and with practitioners in society. Collaborative learning is facilitated and guided by the teacher and requires learners to develop teamwork skills and to see individual learning as essentially related to the success of group (Dillenbourg *et al.*, 1996). This process is often seen as one of the peer interaction that is mediated and structured by the teacher. In this process, discussion can be promoted by the presentation of specific concepts, problems or scenarios, and guided by means of effectively directed questions, the introduction and clarification of concepts and information, and references to previously learned material (Taylor, Lucas, and Watters, 1999). From the Social Constructivist perspective, the teacher's role is that of a facilitator who supports and guides rather than transmits content. The facilitator provides guidelines and creates the environment for the learner to arrive at his or her own conclusions. The learning environment is designed to support and challenge the learner's thinking. Activities that are used to engage the learner should emphasize observing, collecting data, generating and testing hypotheses, and working collaboratively with others.

According to Geddis (1991), science teachers should be less concerned with student misconceptions and more concerned about using constructivist teaching methods to promote critical scientific thinking. Teaching all students to understand and apply key science ideas in real situations have been a significant ideas within the Social Constructivist framework. Thus, implementing Social Constructivist practices in elementary science classrooms may call for changing conventional teaching, learning, and assessment practices.

The next section of the theoretical framework will discuss and clarify various conceptions of curriculum development. This section addresses the various elements

of importance to curriculum development, their conceptualization and the research approaches that may be used to facilitate the study of curriculum development as part of teacher professional development.

Curriculum Development

Teaching is a process that engages teachers on a daily basis. Teachers are inevitably involved in curriculum design. Curriculum development is a routine that all teachers do. According to Cheung and Ng (2000), curriculum design may be defined as a set of value premises from which decisions about curriculum objectives, content, organization, teaching strategies, learning activities and instructional assessment are made. Teachers engage in or initiate actions based on decisions and choices they have made concerning what students should learn (i.e., curriculum) and which strategies present the best opportunities for learning (i.e., instruction). The success of this process is dependent on how well the learning experiences offered match the needs and capabilities of the learners (Zais, 1976; Knowles, 1984).

The word curriculum has been in existence since about 1820 and has been used professionally in the area of education since the early twentieth century (Wiles and Bondi, 2002). Curriculum is a word derived from the Latin word *curreo* which means to “run” or to run a “course” (Walker, 2003, p. 29). Most non educators think of curriculum and curriculum development in terms of this traditional definition, equating the term with a course of study or a text containing those items that comprise a course.

Educational literature is rich with definitions and categorizations of perspectives on curriculum. According to Glanz and Behar-Horenstein (2000), “curriculum has been variously defined as content or subject matter, a plan, experience, a system and field of study. For example, Taba (1962) defined curriculum as a plan for action that includes strategies for achieving desired goals or ends. This view includes strategic and sequential planning. By contrast, another view

of curriculum is much broader: it includes all the experiences that a child has during the school day (Ragan, 1960).

Each definition statement included above possibly reflects the historical/ social/ economic/ political context in which it was derived. Definitions of curriculum represent a selection of the ideas, skills, values, norms and practices available within a society. Recent radical changes in knowledge and understanding in numerous fields of inquiry suggest there is a growing rejection of explanations of the world which view entities as independent of their environment or other entities; of adhering to linear, cause-effect predictions of change and of accepting that there can be one universal explanation of events (Von Bertalanffy, 1971; Bateson, 1979; Broffenbrenner, 1979; Prigogine, 1980; Sameroff, 1982; Gardner, 1985; Goodall, 1986; Giroux, 1990). This represents a widespread paradigm shift. This paradigm shift also confronts traditional conceptions of curriculum and can be generally applied to curriculum design and frameworks.

There are many different points of view, models, functions and strategies attributed to curriculum development which reveal an interesting diversity of thought that makes for a dynamic and creative field of scholarship. For example, conceptions of curriculum have been significantly influenced by the ideas of Walker (1971), Babin (1981), Schwab (1983), and Chapparo and Ranka (1997).

A first perspective relates to Babin's (1981) deliberative model for curriculum development. This model begins with the identification of a curriculum focus and continues with the following procedures: interpersonal and group interaction and consciousness raising, needs assessment, identification of discrepancies, criteria, and procedures, establishing a knowledge base and policies, formulating alternatives and their consequences; making design decisions (in priority order) and implementing design strategies; and finally, the emergence of a new curriculum.

Schwab (1983) conceptualized curriculum as what is successfully conveyed to differing degrees to different students, by committed teachers using appropriate

materials and actions of legitimate bodies of knowledge, skill taste, and propensity to act and react. Schwab explained that the four commonplaces of education- teacher, student, what is taught, and the milieu of teaching-learning-are of intrinsically equal importance in curriculum development.

As the twentieth century drew to a close, the purpose and rationale of education, and even the method of becoming educated, was in chaos. Postmodern theorists urged the oppressed and enlightened to throw off the shackles of the public school and create their own “curriculum” with personal relevance based on their own values. From a postmodern perspective, Chapparo and Ranka (1997) state that postmodern curriculum is one which blends process with product. It is not bound by rigid and pre-determined objectives, plans and assessment strategies. These emerge as the “lesson” progresses. The curriculum responds to, grows from and seeks unpredictable challenge. The boundary between teacher and learner is flexible. It seeks to achieve within teachers and learners a deeper understanding of self, knowledge and the environment.

A forth notion of curriculum which is particularly salient to this study is Walker’s naturalistic model (1971) for curriculum development, which consists of three elements: the curriculum platform (a system of belief, values, conceptions, and assumptions which the curriculum developer accepts and which serves as the basis for the participation of choices), curriculum deliberation or justification of choices (formulating decision points, devising alternative choices, considering arguments for and against suggested decision points, and decision alternatives, and finally, choosing the most defensible alternative subject to acknowledge constraints), and curriculum design (the end or output of the process of curriculum development represented by the choices that enter into its creation).

The notion of Walker’s conception of curriculum is the most salient to this research because the researcher will study about how teachers use their knowledge and belief (the curriculum platform) to decide and design lessons for their classroom (curriculum deliberation or justification of choices) related to Social Constructivist

learning theory. The product of this process will be presented as lesson plans that correspond to the third element of Walker's conception (curriculum design). Because teacher involvement in curriculum development has been found in educational reform and corresponding curricular initiatives over the last twenty years, educational reform has called for greater teacher participation in decisions related to curriculum and instruction as one way in which to promote educational improvement. Empowering teachers and professionalizing teaching were, and continue to be common themes in discussions of teacher involvement in curriculum development (Sizer, 1992; Paris, 1993; Giroux, 1994). According to Fitzharris (1999), teachers must be empowered to more effectively design their own curriculum, and to move from the position of curriculum conveyer to that of curriculum designer. The literature reveals that when teachers do not understand the intent of the curriculum decisions, they simply remold the new curriculum to fit their traditional practice (Olson, 1981; Sarason, 1982; Powell, Farrar, and Cohen, 1985; Clark and Peterson, 1986; Apple, 1990; Dow, 1991; Ball and Cohen, 1996). Accordingly, Clandinin and Connelly (1992) suggest that separating teachers from the process of curriculum development (in effect, to have external curriculum experts develop a curriculum to be implemented by teachers) is ineffective because teachers' and students' perceptions, values, beliefs, and experiences serve to mediate the curriculum.

Curriculum development has become a vehicle for professional development and school reform. Parke and Coble (1997) designed a model for transformational science teaching focused on linking theory and practice through curriculum decision making that has been the framework for professional development sessions for middle-grade science teachers. Tippins, Kagan, and Jackson (1993) examined how pre-service secondary science teachers understood particular learning theories by analyzing lesson plans that they designed. In curriculum design, teachers should have opportunities to engage in a decision making as they reflect on the connection between theory and practice. According to Parke and Coble (1997), they should experience professional development that is not based on an assumption of teacher deficiency or the belief that the teacher alone makes decisions; rather, curriculum development should emphasize and value the ability of teachers to design curriculum

and classroom environments collaboratively. Ball and Cohen (1996: 70) described the relationship between curriculum [materials] and professional practice as follows:

...Curriculum is jointly constructed by teachers, students, and materials in particular contexts. Even close use of materials is a construction of curriculum, even if it seems to be only a partial reconstruction of received materials. Materials could be designed to place teachers in the center of curriculum construction and make teachers learning central to efforts to improve education, without requiring heroic assumptions about each teacher's capacities as an original designer of curriculum...

Teacher involvement in curriculum development is not a new idea in education. However, today it is increasingly important for teachers to collaborate in curriculum efforts. Griffin (1999) claims that today's teachers are increasingly involved with one another in curriculum development work, school-based decision making, peer evaluation and mentoring, team teaching, and other school wide activities. In this study, the curriculum development process will be viewed as holistic and comprised of phases of planning, development, implementation and evaluation. The researcher views curriculum development as a process of making decisions and judgments which are based on teachers' practical knowledge. Curriculum is also viewed as a problem solving process, in which teachers process a complex variety of information and use this to make decisions and solve problems.

To design the curriculum or associated instructional design in accordance with learning theories can be a somewhat confusing and uncomfortable process for teachers. This problem comes to the fore in teacher professional development. Why does it seem so difficult for teachers to transfer theory into practice? The need for answers to this question sparks investigation into the available literature on linking theory into practice. The next section of the theoretical framework will consider some of the problems that are inherent in the relationship between professional knowledge and the act of teaching, often called the theory-practice divide.

The Link between Theory and Practice in Science Education

Professionalism is about the quality in teachers' work and indicates different aspects of teaching. One aspect of professionalism relates to how professional knowledge is organized and used. In this sense, professionalism has been perceived as a systematic relationship between "theory" and "practice". Theories serve as bridges between research and educational practices and as a tool to organize and translate research findings into recommendations for educational practice (Schunk, 2004). Practice is perceived to apply theory by acting. Therefore, good practice should be based on theory which provides a framework to use in making educational decisions. Theory without practice can be misguided (Potgieter *et al.*, 2005).

Research suggests that the traditional lecture approach in science teacher education has flaws, and creates a gap between theory and practice (Korthagen *et al.*, 2001). This situation in science teacher education is similar in many places in the world at large. Both pre-service and in-service teacher educators are faced with the challenges of translating theory into practice. According to Barone *et al.* (1996), many science teacher education programs consist of a collection of separate courses in which theory is presented without many connections to practice.

In many places throughout the world, a teacher educator and/or science teacher educator (an expert in a certain area) is in front of the classroom and lectures on recent theories in the field of learning psychology, or general education. Then the pre-service teachers or in-service teachers discuss how it should be enacted in their classrooms, whereby they generally do not find success. Britzman (2003) suggests that when theory is presented apart from practice it appears to be too abstract, too theoretical, and too far removed from the classroom. Teachers lack experiences where they can design their work based on the theoretical understanding they have developed. They are expected to do things that they have never done before. They are asked to rely on their professional knowledge for questions and issues with which they have little or no experience.

Although the theory-practice dilemma in teacher education is well-known and its causes have been thoroughly studied, it is remarkable that many teacher education programs still reflect the traditional “application-of-theory model” (Korthagen and Russell, 1995). The traditional view of teacher education has basically not changed and even many “new” approaches often take form of sophisticated procedures to try to bridge the gap between the theory presented and teaching practice.

As a reaction to weaknesses of the traditional approach to teacher education, new ways of preparing teachers for their profession have emerged. In many teacher education programs, an alternative view of teaching and learning is currently being explored. For example, Freudenthal (1991) proposes an approach which would start with real problems encountered by teachers during their teaching and learning situations. Many of the attempts to address the theory-practice issue are characterized by an emphasis on reflective teaching (Calderhead, 1989). Valli (1997) regarded reflective teaching as an inquiry into the practice of teaching and believed that teachers must reflect if they are to be successful in the classroom. Valli (1997: 70) stressed how successful teachers reflect:

...Reflective teachers link theory to practice by using varied sources of information, examine their own practice and school policies in order to become better teachers, analyze problems from multiple perspectives, and use new evidence to reassess decisions. Reflective teachers can alter their teaching behavior and context to accomplish desirable goals...

In accordance with these new models, teachers should develop knowledge in a process of collaborative reflection on practical situations. Korthagen *et al.* (2001) suggests that professional development in school, reflection and collaborative approaches are elements of models that allow for the real integration of theory and practice. This means that teacher development should be increasingly conceptualized as an ongoing process of experiencing practical teaching, reflecting under the guidance of a more experienced colleague and developing one’s own insights into teaching through collaborative interactions. This implies the need for strong,

productive ways of helping teachers acquire the necessary knowledge and skills in a manner that helps them to apply what they are learning. This also suggests the importance of helping teachers understand theory about learning and teaching science in ways that are directly relevant to classroom practice.

Summary

In summary, constructivist perspectives on learning and teaching science have been strongly advocated by science educators and researchers. The underlying framework of the paradigm is Social Constructivist learning theory, which suggests that human beings construct knowledge through acting on their environment and interacting with other humans. Contemporary research on teaching and teacher professional development has emphasized the role of teachers play in generating professional knowledge, and the highly contextual nature of teachers' knowledge and practice. Alternative perspectives of teacher professional development suggest that teachers continuously engage, construct, or reconstruct their professional knowledge through their everyday routines with students, and through their reflective deliberation with colleagues. Traditionally, teacher professional development programs moved from theory to practice. To move beyond this framework, a more dialogical professional development must be based on an active learner model in which teachers work in a collaborative group on problem solving and reflective activities.

As a consequence of the emerging epistemology of Social Constructivist learning theory, a collaborative model of in-service science teacher development serves as a context in this study for investigating teachers' knowledge and practice. The researcher believes that one advantage of this model of professional development is that teachers will have a stronger voice in planning, teaching and linking theory and practice. In this way, as teachers negotiate curriculum, we can better understand their knowledge and belief about Social Constructivist Learning Theory. Moreover, teachers can also monitor their ideas, reflect on the preconceptions they hold and consider alternative theories and ideas based on practical work.

Review of Literature

The purpose of this review is to survey the body of literature that informs this study. The literature relevant to this study falls primarily into four categories. The first section addresses students' and teachers' alternative conceptions related to properties of matter. In the second section, this review examines studies of importance to science teacher professional development. In the third section, studies concerning the role of reflection in the professional learning of science teachers is reviewed and synthesized. In the final section, this review examines relevant literature that informs the use of Lesson Study as a tool for studying teacher knowledge.

Alternative Conceptions of Properties of Matter

Matter is an important topic that appears in the Basic Education Curriculum not only in Thailand, but in many other countries, including England, France, and Spain (Martin, 2001). In Thailand, this topic includes three Properties of Matter (IPST, 2001) represented in two standards:

Standard SC 3.1 Understanding matter, its quality and relationship with structure, skills in searching for knowledge, procedures, possessing science consciousness, communicating acquired knowledge, and application of knowledge.

Standard SC 3.2 Understanding the nature and changing situation of matter, matter solutions, chemical reactions, skills in searching for knowledge, procedures, possessing science consciousness, communicating acquired knowledge, and application of knowledge.

Many researchers claim that matter is a foundational domain concept in science (Ryan and Charly, 1990), particularly in chemistry, which is a science of matter and its transformation (Martin, 2001). Understanding matter and its transformation is essential to the learning of more advanced science concepts including solutions, chemical bonding, chemical reactions, and ions (Griffiths and

Preston, 1992). Other researchers also claim that an understanding of concepts related to matter and its transformation facilitates more complex conceptualizations such as the particulate nature of matter or atomic molecular theory, essential chemistry concepts (Nakhleh and Samarapungavan, 1999; Valanides, 2000; Martin, 2001).

Over the past decade, a variety of studies have investigated students' (Stavy, 1990; Nakhleh and Samarapungavan, 1999; Johnson, 2000; Kikas and Eve, 2001; Krnel *et al.*, 2003; Sanguansin, 2005), pre-service teachers' (Ryan and Charly, 1990; Haidar, 1997; Martin, 2001; Valanides, 2000) and in-service teachers' (Kruger *et al.*, 1992) conceptions of matter. Most of these studies have focused on the four major concepts of matter: conservation of matter, composition and structure of matter, physical properties and change, and chemical properties and change as presented in table 2.1.

Table 2.1 A summary of alternative conception of properties of matter in students, pre-and in-service teachers

Participants	Topic	Citation
Students	Conservation of matter	Stavy (1990), BouJaoude (1991), Watson <i>et al.</i> (1995)
	Composition and structure of matter	Doran (1972), Novick and Nussbaum (1978), Stavy (1991), Benson <i>et al.</i> (1993), Krnel <i>et al.</i> (1998), Krnel <i>et al.</i> (2003)
	Physical properties and change	Osborne and Cosgrove (1983), Bar and Travis (1991), Lee <i>et al.</i> (1993), Krnel <i>et al.</i> (1998)
	Chemical properties and change	Voelker (1975), Johnson (2000)

Table 2.1 (Continued)

Participants	Topic	Citation
Pre-service teacher	Conservation of matter	Haidar (1997)
	Composition and structure of matter	Martin (2001)
	Chemical properties and change	Valanides (2000)
In-service teacher	Physical properties and change	Kruger <i>et al.</i> (1992)

Conservation of Matter. Conservation of matter refers to the idea that although matter can undergo various changes, it can never be destroyed or created. In this section, studies describing students' and pre-service teachers' conceptions are reviewed. Stavy (1990) interviewed 4th to 9th grade students on their conceptions about conservation of matter during state change (i.e. acetone evaporation and iodine sublimation). For acetone evaporation, about 30% of 4th graders believed that when acetone is invisible, it no longer exists and therefore all of its properties disappear with it. This alternative conception indicates that students' conceptions of conservation of matter in the elementary grades are limited to what they can perceive, i.e. visible or invisible. In terms of iodine sublimation (state change from solid to gas), about 15% more students than in the acetone evaporation situation demonstrated an understanding of conservation of matter. This finding suggests that when students are able to see the colored gas of iodine, they are able to recognize the existence of matter during state change. BouJaoude (1991) studied 8th grade students' by interviewing them about mass changes while observing a burning candle. Most of the students responded that there was no mass change to the candle, because the wax simply melted and then solidified with nothing lost or produced in the process. Watson, Prieto, and Dillon (1995) studied 14-15 years-old students' understanding of combustion. They found that conceptions about conservation of matter were limited by students' sense experiences. The above results on conservation of mass have also been found in studies of pre-service teachers. Haidar (1997) studied pre-service

teachers' conceptions of total mass of product. He asked students to calculate the mass of reactant and product from equations. The results of this study showed that 80% of the pre-service teachers had no understanding of this concept. Even though most of them were successful in doing the calculation, they could not interpret it. Only one pre-service teacher was able to answer questions about the task successfully. From this result he inferred that most pre-service teachers depend on mere memorization of concepts without the development of meaningful understanding.

Composition and Structure of Matter. The composition and structure of matter refer to physical characteristics and classification of matter. This topic also includes studies at the micro level which involve students' understandings of the particulate nature of matter. In this section, research studies describing students' and pre-service teachers' conceptions of the composition and structure of matter will be reviewed. Stavy (1991) asked students from 1st, 3rd, 5th, and 7th grades to describe matter. She found that children always explained matter in terms of physical characteristics such as solids, powders, rigidity, non-rigidity, liquid, or biological materials. Krnel, Watson, and Glazar (1998) conducted a comprehensive review of findings on students' classification of matter. They found that children described objects and materials as matter by (a) age, (b) size of objects, (c) familiarity with the objects, (d) form of the substance (e.g. powder or cube), and (e) what the substance is. They also found that children have great difficulty in conceptualizing gases as matter. In a follow-up study, Krnel *et al.* (2003) found that children from ages 3 to 13 used criteria to classify objects which shifted from using size, function, shape, or color to using states of matter. Moreover, Doran (1972) analyzed grade 2 to 6 students' alternative conceptions related to the particulate model (e.g. particles do not move) using multiple choice questions. The number of students who considered particles to be static changed from 12% to 11% from 2nd grade to 6th grade. The percentage of students that consider the speed and motion of particles unrelated to temperature decreased from 33% to 21% from 2nd grade to 6th grade.

Based on these findings, Doran (1972) suggests that the particle model of matter is too advanced for most elementary students to understand. Novick and

Nussbaum (1978) interviewed grade eight students about conceptions of the particulate model of gases. All students in this study had already formally studied the particulate model of gases in their science classes. The result of this study indicated that over 30% of students failed to correctly describe the expansion of a gas in an enclosed space and two-thirds of this group persisted with their alternative conception even when shown the “correct” picture. Benson, Wittrock, and Baur (1993) studied over one thousand students ranging from second grade to university chemistry students about their conception of the nature of gases. The conclusion of their study suggests that substantial understanding of the particulate model of gases may begin to develop at high school and be mastered during university studies.

Similar results with respect to students’ understandings about conservation of mass are also found in pre-service teachers. Martin (2001) studied pre-service elementary teachers’ ideas by using concept mapping to understand their ideas of composition of matter. The results were analyzed around three variables: (a) the relationship of concept between macroscopic and macroscopic properties, (b) macroscopic and microscopic properties, and (c) microscopic and microscopic properties. Half of the pre-service teachers were unable to establish relationships between microscopic and microscopic properties and microscopic and macroscopic properties.

Physical Properties and Change. Studies related to physical properties and change of matter involve students and in-service teachers explaining physical properties and changes in terms of state changes. Osborne and Cosgrove (1983) studied 8 to 17 years-old students’ conceptions about the state change of water. They concluded that a) even though students may be able to associate the scientific term with the phenomenon, they still may not have a solid understanding of what is happening, b) despite exposure to scientific concepts in the class, older students may still hold similar views to that of younger students and c) some nonscientific ideas are more popular with older children than with younger children (i.e. water changing into hydrogen and oxygen upon boiling). The above findings were confirmed by a later study by Bar and Travis (1991) who studied 6 to 15 years-old students’ conceptions of

phase change. In a study conducted by Krnel *et al.* (1998) the authors concluded that the majority of 12- to 15- years olds understand the transformation of water from solid to liquid, but are unable to completely generalize this phenomenon to other substances. One-third of 5-7 years olds think water disappears during evaporation. Lee *et al.* (1993) studied 6th grade students' ability to explain physical properties and change of state, expansion and compression of gases, thermal expansions, dissolving, melting, freezing, boiling, evaporation, and condensation. They concluded that matter and molecules are concepts too difficult for 6th grade students to understand, especially at the molecular level.

Alternative conceptions of physical properties and change are also found with in-service teachers. Kruger *et al.* (1992) studied elementary teachers' understanding of changes that occur in common materials such as water, paraffin and wax. They found that teachers were uncertain about chemical change or confused about physical change. The physical transformation of water during boiling was poorly understood. Over two thirds of the teachers could not consistently give scientifically correct interpretations of two or more of the instances presented in terms of molecular models. Some teachers lacked an understanding of basic scientific ideas such as latent heat (about two thirds) and saturation (nearly a quarter). One third of the teachers had difficulties distinguishing melting from dissolving.

Chemical Properties and Change. Studies which investigated students' and pre-service teachers' conceptions about chemical properties and change involved their ability to differentiate physical and chemical changes. Voelker (1975) studied the effectiveness of introducing the classification of physical and chemical changes to grades 4-6 students. He concluded that it is not appropriate to teach the concepts of physical and chemical changes prior to grade 6 if instruction is in a large group, teacher directed format. Johnson (2000) followed a group of British students from age 11 to age 14 in terms of their conceptual understanding of substances and chemical changes. He found that students in this age range do not possess a scientific notion of substance in terms of its identity; rather students think about substances in terms of the history of the sample of materials (origin, source, and action such as

mixing, etc.). Even though they were taught about mixtures, students considered mixtures to be the result of simply mixing up. They believed that once substances are mixed up, it is impossible to un-mix them.

In terms of pre-service teachers, Valanides (2000) studied twenty female teachers to describe the changes in macroscopic (color, taste, volume, density, flammability) and microscopic (kind and movement of molecules) properties of substances when dissolving salt or sugar in water, when mixing water and alcohol, or when filtering or heating the respective water solutions. The results indicated that pre-service teachers thought that molecules share in observable properties of matter and combine together to give new molecules, without realizing the changes in the structure and properties of matter or without being able to distinguish physical from chemical changes.

The review of literature above suggests that both students and pre-and in-service teachers need experiences designed to more fully develop their conceptual understandings of matter. Studies have shown that science teachers' knowledge of the subject matter either enhances or limits students' learning (McDiarmind and Anderson, 1989 cited in Haidar, 1997; Anderson and Mitchner, 1994). Therefore, in order to facilitate student learning, teachers need to be educated and prepared themselves to be ready and capable of teaching physical science concepts such as those associated with matter.

Professional Development of Science Teachers

One science education reform strategy that is clearly at the top of the list in both developed and developing countries is the idea of restructuring science teacher education according to a more student-centered view of learning. Whereas, the vision of science education described in the Thai standards requires changes throughout the entire educational system, the success of reforms in science education will eventually depend on teachers. Teachers are the key to enhancing learning by students in schools. The thoughts that teachers have about teaching, learning and content influence the way in which they teach (Hewson *et al.*, 1999). Bransford *et al.* (1999)

emphasized that in order to teach in a manner consistent with new theories of learning, extensive learning opportunities for teachers are required.

As contemporary ideas of both science teaching and learning change, so too must the opportunities for teachers to study and engage in the theories and research that drive these reformative changes. More contemporary views of professional development promote a constructivist approach in the conceptualization and implementation of professional development programs. According to Posnanski (2002), in a constructivist based a professional development program, teachers develop the knowledge base to effectively analyze their own teaching situations and choose from a variety of strategies to enhance teaching behaviors and student learning. Teachers draw upon a repertoire of knowledge bases (i.e. learning theory, pedagogy, content knowledge, and curriculum development) to promote effective teaching and student learning. Many researchers emphasize that professional development is needed that allows teachers to construct professional knowledge about pedagogy, content, and technology, as well as strategies for managing the changing teaching and learning process brought about with the creation of constructivist learning environments (Hewson *et al.*, 1999).

Several authors have chosen to emphasize approaches to improving pre- and in-service science teacher professional development that have their foundation in literature on constructivist theory. For example, Howe and Stubbs (1996) studied the content and pedagogical content knowledge of in-service elementary teachers who participated in a professional development program based on constructivist and sociocultural theory. The workshop program started with research scientists presenting current research findings, followed by teachers reflecting and brainstorming ideas about ways to use this information in their classrooms and develop appropriate activities for their students. The results of their study indicated that participants were able to increase their knowledge of science and infuse this knowledge into science curriculum materials. Furthermore, they found that participants became more self-confident and professional as they were involved in collaborative work. Marion *et al.* (1999) studied how elementary pre-service teachers

developed their practice of teaching over the course of a constructivist-based science teacher education program. Data were gathered by observing the methods courses, interviewing the course instructors, and observing prospective teachers teach in practicum settings. The results indicated that pre-service teachers were constructing their own knowledge of what might work best in a science learning environment by evaluating experiences from methods class and discussing those they would like to try out with their own students.

According to Haney, Czerniak, and Lumpe (1996), Gibbons, Kimmel, and O'Shea (1997), and Reys *et al.* (1997), more traditional models of professional development (i.e. one-day workshops, infrequent in-service sessions and/or planning days) need to be elaborated upon if teachers are to partake in professional learning experiences guided by national standards. Today many new approaches have been proposed or are being implemented with the goal of transforming thinking about professional development. Studies of science professional development programs highlight the various strategies that are being used to achieve many purposes concerning professional learning of science teachers.

For example, Feldman (1996) studied a group of eight physics teachers during a three-year project. Activities included the use of anecdotal stories as a tool for teachers to share their knowledge, the trying out of new ideas about teaching and learning in the classroom, and systematic inquiry. Feldman concluded that since these activities were closely connected to the normal practice of the participants, they had the potential to be embedded in the practice of other science teachers, and lead to the enhancement of teachers' practice. Parke and Coble (1997) used a collaborative action research approach to involve teachers in curriculum development activities, as a vehicle for professional development. They designed an approach in which teachers communicated continuously with colleagues as well as university staff. The development of curriculum materials was preceded by a dialogue about science education reform goals. Next, in the organization of the curriculum development activities, attention was given, in particular, to the alignment of the curriculum materials teachers developed with the personal beliefs they articulated, and the school environment in which the curriculum was to be implemented. Parke and Coble

(1997) concluded that their approach supported teachers in becoming architects for change through building upon their current conceptions instead of attempting to remedy them. Darling-Hammond and Snyder (2000) described several professional development contexts in which cases were used to facilitate teachers' professional learning. On the basis of their research, they gained insight into several important issues to consider when using cases for professional development: (1) the case writer or case user should have some knowledge or frame of reference for an adequate analysis of the nature of the issue addressed in the case, and (2) the case writer or case user should be encouraged to generalize from the single instance represented in the case to a well-grounded set of principles for interpretation of practice. Darling-Hammond and Snyder (2000) described examples of cases in their research where these problems were avoided.

There are many studies that examine various aspects of professional development in relation to elementary science teacher learning. Through this review of professional development research, several themes have been identified: teachers' beliefs and practices, process skills and attitude, and teachers' knowledge. Table 2.2 and 2.3 summarizes all of these aspects and relevant research studies with respect to pre-and in-service teachers.

For example, in terms of in-service professional development programs with a focus on teachers' belief and practice, Lee *et al.* (2004) studied 53 in-service elementary teachers about beliefs of inquiry. The teachers attended a four day workshop which focused on inquiry-based science instruction. Workshop activities were structured to encourage active involvement of all teachers. Participants worked in small groups to reflect on their own beliefs and practices. Multiple data sources included focus group interviews, a questionnaire and classroom observations. The results indicated that teachers developed an enhanced knowledge of science content, used more hands-on activities and held stronger beliefs about inquiry-based science instruction. In another study Posnanski (2002) focused on the analysis of an inquiry-based professional development program via data obtained from in-service elementary science teachers. The professional development program was based on

materials adapted from the Biological Science Curriculum Study (BSCS) in-service program for science teachers entitled *Decisions in Teaching Elementary School Science*. The program was developed to enhance teachers' science self-efficacy. Activities in the program allowed participants to share their knowledge through discussion. The results showed that participants had increased self-efficacy after participating in this program. In essence, the professional development program had a positive influence on the participating teachers' beliefs about their ability to teach science effectively.

AbuSharbain (2002) also studied the beliefs of in-service elementary teachers and their scientific skills. Teachers in this study participated in a 4-day workshop which emphasized the execution of inquiry-based investigations in the local outdoor environment. They also learned how to assist their own students in developing inquiry-based experiments. Positive changes were found with respect to teachers' development of scientific skills. Findings of the study suggest that this model of teacher professional development was successful in changing teachers' beliefs.

In addition to the study of teacher beliefs, several studies in the professional development context examined the development of process skill attitudes and context knowledge. For example, project LIFE was a state systemic initiative professional development program for elementary and middle-grades life science teachers. In this study, Radford (1998) examined how teachers changed their pedagogical practice to more inquiry based/student centered practices. The teachers attended a three-week summer session which focused on practicing hands-on science and understanding how to implement the learning cycle. The results of the study indicated that after the teachers were introduced to a learning cycle model of instruction, together with the LIFE curricula, their science content knowledge, process skills and the attitudes toward science improved. Likewise, the attitudes and achievement of their students improved as well.

Table 2.2 A summary of aspects of professional development and in-service elementary science teacher learning

Participants	Themes	Citation	Key Study	Key Finding
In-service	Teachers' beliefs and practices	Lee <i>et al.</i> (2004)	To enhance inquiry-based science instruction.	Teachers enhanced knowledge of science content, more hands-on and stronger beliefs about inquiry-based science instruction.
		Posnanski (2002)	To enhance the teachers' self-efficacy belief	Participants had more self-efficacy after attending this program.
		AbuSharbain (2002)	To enhance teachers' beliefs regarding constructivist teaching.	Teachers' beliefs change to be more consistent with constructivist teaching
	Teacher process skill and attitude	AbuSharbain (2002)	To enhance teachers' scientific skill by using workshops	Positive changes were found in teachers' scientific skill
		Radford (1998)	To enhance science teachers' process skills	Teachers' process skill and attitude improved.
	Teachers' knowledge	Radford (1998)	To enhance teachers' content knowledge	Teachers' science content knowledge improved.
		Morgan (2004)	To enhance pedagogical knowledge by mentoring	The finding indicated that collaborative discussion contributed pedagogical knowledge of the teacher.
		Howe and Stubbs (1996).	To enhance teachers' content knowledge and pedagogical knowledge	Teachers' knowledge of environmental science and pedagogical knowledge improved

Table 2.3 A summary of aspects of professional development and pre-service elementary science teacher learning.

Participants	Themes	Citation	Key Study	Key Finding
Pre-service teacher	Teachers' beliefs and practices	Plourde (2003)	To enhance teachers' beliefs and regarding constructivist teaching and practical application of this knowledge.	As the student teachers' knowledge of constructivism increased, their belief that they would be "able to apply constructivist principles in the classroom learning situation" tended to increase.
	Teacher process skill and attitude	Liang and Gabel (2005)	To improve attitude toward science	A new constructivist curriculum promoted positive attitudes toward learning and teaching science.
		Liang and Gabel (2005)	To improve science concept	A new constructivist curriculum enhanced conceptual understanding of science concept.
	Teacher's knowledge	Lee and Krapfl (2002)	To integrate science content knowledge and pedagogy knowledge in pre-service teacher education	This program has been effective in preparing pre-service teacher to teach elementary school science.
		Peterson and Treagust (1998)	Used problem-based learning framework to develop science content knowledge, curriculum knowledge, and knowledge of the learner.	The opportunity to work on the problem and peer work were important in facilitating pre-service teachers enhanced knowledge of their teaching.

Other studies of elementary science teacher professional development are centered on the theme of teacher knowledge. Morgan (2004) examined the relationship between pedagogical knowledge and teacher reflection in a mentoring relationship. Classroom cases were used as a stimulus for discussion among in-service elementary teachers. The participants were asked to write a brief reflection on cases before meeting and subsequently met weekly to discuss those cases. Morgan (2004) found that collaborative discussion influenced reflective practice which contributed to the accumulated pedagogical knowledge of the teachers.

Howe and Stubbs (1996) developed a professional development program based on constructivist and sociocultural theory with the goal of increasing teacher knowledge of environmental science. Their model of professional development was a continuing process which began with a workshop where research scientists and science teachers were brought together by a science educator who acted as facilitator and liaison. The professional development experiences continued as teachers developed curriculum materials for their own students, shared their knowledge and materials with colleagues, and formed a network that encouraged and supported their efforts. Results from a telephone survey, information elicited during a focus group interview, and the record of teachers' presentations all indicated that many of the teachers involved became increasingly knowledgeable and competent of content and pedagogy.

Like the studies of professional development with in-service teachers, a number of studies focus on pre-service teachers' beliefs and practices. Plourde (2003) examined the impact of a constructivist learning model on elementary pre-service teachers' beliefs in reference to their knowledge and the practical application of this approach. According to Plourde (2003), a constructivist science teacher preparation program was intentionally designed to give pre-service teachers opportunities to make new connections in a setting focused on personal empowerment and critical reflection. The program challenged pre-service teachers to move toward self-directed, life-long learning. The Pearson product-moment correlation (Pearson r) was the relational measurement utilized to determine if there was a statistical correlation between

constructivist knowledge and beliefs. The results showed a high correlation which led the author to assume that the more knowledgeable student teachers are in regard to constructivism, the more likely they believe they will be able to apply constructivist principles in the classroom.

In addition to the study of process skills and attitudes, and knowledge in pre-service teachers, Liang and Gabel (2005) examined the effectiveness of a new constructivist curriculum model, Powerful Ideas in Physical Science (PIPS) on pre-service elementary teachers' understanding of science concepts and the development of positive attitudes toward learning and teaching science. This new curriculum model integrated a conceptual change perspective with a hands-on, inquiry-centered approach. The results of Liang and Gabel (2005) suggest that the constructivist-based approach was effective in enhancing conceptual understanding and promoting positive attitudes toward learning and teaching science.

Moreover, several studies focus on pre-service teachers' knowledge. Lee and Krapfl (2002) also examined the effects of a constructivist learning environment on elementary pre-service teachers' science content and pedagogy knowledge. In this study, pre-service teachers were involved with science activities that employed conceptually oriented teaching models, inquiry, and authentic assessment strategies particularly useful in teaching science. They also reflected on what was taught, how it was taught, and why it was taught in such a manner. This constructivist learning environment created opportunities for pre-service teachers to internalize or transform new information creating and expanding their individual cognitive structures. Tentative findings suggested this program has been effective in preparing pre-service teachers to teach elementary school science. The results indicated that pre-service teachers understood and attempted to utilize hands-on science and the learning cycle, and developed very positive attitudes towards teaching science.

Another model used in the context of pre-service professional development was Peterson and Treagust's (1998) problem-based learning framework. This approach emphasized the development of pre-service elementary teachers' knowledge

base with respect to science content knowledge, curriculum knowledge, and knowledge of the learner. As part of this program, problems were designed so that pre-service teachers could develop and apply their knowledge, through the use of a pedagogical reasoning process, to a typical primary classroom teaching situation. Participants worked in small groups (three or four) on a problem over a 6-week period. A case study approach was used to evaluate the knowledge base and pedagogical reasoning components considered of two randomly selected participants in this study. The authors found that the opportunity to work on the problem and peer collaboration were important in allowing pre-service teachers to develop enhanced knowledge of their teaching.

Over the past twenty years ideas about the professionalism of teachers has been extended. A culture of professional development has emerged in teaching, supported by increased levels of funding for in-service training. According to Abell (2000), there is a growing emphasis on school-focused activities entailing greater professional collaboration. Abell (2000) emphasizes that in-service teachers need time in the field, working with students and reflecting on practice. When teachers have shared problems, collaboration can help: it can generate new suggestions and ideas that become obvious. The following section reviews the role of reflection in teacher professional development and its relationship to teachers' actions, particularly in the context of in-service science teacher education.

The Role of Reflection in the Professional Learning of Teachers

Reflection appears to play a critical role in developing professional knowledge, which is essential to effective teaching (Sergiovanni, 1987). The importance of reflection is associated with the fact that teaching is a complex activity that occurs in a multi-faceted environment. This complexity is evident in the work of Schon (1983, 1987), who suggested reflective practice as a new way of conceptualizing the relationship between theory and practice. Reflective teachers link theory to practice by using information, examining their own practice and school policies, analyzing problems from multiple perspectives, and using new evidence to reassess decisions.

Holly (1989) stresses that reflection can make insight possible, experiences comprehensible, problem solving practical. Through reflection, as teachers interact with a complexity of variables related to teaching and learning in active, thoughtful, reflective practice, they are able to develop their professional knowledge.

What is reflection? In psychological terms, reflection refers to a mental image or representation. Reflection and reflective teaching have been conceptualized in numerous ways. Dewey (1933: 9) traditionally defined *reflective thought* as the “active, persistent, and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and the further conclusions to which it tends”. According to Dewey (1933: 12), the process of reflective thinking occurs in two phases. First, a person enters “a state of doubt, hesitation, perplexity, mental difficulty, in which thinking originates”. In essence, the person recognizes something as problematic. What follows is “an act of searching, hunting, inquiring, to find material that will resolve the doubt, settle and dispose of the perplexity”.

Building on the work of Dewey, Schon (1983) postulated the idea of “the reflective practitioner”. Schon viewed reflection as a complex activity that helps the teacher contextually frame ideas, questions, and problems in the classroom. Schon introduced the concepts of reflection-in-action and reflection-on-action. Reflection-in-action refers to the process of interpreting, analyzing, and providing solutions to complex and situational problems during an action, the period of time in which we remain in the same situation. Reflection-on-action takes place when the practitioner has left the arena of endeavor and mentally reconstructs that arena to analyze actions and events.

Garman (1986: 15) further clarified the meaning of reflection, describing it in this way: Reflection is done carefully, using stable versions (often written) of the experience with more than one round of written interpretations. She continued by explaining the process of reflection as reflection on action and reflection through recollection. However, Garman, along with Dewey and Schon, saw reflection as a way for teachers to consider and attempt to improve their teaching strategies.

Reflective teaching is not viewed as synonymous with any particular changes in teacher behaviors (Wunder, 2003). Rather, it seeks to help teachers become more aware of themselves and their environments in a way that changes their perceptions of what is possible (Wunder, 2003). Hatton and Smith (1995: 34) stated that: reflective thinking generally addresses practical problems, allowing for doubt and perplexity before possible solutions are reached, concluding that reflective thought must occur with some sort of action. Darling-Hammond (1998: 7) asserted that: teachers learn best by studying, doing, and reflecting; by collaborating with other teachers; by looking closely at students and their work; and by sharing what they see. In particular, Schön (1983, 1987) suggested that teachers should be reflective practitioners who contemplate and negotiate the complexities of teaching and learning in order to enhance their decision-making power and autonomy in classrooms.

When a teacher faces a complex, ill-defined, and context-specific problem, he or she has to decide a course of action by engaging in reflective practice. The demand for a conclusion to a problem is a definitive characteristic of reflective thinking. According to Sergiovanni (1987) when thought and action work together in reflective practice, a teacher creates professional knowledge. Accordingly, reflective teacher education focuses on how successful teachers think. It promotes a thoughtful, contextualized view of teaching in which teachers learn how to make choices about educational goals and practices (Kennedy, 1989). Reflective teachers have the ability to think about their teaching behaviors and the context in which they occur. They can look back on events; make judgments about them; and alter their teaching behaviors in light of craft, research, and ethical knowledge.

Every day teachers face a number of complex and context-specific problems about which there are not easy answers. In this regard, it has been advocated that teacher educators prepare teachers to cope with their unique teaching situations. However, teacher education programs cannot prepare teachers for every situation, they may encounter, nor can the programs provide teachers with all of the knowledge and strategies they will need for an entire career. Instead, teacher educators can educate pre- and in-service teachers to become effective decision makers who are able

to appropriately translate content or pedagogical knowledge into practice (Zeichner, 1986).

A fast-growing literature on reflective teaching has suggested the importance of reflection both in the initial process of learning to teach and in professional growth (Korthagen, 1985; Calderhead, 1989; Strahan, 1990; Bednar, 1991; Gipe and Richards, 1992; Rovegno, 1992; Tsangaridou, 2005). Much of the research on reflection with respect to elementary science has focused on pre-service teachers (Feiman-Nemser *et al.*, 1989; Abell and Bryan, 1997; Bryan and Abell, 1999; Sillman and Dana, 1999; Zembal-Saul, Krajcik, and Blumenfeld, 2002). A few studies have been published concerning reflection in relation to in-service teachers (Briscoe and Wells, 2002). A summary of research focusing on the role of reflection in the professional development of elementary science teachers is presented in table 2.4. This table illustrates different aspects of reflection that were studied in the context of pre-and in-service elementary science instruction.

Table 2.4 A summary of aspects about reflection in pre-and in-service elementary science education

Participants	Theme	Citation	Key Study	Key Finding
Pre-service teacher	Changing belief	Feiman-Nemser <i>et al.</i> (1989)	Used reflective journal writing and cases to enhance conceptions of teaching	Pre-service teachers' conceptions of teaching evolved to a complex process of assisting students' understanding.
		Sillman and Dana (1999)	Metaphor as a tool for reflection	Metaphor is a useful tool for reflection that helps pre-service teachers change their beliefs.
		Bryan and Abell (1999)	Investigated pre-service teachers' beliefs about science teaching and learning	Reflective is an important experience in pre-service teachers.
		Abell and Bryan (1997)	Encouraged pre-service teachers' beliefs about science teaching and learning	Course activities can help teachers accommodate new ideas, beliefs and values about science teaching and learning.
In-service teacher		Briscoe and Wells (2002)	Examined the process of action research and how it contributed to the professional development of a first-grade teacher.	Reflection is an important factor in promoting teachers' beliefs about teaching and learning.
Pre-service teacher	Encourage Pedagogical content knowledge	Zemal-Saul <i>et al.</i> (2002)	Encouraged pre-service teachers' understanding of the influence of context and the role of the cooperating teacher.	Reflection can enhance pre-service teachers' science teaching.

A number of studies focus on the role of reflection in developing pre-and in-service elementary science teachers' beliefs. Sillman and Dana (1999) explored the usefulness of metaphor generation and analysis as a tool for reflection. Four pre-service elementary teachers in this study reflected on their ideas of learning and teaching science during a field experience. The results showed that metaphor was a useful tool for their reflection. It helped the prospective teachers identify and actualize some of their beliefs and change their beliefs about science learning and teaching. Feiman-Nemser *et al.* (1989) examined the usefulness of other tools in promoting reflective thinking during a course which was intended to change elementary pre-service teachers' beliefs through various ways, including reflective journal writing, analyses of cases and videotapes of classroom teaching, discussions, and field observations. They found that pre-service teachers' conceptions of teaching generally evolved from a linear process of knowledge transmission to a complex process of assisting students' understanding.

According to Bryan and Abell (1999), pre-service elementary teachers' experiences within the context of reflective science teacher education influence their development of professional knowledge. They conducted a case analysis to investigate one pre-service teacher's beliefs about science teaching and learning. They collected data from written reflections, group discussions, individual interview and observation during a science methods course and corresponding field experience. Their findings underscore the significance of offering reflective experience early in the careers of prospective teachers. Likewise, Zembal-Saul *et al.* (2002) studied three pre-service elementary science teachers who enrolled in an experimental teacher preparation program designed to enhance the teaching of science at the elementary level. The program was designed to engage pre-service teachers in cycles of planning, teaching, and reflection. The findings of this study suggest that when pre-service teachers are provided with opportunities to apply and reflect substantively on their developing considerations for supporting children's science learning, they are able to maintain a subject matter emphasis.

Action research on portfolio assessment was used to promote reflection in a study conducted by Briscoe and Wells (2002). Their study explored the research process experienced by a first-grade in-service teacher as she examined whether portfolios could be used as an effective means for facilitating and assessing young children's development of science process skills. Reflection was an essential part of the experienced elementary science teacher's action research. The teacher used journals and a portfolio as a tool for developing solutions to the difficulties she encountered in teaching first-grade. Results of the study provided further support for the idea that reflection on one's beliefs about teaching and learning is an important factor in understanding changes in practice, particularly in the context of an action research process.

Other studies of elementary science teachers focus on the role of reflection during professional development centered on teachers' pedagogical content knowledge. Abell and Bryan (1997) used a reflection orientation in an elementary science methods course to guide pre-service elementary teachers in constructing viable science teaching and learning theories and classroom practice. Throughout the methods course, pre-service teachers reflected on others' teaching via integrated media cases of conceptual change teaching, reflected on their own teaching via field experiences in a partner school, reflected on expert opinions via course readings, and reflected on themselves as science learners via participation in science learning activities. Activities within the four reflection contexts encouraged pre-service teachers to consider their beliefs and values in science teaching and learning.

As the above studies suggest, there are numerous practical methods that teachers can use to reflect in the context of professional development programs. Nichols, Tippins, and Wieseman (1997) suggest various tools for facilitating reflection including portfolios, journals, cases, learning maps, stories re-told, metaphors, and proverbs. They view reflective tools as a means for teachers to engage in learning about and from their own views and practices of science teaching and learning. Likewise, Valli (1997) emphasized several methods that she used with pre-service teachers that classroom teachers could likewise use: action research,

journaling, case studies, supervision, and classroom activities and discussions. Using these practical methods, teachers can reflect on their past, present and future science teaching and learning practice. In this inquiry, Lesson Study will be used as a tool to facilitate reflective practice and to study teachers' practical knowledge. The following section summaries what research says about the Lesson Study approach.

Lesson Study as a Tool for Studying Teacher Knowledge

With respect to in-service teacher professional development, a number of new approaches have been proposed or are being implemented in science education. One approach that has gained in popularity in recent years has been to have teachers engage in direct learning experiences that center on the concrete examination of practice, or indirect experiences through the analysis of artifacts produced during teaching (Cochran-Smith and Lytle, 1999; Putnam and Borko, 2000; Feiman-Nemser, 2001). It is in this climate that a growing interest has developed in Lesson Study, a practice where teachers learn about teaching by jointly developing and examining actual classroom lessons (Lewis and Tsuchida, 1997; Yoshida, 1999; Fernandez, 2002; Fernandez *et al.*, 2003).

Lesson Study is a Japanese approach to teacher professional development that has recently become popular in the United States and other countries. In 1999, in a publication of the Teaching Gap, Stigler and Hiebert introduced the idea that "Lesson Study embodies a set of concrete steps that teachers can take, over time, to improve teaching. These steps may need to be modified to work in the United States." The popularity of the Teaching Gap publication may have helped convince others about the need for a similar approach, and certainly helped spark interest in Lesson Study in other countries. Given its current appeal, Lesson Study appears well positioned as an important tool to exert a significant impact on instructional improvement (Chokshi and Fernandez, 2005)

According to Stewart and Brendefur (2005), Lesson Study is driven by a well-defined image of effective classroom learning and teaching. It provides opportunities

for teachers to build their knowledge and examine practice. In this approach, teachers receive opportunities to collaborate with colleagues and other experts to improve their practice. Moreover, teachers are involved in observing students, listening carefully to the ideas of colleagues and using information to make instructional decisions. A premise of Lesson Study is that discussing others' points of view enhances the learning process. In Lesson Study, teachers have a chance to reflect on their own teaching practices and those of others. Teachers strive to improve their teaching through reflecting on the feedback from their peers. Lesson Study is a process that requires continual reflection. In Lesson Study, teachers are involved in a Lesson Study cycle: plan the lesson, implement/observe the classroom, reflect and discuss evidence from the research-based lesson, revise and re-implement research lesson and engage in further reflection. Lewis (2004) explained that Lesson Study is a teacher-led activity that requires collaboration and a deep commitment to improving instructional practice and student learning. She noticed that while observing in classrooms and compiling her field notes, she was also learning from the science lessons she was experiencing. Lewis also writes:

... Throughout the process of Lesson Study, teachers have opportunities to deepen their own content knowledge as they compare various curricula and standards, select and modify a lesson, try the problem themselves, anticipate student thinking, and analyze student responses to the lesson... (Lewis, 2004: 139)

Lesson Study begins with a group of teachers identifying a common goal (eg. helping students develop science process skills and a content area (eg. properties of matter)) to focus on. Teachers agree on a topic, consider a unit plan and where a lesson will fit in the unit, examine existing resources, share their own ideas and experience, select or design a task, and discuss and anticipate student thinking. Then, one member of the teacher team teaches the lesson while the rest observes. After the lesson, all observers discuss the lesson, ask questions and make suggestions. Then, teachers cooperatively revise the lesson based on their reflections and evaluation. After that the revised lesson plan is taught again and other teachers observe, evaluate and reflect on the lesson a second time and share their thoughts.

During Lesson Study, teachers work collaboratively on a small number of lessons by planning, teaching, observing, revising and reteaching them. Over the course of a year, a Lesson Study team may produce only a few lessons, but the experience of the process- the collaboration and sharing, the insight about student thinking- is what teachers find invaluable. Chokshi and Fernandez (2005: 675) point out the advantage of Lesson Study as follows: Lesson Study has the potential to help build such a knowledge base, since it provides a process for breaking teachers' isolation and allows them to collaborate in order to develop, test, and share new ideas that are meaningful to them as professionals. The research of Chokshi and Fernandez (2005) suggests that Lesson Study can help teachers break out of their traditional isolation, giving them a sense of belonging to a larger professional community. Furthermore, because Lesson Study generates knowledge in the context of group discussion, the resulting knowledge is open to criticism and revision. Finally, these authors found that Lesson Study creates a culture of examining and learning from practice, demands rigorous work and encourages lifelong professional learning. These researchers concluded that Lesson Study helped teachers enact progressive curriculum changes and ultimately led teachers to adopt a new way of teaching.

Little research has been conducted about the application of Lesson Study to professional development in science education. However, some studies have been published about the use of Lesson Study in elementary mathematics professional development contexts. For example, Puchner and Taylor (2006) studied how teacher efficacy developed as part of the Lesson Study process with four elementary mathematics teachers. The Lesson Study process involved the teachers meeting once a week for 2-3 months after school to plan a lesson that they then taught near the end of the semester. Teachers also attended the teaching of the lesson and the debriefing session. The theme of teacher efficacy emerged in analysis of this study. The data indicated that Lesson Study revealed to all four teachers that in-depth planning and attention to a lesson can bring about student engagement and learning that they had not previously felt was in their power. Finally, this study revealed that collaboration among teachers was identified as one of the most important features of the school culture in terms of fostering professional development. Similarly, Lewis *et al.* (2006)

studied 26 elementary mathematics teachers At Highlands Elementary School about their teaching in the context of a Lesson Study approach. Lesson Study groups typically included three to six teachers from the same or adjacent grade levels. They conducted two Lesson Study cycles during the 2000-01 school years. Each Lesson Study cycle consisted of studying relevant background materials, collaborative planning of a “research lesson” that was taught by one team member while others observed and collected data on students, and a post-lesson discussion in which teachers shared information and discussed implications. The results showed teachers’ desire to improve and redesign their instruction was stimulated as they saw what worked well and what was not working in their classrooms.

In the Lesson Study approach, teachers collaboratively plan, observe, and analyze actual classroom lessons, drawing out implications both for the design of specific lessons and for teaching and learning more broadly. The link between collaborative work, collegiality, and positive outcomes in schools is well established. This review of literature suggests that Lesson Study holds a potential dynamic promise of teacher change and a vision of a tool for teacher professional development.

Summary

This review starts with an examination of studies that have explored students’ and pre-and in-service teachers’ alternative conceptions related to properties of matter. The review suggests that students and pre- and in-service teachers need first-hand experiences to better develop their conceptual understanding. Teacher preparation in elementary science has undergone a major transformation over the last thirty years. However, appropriate preparation of elementary science teachers has remained an issue of concern. Since the 1990’s, high-quality professional development programs have been empirically linked to the presence of constructivist theories of learning and to the enactment of practices, including collaborative group structures. With the emergence of school-based teacher learning and other inquiry-oriented models of professional development, reflection has become a central link between theory and practice. Metaphors, cases, journals, learning maps, photoessays, portfolios and proverbs are some strategies that are used to engage teachers in

reflective environments. Research suggests that reflective activities can help teachers rethink and examine their own practice in ways which help them become better teachers. This review of literature also emphasizes the importance of Lesson Study as one approach to teacher professional development which enables teachers to construct ideas and reflect in real situations. During Lesson Study, teachers continuously engage, construct, or reconstruct their professional knowledge through their everyday routines with students, and with their reflective deliberation.

The next chapter describes the methodological framework that will help to define the research design, collection and analysis of data and its relationship to the theoretical framework.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

The purpose of this study is to examine how elementary in-service science teachers translate their understandings of Social Constructivist Learning Theory into practice. The study investigates the relationship that exists between teachers' conceptions of learning theory and their designs of lesson plans. Furthermore, the study explores how collaboration in The Lesson Study Model helps teachers understand Social Constructivist Learning Theory. This chapter will explain the design of the study and a description of research methodology as well as the qualitative methods used to gather and analyze data. The researcher first provides a rationale for using qualitative inquiry, specifically, interpretive research methodology and case study method for conducting this study. This is followed by a description of the context in which the research is situated, followed by portraits of research participants and the context of The Lesson Study Model. The chapter includes a section describing the data collection and analysis methods and process. In the last part of the chapter, the researcher discusses strategies employed to enhance trustworthiness of this study.

Methodological Framework

Methodology

All research is guided by basic belief systems based regarding ontological, epistemological, and methodological assumptions (Guba and Lincoln, 1994). A Social Constructivist philosophical stance guided the qualitative inquiry of this study. According to Social Constructivist Learning Theory, knowledge is individually constructed through social interactions and bounded within contexts (Bryman, 2001). Social Constructivist Learning Theory posits that learning and knowing are built via

active and interactive activities in a classroom (Bauersfeld, 1988; Cobb, Wood, and Yackel, 1991). In qualitative research grounded in a Social Constructivist epistemology, there are multiple, subjective realities that are socially constructed by individuals (Guba and Lincoln, 1988; Creswell, 1998; Spector and Glass, 1991). The theory of Social Constructivism argues that every human constructs unique understandings by experiencing, evaluating and interpreting the world and by merging these interpretations with their earlier interpretations of the world (Leinonen *et al.*, 2000). Thus, learners communicate by making their own interpretations of the information received. While each individual constructs his or her own notions about reality, these are socially mediated. The qualitative researcher in science education usually does not intentionally manipulate the participants or environment. Rather, qualitative researchers focus on the participants' perspectives, and on understanding the meanings they give to phenomena. The aim of qualitative research is to study the way people respond to the world, as they perceive it.

This study is based on an interpretive research methodology in science education (Erickson, 1986; Gallagher, 1991). The major aim of interpretivist researchers is to understand how the research participants interpret the social world, construct new meanings and act within a socially bounded context. In doing so, interpretivist researchers must immerse themselves in the natural setting in which the participant is involved and try to discover and understand how he/she constructs social meanings. In the case of this particular study, the researcher began with the expectation that each individual would have her own unique views about student learning. The challenge was to find evidence of individual teachers' practical knowledge about Social Constructivist Learning Theory. This study is particularly amenable to a qualitative research design because the researcher is seeking to ascertain the subjective perceptions of elementary science teachers. The researcher does not assemble variables to manipulate. Rather, the researcher gathers data in the form of observations, interviews and documents, and then analyzes these data to identify what the researcher perceives to be recurring patterns, or categories, which explain the data.

Methods of the Study

The case study method is generally used in education to gain an in-depth understanding of the situation and its meaning for those involved. The context and phenomena of interest is the focus rather than a specific variable within. The term “case study” has been used to describe a qualitative research method that results in an intense and holistic description and analysis of an event or social unit. According to Yin (1994), case study is a term used to describe a research process of empirical inquiry that “investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 1994: 13). Stake (1994: 242) wrote “qualitative case study is characterized by the main researcher spending substantial time, on site, personally in contact with activities and operations of the case, reflecting, revising meanings of what is going on”. Another aspect of case study method is the dependence on multiple data sources (interviews, observations, examinations of records and documents, and evaluation tools) and the use of “thick description” (Merriam, 1998). Data necessary for “thick description” are collected through intense interviewing and participant observations.

Given that this study aimed to explore in-depth teachers’ practical knowledge of Social Constructivist Learning Theory, a case study appeared to be most appropriate for this purpose. The data are embedded in three participants and their experiences within a professional development teaching learning context and their subsequent classroom teaching. Carter (1990) suggested that case study method can be used to tap sources of teacher knowledge and ways of thinking about learning to teach.

Context of the Study

School Context

This study took place in a large suburban school district in the second educational area of Nonthaburi province. The second educational area system is comprised of 151 schools serving over 102,545 students in grade K-12 in both private and public school. The normal organizational structure of all schools in this province is based on two-semester system per year. The first semester spanned from May to September. The second semester spanned from November to March. All school systems outlined school holidays were Buddhist religious days and Royal holidays.

This research was carried out within Koonatum School (pseudonym) which was one of the public elementary schools in Pakkret district in the second educational area of Nonthaburi province. Koonatum School was founded in 1933 and has enjoyed tremendous support from its neighborhood district throughout its 74-year history. In 1996, the school was extended to include the middle school level. Some community resources like Nonthaburi local government have provided the school with funds for buildings and a playground. The student enrollment of the Koonatum School in the 2006-2007 academic years was 570. There were 19 teachers who were hired by the center government. The school had several substitutes after the regular teacher had to leave due to retirement including: 7 teachers hired by Nonthaburi local government, 4 teachers hired by Pakkret local government and 2 teachers hired by the educational service area. The classrooms contained 30-35 students which each level consisting of students in two classrooms.

Koonatum School had a sports field, playground, language laboratory, computer room, library, and science laboratory room. This school was situated in a suburban area surrounded with middle class housing, apartments, rented homes, factories, a market and a temple. Almost all students and teachers in this school practiced the Buddhist religion, although there were a few Christian and Muslim families. People who lived around the school still maintained religious customs such

as doing merit by giving monks food, and donating and celebrating Buddhist holidays. Most students came from low socioeconomic families whose parents did not have high education and were workers, employees in factories or merchants. It appeared as though parents did not have much time to pay attention to their children's education. Many students did not live originally in the vicinity of the school community, but rather moved from other areas following parents who were migratory workers.

With respect to teaching and learning science, the science subject appeared in all study levels. Science content was taught based on the National Science Curriculum Standards. The teachers who were responsible for teaching science also taught in other subject areas such as mathematics, social science or art. The teachers did not write lesson plans for all subjects. The principals allowed them to write lesson plans only for the subjects that they were interested in.

Participants

As a qualitative case study, the type of sampling selected for this study is purposeful sampling. Purposeful sampling (Patton, 2002) is the appropriate and logical technique to select a sample that provides a prototype and yields in-depth understanding rather than generalization from the sample to a larger population. The study included a total of three participants who were elementary science teachers teaching at Koonatum School in Nonthaburi province. The teachers were recruited through consent letters sent to the school principal. The principal allowed the three teachers to participate in a five month Lesson Study Model of professional development conducted in the second semester of the 2007 academic year. The three participants had been varying backgrounds. The pseudonyms that were used to represent the elementary in-service science teachers' names were Duangjai, Somsri and Palita.

Duangjai. Duangjai was 38 years old and was born and raised in a small rural district of Nakhon Ratchasima province. She attended elementary school and high school in the same region. Duangjai loved to teach. When she was young, she played

with her friends pretending to be a teacher by writing on a blackboard and giving her friends homework. Duangjai studied at the institute of teacher preparation at Ratchaburi province for four years. Her major was Thai Language Teaching. After the completion of her bachelor's degree, she started her teaching career in a metropolitan elementary private school in Bangkok. Duangjai worked there for three years until she passed the government examination and was hired by center government in the elementary public school at Nakhon Ratchasima province where she taught for nine years. After getting married and having three daughters currently studying in grade eight, five and two, her husband and her decided to move to Nonthaburi province in 2003. Duangjai started teaching at Koonatum School in the elementary level in grade one and two. In 2005, she decided to study for the master's degree in Curriculum and Instruction at Rajchapat University. At the time of this study, she was teaching science in grade 1 and mathematics in grade 2.

Duangjai had teaching experience at the elementary level for sixteen years in mathematics, Thai language, and social science. However, she had not taught much science before this study. After she moved to Koonatum School, she was assigned to teach science in forth grade for two semesters of the 2005 academic year. At that time, she was not happy because she did not want to teach science. She felt that she was compelled to teach science. Teaching science for her was a difficult task. She did not know the science content and teaching methods. Duangjai was an enthusiastic teacher. She wanted to learn and try something new in her classroom. She decided to join the teacher professional development program because she wanted to develop her career as a professional.

Somsri. Somsri was a female elementary teacher working with fifth grade at Koonatum School. Her age was 49. She was born and studied in elementary school and attended high school in Tak province. She attended the institute for teacher preparation at Kamphaeng Phet. Her major was home economics teaching. After Somsri completed college, she passed the government examination and started her teaching career in an elementary school in Tak. Somsri taught in Tak for two years. After getting married and having one daughter, Somsri moved following her husband to Nonthaburi province. She taught in an elementary school in Nonthaburi for six

years. She moved following her husband again and taught at an elementary school in Ranong province. Somsri taught at Ranong for six years before she moved back to Nonthaburi province. Since moving back to Nonthaburi she has taught at Koonatum School since 1994. Somsri had teaching experience at the elementary level for 27 years. She taught science for 13 of those years. After she moved to Koonatum school, she was assigned to teach science in grade five and social science at the middle school level. Somsri decided to join the teacher professional development program because she wanted to receive some experiences that would guide her in doing classroom research to get a promotion in the future.

Palita. Palita was born and raised in Bangkok. Her age was 55. She received her education from the elementary level through college in Bangkok. She graduated with a degree in social science teaching. Palita started her career as a teacher after she passed the government examination. She taught in Nonthaburi province in one elementary school for two years. She moved to teach in Koonatum School in 1965 and has taught in the elementary level for 20 years. Palita taught Thai language at the elementary level. In 1996, when school expanded to the middle school level, Palita had responsibility for teaching Thai language at this level because the school did not have enough teachers. In 2004, the grade six science teacher left the school. Palita was assigned to teach science in grade six.

Palita had 32 years of previous teaching experience and had taught science for 4 years. She was a successful teacher in terms of her teaching career, having received promotions to skillful positions in the Thai education system. Palita decided to join the teacher professional development program and wanted to receive some new experiences because she had not participated in any training course for science teaching in three years.

Professional Development Context

Collaboration among teachers has been identified as one of the most important features of a school culture that fosters professional development. Most

school cultures are characterized by individualism, isolation and feelings of insecurity that can lead to competition, and a lack of desire to share ideas (Joyce, Bennertt and Rolheiser, 1990; Short, 1992; Gersten *et al.*, 1995). Many studies indicate that Lesson Study may lead teachers to collaborate. Lesson Study can help teachers engage in a new way of talking about science teaching and learning.

The heart of the Lesson Study process is as follows: first, a topic is chosen by a group of three to five teachers. Teachers usually of the same grade level, meet regularly to collaboratively plan Lesson Study in a small group. However, for this study, teachers in the group were not in the same grade level because there were just two teachers at the same grade level in the context of the research site. Furthermore, teachers at Koonatum Elementary School do not teach only science or in the same grade every year. In Thailand, teachers typically change grade levels from year to year. Therefore, The Lesson Study Model in this study was comprised of teachers who were teaching different grade levels (grade 1, 5 and 6). However, the diversity of the group helped teachers broaden the ideas about teaching and content knowledge and also prepared them to teach science at other levels. Second, after teachers had collaboratively produced a lesson plan, one of them taught this lesson in the classroom while the other teachers observed and took notes. Following the lesson, all teachers met to share and give feedback in a debriefing session. Often, but not always, teachers then revised the lesson again, and shared the results.

Before new teaching pedagogies can be designed or translated into practice, teachers need to learn the underpinning theory. In this study, the teachers were invited to participate in a 2-day workshop and were provided a small stipend for attending. During the workshop, the teachers learned theoretical principles and engaged in activities related to Social Constructivist Learning Theory. The workshop was assigned to help them understand the theory and apply it in their lesson plans and teaching practices. Therefore, this teacher professional development experience, The Lesson Study Model, was composed of three phases including: Phase I: Workshop; Phase II: Teacher collaborative lesson planning and Phase III: Teacher practice in the classroom. The overall setting for the study was one elementary public school in

Nonthaburi province. In this study, teacher learning was situated within a model of professional development known as Lesson Study. This model was composed of objectives, assumptions, and procedures which are described below.

Objectives. There were two objectives at the heart of The Lesson Study Model.

1. To enhance in-service elementary science teachers' understanding of learning theories, specifically Social Constructivist epistemology.
2. To support and encourage in-service elementary science teachers to translate understandings of learning theories into practice.

Assumptions. The Lesson Study Model was based on fundamental assumptions about teacher learning which include the following:

1. Teachers desire to increase their knowledge and want to improve their profession. They want to take what they learn back to the classroom.
2. Teachers are competent professionals who know how to teach their students and understand appropriate curriculum for their classroom.
3. Teachers learn by constructing their own knowledge through active learner and social interaction.
 - 3.1 Teachers become science learners as students. Teachers increase their content and pedagogical knowledge from experiences by doing activities that challenge their own level of competence.
 - 3.2 Collaborative activities provide teachers with numerous opportunities to learn from other teachers in and outside of their school.

4. Teachers can grow professionally and be motivated to use more effective practices through the Lesson Study Approach.

5. The Lesson Study Model can fit with all participating teachers interested in the same goal.

Procedures

Phase I: Workshop. The objective of this phase was to educate participants about Social Constructivist Learning Theory with respect to five basic tenets: the role of students, the role of prior knowledge, the role of teacher, group work and discussion (appendix A 1). The teacher learning centered around a workshop which consisted of two days and ten hours of activities. The workshop occurred during the first semester break in October, 2007. During the semester break, the participants were released from teaching responsibilities and first had some time with their family to relax outside of school. The workshop was conducted in a university with a medium size lab classroom. The instructional team consisted of elementary teachers, a science educator, and a researcher. All of them were in the classroom throughout the course. The administrator of the school was invited to participate in this program as an observer in order to make him aware of the nature of this science teacher professional development experience.

The workshop was designed for elementary teachers and concepts related to the properties of matter science were addressed in the workshop. The workshop used activities based on Social Constructivist Learning Theory as a basis for fostering teachers' understanding of the five aspects of Social Constructivist Learning Theory and how to apply them to classroom teaching. The learning environment was highly interactive and supportive of hand-on/mind-on learning. Participants had an opportunity to collaborate and reflect on activities. The activities in the workshop were conducted through both individual and group work. As noted in the review of literature, short workshops are not typically effective in fostering teacher learning where connections are built between what was learned and application in the real

classroom setting. Short workshops are not long enough to truly develop teachers' professional growth (Shields, Marsh, and Adelman, 1998; Weiss *et al.*, 1998; Kayler, 2003). Therefore, this study tried to reduce this shortcoming by extending the professional growth opportunities for participants through Phase II: Teacher collaborative lesson planning and Phase III: Teacher practice in the classroom.

The workshop was composed of 12 activities included building rapport, introducing the program, measuring teachers' understanding of teaching and learning, and activities which modeled lessons on the topic of properties of matter consistent with the tenants of Social Constructivism. The researcher introduced and engaged teachers in activities. The teachers became students and learned in the same way that students might learn in the classroom. The activities actively involved the participants. The activities were designed to help participants understand content and learning theory and provide them with an overview of how learning theory could be incorporated into the design their of lesson plans. The activities in this phase were also intended to help the teachers recognize the importance of learning theory in designing lesson plans and teaching. A brief summary of activities is provided below and an outline and scope of this workshop are provided in appendix B 1.

Activity I: My Mask. The teachers and researcher initially participated in a Mask activity together. This activity was designed to relax participants, informally introduce them to each other and built rapport between researcher and participants. Teachers and the researcher created their own mask. They selected a face and different eyes, nose, mouth and hair correlate to their background information such as highest education degree, science teaching experience, birth-place, pet owned, and right or left handedness in writing. This activity was also designed to model the process of data collection and analysis. In doing so, teachers and researcher introduced each other by using information represented on their completed masks. Teachers and researcher not only had interaction together but also learned science process skills through this activity.

Activity II: Introduction to the Teacher Professional Development Experience. For an effective teacher professional development, participants should know and understand the objectives and the sequence of activities of the program. An introduction to the program should help teachers know and recognize the behaviors which will help them learn through participation in professional development experiences. In this activity, the researcher formally introduced herself and provided an overview of the teacher professional development program including objectives, overview, financial details, expected outcomes of program participation, and a chance for participants to ask questions.

Activity III: Written Reactions to Learning Theories Vignettes. The objective of this activity was to explore the understandings of elementary teachers about science teaching and learning before they attended the workshop. The notion of Social Constructivist Learning Theory vignettes was introduced to the teachers. Using the vignettes, teachers read the story of another teacher, reflected on multiples dilemmas represented, and suggested various ways that the teacher in the story might solve the dilemmas. The central themes of each vignette were designed based on five aspects of Social Constructivist Learning Theory (appendix C).

Activity IV: How do Elementary Students Learn Science? The purpose of this activity was to explore the understanding of elementary teachers about student learning before they attended the workshop. In this activity, participants discussed and shared their own ideas with peers after they reflected their own thinking about student learning. The activity was intended to broaden teachers' mind and helped them rethink and compare their ideas to those of others. Furthermore, in this activity, teachers had a chance to review their understandings of students' learning.

Activity V: Describe the Story from the Pictures. In this activity, participants worked in groups to arrange pictures of a modified story of Little Red Riding Hood in order and narrate the story from those pictures. Thirteen pictures were given to the teachers. Each group of teachers was asked to construct a story from those pictures. Teachers observed the clues in the pictures and used their prior

knowledge to sequence them and construct to the story. This activity was designed to help participants feel familiar with working in groups, motivate them to participate in discussion and energize and prepare them to focus individually and as a group for activities that would follow. The goal was for teachers to learn the importance of group work and discussion and also realize that prior knowledge had an influence on their decisions. The activity also reinforced the idea that multiple interpretations of data highlight the subjective nature of science.

Activity VI: What I Know and What I Want to Know. In this activity, participants developed a KWL chart (what I *Know*/ what I *Want* to know/ what I *Learned*) to reflect on their prior knowledge about properties of matter. Teachers individually reflected on what they knew, and what they wanted to know about properties of matter. They also reflected on what they had learned about this topic after they completed doing activities in the workshop. Teachers then expressed and compared their ideas with peers in group. This activity was intended to help teachers learn the technique of KWL as a tool for ascertaining prior knowledge and student interest or for evaluation.

Activity VII: What do You Call Me? In the activity, teachers learned about concepts of matter, energy, objects and materials. They also had an opportunity to learn how to use prior knowledge to design a teaching activity. The researcher distributed a flashlight, fan, wood doll, wood, and plastic to teachers. Teachers worked in groups touching materials and using their prior knowledge to categorize these objects. The goal was for teachers to learn the importance of ascertaining prior knowledge in designing teaching activities.

Activity VIII: Categorizing Matter. In this activity, teachers had experience doing an activity with a group and learned about the concepts of physical properties and states of matter. The activity started by teachers putting five things of their choice in a shoe box. The researcher then discussed with teachers about their prior knowledge of physical properties such as figure, color, and materials and also asked them to categorize the five things by using the physical properties. The

researcher distributed a bottle of water and plastic cup to teachers for observing the physical properties of water. After that, teachers were asked to select three things from the shoe box and put them on a table for classifying using a Venn diagram. Teachers were asked to categorize water in the bottle and three things that they selected in relation to states of matter. The researcher then distributed a balloon filled with air to teachers and asked them to categorize this by using states of matter. The objects were categorized using a Venn diagram because some of them had two states such as the bottle of water and the air in the balloon. At the end of activity, the teachers and researcher discussed the activity in terms of how it linked to the role of teacher and role of student, to help the teachers reflect on students as active learner and teacher as facilitator as possible metaphors.

Activity IX: Making Monsters. In this activity, participants worked in groups to create a monster and conducted a test on three different monster formulas in order to find which formula would make the strongest monster. The teachers had a chance to work with a group and discuss with peers how to choose the best formula. After teachers finished the activity, they learned the testing methods of physical properties; this sequence was consistent with Social Constructivist Learning Theory. The teachers and researcher also discussed the aspects of Social Constructivist Learning Theory that appeared in the activity including: the role of student, the role of teacher, the role of prior knowledge, group work and discussion. In this activity, teachers not only learned science content but also learned about Social Constructivist Learning Theory.

Activity X: Mysterious M&M's. In this activity, teacher worked in groups to explore the physical properties of M&M's and designed an experiment for testing their hypothesis about dissolving. First, teachers explored dissolving following the commercial slogan that "M&M's dissolve in your mouth but not in hand". The teachers tried to dissolve M&M's in water. They placed M&M's in a dish that had water and observed changing of the sugar and color coating. The color spread out in a circular pattern around the M&M. Teachers compared their results with other groups and discussed explanations for the results. After that, the researcher posed the

question of what would happen if the M&M's were placed in a different environment. Teachers created a hypothesis and designed and conducted an experiment to explore this question. In this activity, teacher learned about the concept of dissolving, identifying and controlling variables and designing a fair test. The teachers had an opportunity to discuss and reflect their thinking about this activity in relation to aspects of Social Constructivist Learning Theory.

Activity XI: How do Elementary Students Learn Science? The objective of activity was to explore the understanding of elementary teachers about student learning after they attended the workshop. In this activity, participants discussed and shared their own ideas with others after they reflected on their own thinking about student learning. The activity was intended to broaden teachers' ideas and help them rethink and compare their ideas to those of others. Furthermore, in this activity, teachers had a chance to review their understandings of students' learning.

Activity XII: Written Reactions to Learning Theories Vignettes. The objective of this activity was to explore the understanding of elementary teachers about science teaching and learning after they attended the workshop. Teachers revisited the Social Constructivist learning theories vignettes. They read the story of another teacher, discussed the dilemmas and reflected on their own suggestions for how the teacher in the story might solve the dilemmas. The questions and answers accompanying the vignettes were designed based on five aspects of Social Constructivist Learning Theory.

Phase II: Teacher Collaborative Lesson Planning. The second phase of this professional development program took place after the first semester during the October break with the goal of preparing teachers to teach about properties of matter based on Social Constructivist Learning Theory in the second semester. Three teachers from grades 1, 5 and 6 were asked to plan two lesson plans related to the topic of properties of matter and based on Social Constructivist Learning Theory. Each of them chose two topics depending on their responsibilities of teaching in different grades. Duangjai taught grade1. She was interested in developing lessons

about the physical properties of toy and tools such as color, figure, size, surface and materials. Somsri was a grade 5 teacher. She was interested in developing lessons about physical properties of matter such as hardness and elasticity. Palita was a grade 6 teacher who developed lesson plans about the properties of states of matter and the changing states of matter. The teachers collaboratively designed their lesson plans based on their understanding of Social Constructivist Learning Theory with their peers. They discussed their lesson plans with peers and researcher regarding what aspects of Socioconstructivist Learning Theory they used and how these were reflected in their lesson plans.

Phase III: Teacher Practice in the Classroom. Teachers in each grade (grade 1, 5, 6) who participated in the workshop and lesson plan section (Phase I: Workshop and Phase II: Teacher collaborative lesson planning) implemented their lesson plans in the classroom and participated in team meetings after teaching. The teaching and meetings took place during the second semester from November to February. This phase consisted of a) teaching lesson plans b) meeting after teaching and revising lesson plans c) re-teaching lesson plans d) meeting after re-teaching. In this phase, teachers had opportunities to work in groups and collaborate with other teachers who taught in the same school. While the lesson was being taught by one teacher, the other teachers would observe and take notes on what the students and teacher did and said. After teaching, all teachers would meet as a group and critically discuss in-depth what was observed during the teaching of the lesson. They also provided suggestions for improving the lessons. Then, teachers collaboratively revised the lesson plan based on their reflections and evaluation. The revised lesson plan was taught in a different classroom and observed again. All teachers completed their teaching and attended the meetings for both lesson plans.

Data Construction Methods

Prior to beginning the data collection process, the researcher met with all of the participants individually to explain the study and with the school administrator to obtain the consent to conduct the study. When the teachers agreed to participate in

the study, the researcher sent the consent letter to the Dean of the Department of Education, Kasetsart University for approval. After the researcher obtained consent from the department, a consent letter was sent to the school. At that time, each participant received a copy of the consent form.

The data collection period started with Phase I: Workshop in October, 2007 and lasted for a second semester of that academic year. Multiple data sources were used during the research process in order to provide the basis for the triangulation of findings. The methods that were used to collect data included written reactions to learning theory vignettes, individual interviews, classroom observations, lesson plans, and focus group discussions. By using many data sources, it ensured that a deeper understanding of meaning might occur. Data were verified and triangulated across sources. These data collection methods were detailed as follows.

Written Reactions to Learning Theory Vignettes

A vignette is a picture or description of a situation which can have a problem scenario or not (Miles, 1987). In some cases, vignettes are written, while in other cases, they are audio and/or visual representations of a “live” classroom (Akaishi and Saul, 1991; Smith, 1994). In many instances, the vignette represents an ideal of what is real and creates an opportunity to discuss issues surrounding teaching and learning. Vignettes are “tools that can promote discussion, engage diverse perspectives, and explore critical issues of science teaching and learning” (Koballa and Tippins, 2000: 8). Content specific vignettes bring the areas of content and pedagogy together to help inform teachers about the subtleties of teaching specific topics. When using for this purpose, vignettes capture the context of teaching. Vignettes have been used for many educational purposes: to investigate individual’s ethical principles and behavior (Lampe and Walsh, 1992); in the context of teacher in-service workshops for professional development (Lieberman, 1987; Smith, 1994; Walen and Williams, 1995); in teacher education courses (Hatfield and Frederick, 1991; Stivers, 1991; White and McNergney, 1991) and as tools in qualitative research (Lieberman, 1987; Miles, 1987).

For the purpose of this study, vignettes were constructed as a tool to reveal in-service elementary science teachers' knowledge/ belief about Social Constructivist Learning Theory. Several researchers have suggested processes for creating vignettes (Lieberman, 1987; Miles, 1987; Stivers, 1991; Walen and Williams, 1995). The vignettes developed in this study began with a description of a teaching and learning process in the classroom followed by a set of alternative choices regarding Social Constructivist Learning Theory. The learning and teaching process presented in the vignettes reflected the researcher's own experiences with students, teaching, lesson planning, discipline, and assessment. The content of the vignettes came from topics related to properties of matter that are found in National Science Curriculum Standards of elementary level education (IPST, 2001). The vignettes developed for this study were intended to promote thoughtful reflection about potentially problematic incidents that could easily happen in any teachers' classroom. Teachers' written reactions to learning theory vignettes were collected in Activity III and XII: Written reactions to learning theory vignettes. The written reactions to Social Constructivist Learning Theory vignettes are located in appendix C.

Individual Interviews

Kvale (1996) states that interview is one of the most common and powerful ways used for understanding the world from the subjects' point of view. Interview helps to unfold the meaning of people' experiences, and uncover their lived world. According to Shore (1986) an interview elicits actual thoughts of research participants. The interview provides external information on what people, interviewees, are thinking internally. Interview is an effective way to understand what teachers know, and what they do and why from their perspectives. In other words, because we cannot observe everything we might want to know, interviews can provide access to the context of teachers' action (Seidman, 1998), and thereby provide a way for understanding the meaning of that action.

Three common types of interviews, distinguished based on the amount of structure, include structured, semi-structured and unstructured interview (Bryman,

2001). Each technique has strengths and weakness which serve a different purpose. A structured interview is similar to an oral survey in the form of a questionnaire or checklist, and consists of a set of questions with the intention of talking to each respondent through the same sequence of the same questions (Patton, 1990). The structured interview has higher validity and reliability than other types of interviews and also saves time at the analysis stage. However, it reduces flexibility and spontaneity (Patton, 1990). The researcher may not be allowed access the participants' perspectives and understandings of the world. The unstructured interview is similar to an ordinary conversation and consists of open-ended questions which are flexible and exploratory. The interviewer may start with one question and ask the interviewee to respond freely. Questions in the unstructured interview may be changed over time and move in new directions for seeking elucidations and elaborations from participants. The unstructured interview allows the interviewer to be highly responsive to individual difference and situational changes. It is helpful when the researcher does not know much about a phenomena and the interviewee may not realize that they are being interviewed. However, it is time consuming and difficult to analyze because of the variety of data and individual differences. The semi-structured interview has mixed characteristics with the structured and unstructured interview. A list of questions may not follow exactly, but they are prepared as an interview guide to make sure that all relevant topics are covered. The semi-structured interview allows the researcher to access a more in-depth view of interviewee's perspectives.

In this study, interviews provided baseline data about participants' teaching knowledge/belief and reasons for using instructional strategies in their classroom. The study used semi-structured interviews with more open-ended and less structured questions. The benefit of the less structured interview was that the researcher could respond to individuals in unique ways. During the interviews, the researcher could probe interesting emerging issues further, and adapt the interview questions to the specific context. This approach allowed the researcher to move beyond her own experiences and ideas and to better understand the teachers' points of view.

Interviews were conducted at the research site between October, 2007 and February, 2008. These interviews took place in each teacher's office at the research site during the school hours. The interviews lasted from thirty minutes to one hour. The researcher spoke to each participant individually. Interviews were conducted after teachers taught lesson plans and revised lesson plans. The researcher interviewed each teacher about their teaching lesson. These interviews focused on teachers' understanding of Social Constructivist Learning, how they taught, the pedagogical strategies they used in their teaching and the benefits and challenges they perceived in applying Social Constructivist Learning Theory to their practice. The semi-structured interview protocol is included in appendix D. The researcher tried to conduct successful interviews by attempting to ask critical questions and interpreting meanings during the interview. All interviews were audiotape recorded and transcribed. The interview as transcribed word for word so that the essence of meaning was maintained to ensure accuracy in data analysis. To protect participant anonymity and confidentiality, pseudonyms were used throughout the research process.

Classroom Observations

The translation of teachers' knowledge/belief about Social Constructivist Learning Theory into classroom practice was clearly a critical aspect of this study. What teachers said they did was not always reflective of what they actually did. Since teachers could not verbalize all of their practice, the researcher felt that what they knew might also be uncovered better from observation of their performances. According to Van Driel *et al.* (2001) teachers' actions are a more accurate representation of what they know and believe than the usual array of self-report measures. Therefore, classroom observation was necessary to examine teachers' practical knowledge about Social Constructivist Learning Theory. It enabled the researcher to understand the educational environment, the interaction between teachers and students, between students and students, and the pedagogical approach taken in the classroom.

According to Patton (1990), it is impossible to observe everything therefore an observer has to have a framework for observation to make manageable the complex reality observed. The researcher wanted to understand how teachers' knowledge/belief about Social Constructivist Learning Theory transferred into classroom practice. Therefore, the researchers' observations were guided by three target elements corresponding to five essential features of a Social Constructivist classroom:

(a) Science content representations used in teaching

(b) Interactions with students

- Motivating students to asking questions
- Linking students' prior knowledge to instruction
- Responding appropriately to individual students while teaching

(c) Classroom implementation

- Instructional strategies
- Student-centered instruction
- Collaboration between students

The researcher collected data from observations in Phase III: Teacher practice in the classroom between November 2007 and February 2008. In this regard, the researcher observed two lesson plans for each elementary science teacher using a non-participant observation method. The researcher observed each lesson twice: one time before revisions to the lesson plan and one time after revisions to the lesson plan. Observations of a full sixty minute class session were carried out for each participant in her classroom. During the participants' teaching, the researcher took field notes. The field notes consisted of four columns including time, descriptive notes, methodological notes and theoretical interpretations. The time column was concerned with how long the classroom activities and interaction took. The descriptive notes described what was going on in the classroom (e.g. activity, conversation, quotes and questions made by teachers and students). The methodological notes described

aspects related to the research methods themselves. The interpretations were made by the researcher in the context of how the teachers taught their lesson plans based on Social Constructivist Learning Theory. Appendix E shows an example of field notes. The field notes also provided data to support or refute what the participants had mentioned about their teaching during the interview.

Teachers' Lesson Plans

Document review is another method of data gathering which can overcome some limitations of interviews and observations. Documents cover a wide range of written, visual and physical materials that relate to the research (Merriam, 1998). They can be diaries, journals, lesson plans, home videos and so on. Documents are reliable and stable sources of information which are almost always available. In this study, lesson plans and revised lesson plans were reviewed in the context of the use and presence of Social Constructivist Learning Theory. The researcher collected data from teachers' lesson plans in order to compare and analyze changes in teachers' understanding of Social Constructivist Learning Theory. The lesson plans were examined in Phase II: Teacher collaborative lesson planning.

Focus Group Discussions

Through the discourse of teachers interacting with each other, new learning experiences are opened to them (Roth and Alexander 1997). In a focus group discussion, participants are brought together to discuss a specific topic to investigate. They learn together and from each other through participating in common activities and developing a common discourse. In this study, participants were assigned to a specific discussion group in Phase III: Teacher practice in the classroom which occurred between November 2007 and February 2008. In this regard, the teachers engaged in meetings in order to discuss the teaching and learning processes that they observed. Teachers reflected and collaboratively revised lesson plans. Conversations between teachers were audio recorded and collected as participants talk together in the

above activities. All discussions were transcribed from the discourse captured from the tape.

Data Analysis

The process of data analysis for answering the research questions was simultaneously conducted using within-case and cross-case analysis. All text data from data sources (written reactions to learning theory vignettes, interview transcripts, field notes, teacher lesson plans focus group discussion,) were analyzed by qualitative content analysis. This method is a general method of analysis which is purely descriptive. The steps used in this process were as follows:

- 1) The documents are read line by line.
- 2) Coding occurs for units of general meaning.
- 3) The development of coding categories are established based upon the units of meaning and their relationship to the research questions.
- 4) Analytical and methodological notes are used to help in the interpretive process (Glaser and Strauss, 1967).
- 5) Categories are defined and clustered together for additional meaning and data representation.
- 6) The interpretation process begins with the category definitions from the ethic perspective, the data representations, and the analytical notes.
- 7) The categories are constantly compared within three participants.
- 8) The clusters of categories help to diagram a scheme which represents findings relevant to the research questions (Strauss, 1987).

When the time came to complete the cross-case analysis, the relevant themes that emerged with respect to each participant were summarized by research question and then the data regarding each question from all three participants was reread several times. Common themes across participants within each research question were identified and listed in order of decreasing commonality. These became the sources of the broader themes discussed in Chapter V.

Trustworthiness of the Study

To establish trustworthiness of interpretive research, Lincoln and Guba (1985) propose four criteria; credibility, transferability, dependability and conformability. The credibility in this study refers to the extent to which the findings of the interpretive study can be approved to be true for the subjects of the study. Several techniques for increasing credibility such as prolonged engagement and triangulation were conducted to enhance credibility in this research. Prolonged engagement helps to prevent misinformation and establish rapport between researcher and participants, which assists the researcher with immersing in and understanding the context. The researcher immersed herself for a substantial period of time in the natural setting in which participants were involved and tried to build trust and learn about participants' meaning. In this study, the researcher initially took on the role of an instructor to introduce the concept of Social Constructivist Learning Theory and then followed the participants' planning and teaching during the Lesson Study process and in their elementary classrooms. Another technique used to increase credibility involves the triangulation of data and methods in order to enhance confidence in the ensuring findings. Triangulation involves the researchers' attempt to explain the richness and complexity of human meanings and actions by studying them from more than one data source and data collection method. In this study, the data were collected from different sources using different data collection methods.

The degree of transferability is determined by the similarity or fit between two research contexts. In interpretive research, it is important to provide sufficient information of the context for other researchers who want to transfer research findings or make judgment of transferability. In this study, to establish transferability, the

researcher provided a thick description of the specific context and what was learned through the Lesson Study process throughout the study. The school and classroom environment, background of teachers, and other factors affecting teaching and learning were described in detail so that readers could evaluate the feasibility of applying the study to their own situation.

For dependability, a qualitative research view of reliability is based on the assumption of replicability. It is concerned with whether we would obtain the same results if we could observe the same thing twice. However, it can't actually measure the same thing. Thus the idea of dependability involves the researcher describing the changes that occur in the setting and how these changes affect the way the researcher approaches the study. To address dependability in this study, the researcher reported any changes during the professional development program so that readers could understand what factors in the context directed the researcher to decide and interpret in a particular manner during the process. Moreover, the process of conducting research, which covers the research design, the selection of participants, data collection methods, data analyses, the interpretations of data and the researcher's biases, were monitored and audited within the continuous meetings with other experts.

Confirmability refers to the degree to which the results can be confirmed or corroborated by others. The constructions, assertions and facts that were presented in this study were tracked to their source. The technique of member validation was used to address confirmability, in which the respondent was given a copy of the observations or interview to provide feedback. The participants were asked to correct error of facts or errors of interpretation and offer additional information leading to further illumination of a given construction.

Summary

To answer the research questions, interpretive research was used to make sense of teachers' understanding of Social Constructivist Learning Theory oriented within a professional development program. In this study, three teachers participated

in a case study designed to develop an in-depth understanding of their knowledge and practice. This method of study used a number of data gathering techniques to ascertain elementary science teachers' understanding of Social Constructivist Learning Theory and its translation into practice. Data construction methods such as vignettes were used to examine the participants' beliefs before and after they participated in the workshop. Classroom observation, individual interview, focus group discussion and teachers' lesson plans were utilized to study the development of teachers' understanding while they are interacting with instructional strategies and materials during the professional development experience (The Lesson Study Model). Analysis of data from these different sources, prolonged engagement, triangulation and respondent checking were undertaken to enhance the trustworthiness of the research outcomes.

This chapter described the methodological theoretical framework and the methodology employed in this research. It included a description of the research design and procedures for the study. This chapter also included data collection and data analysis procedures. Results obtained from the data were analyzed and are presented in the next chapter. Chapter IV Results of the Study will present what happened when elementary science teachers engaged with Social Constructivist Learning Theory in the teaching and learning process.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

This chapter presents case studies of three elementary teachers. Each teacher's background information and their understanding of Social Constructivist Learning Theory are initially presented. The section that follows illustrates the translation of Social Constructivist Learning Theory into practice. In this part, results are presented in terms of the three sections: 1) the integration of Social Constructivist Learning Theory into science lesson plans, 2) translation of theoretical understandings into teaching practice, and 3) explication of pedagogical strategies. Additionally, the nature of collaboration between elementary teachers during Lesson Study meeting is described. Finally, the advantages and challenges that elementary teachers perceived when they tried to apply Social Constructivist Learning Theory in their classroom are presented. Throughout this chapter, pseudonyms were used to represent the elementary science teachers' names, that is, Ms. Duangjai, Ms. Somsri, and Ms. Palita.

Case I: Ms. Duangjai

General Background of Duangjai

Duangjai was a female elementary teacher working with first and second grade students at one of the suburban public schools in the second educational area in Nonthaburi province. Her age is 38. Duangjai earned her bachelors degree from the institute of teacher preparation at Ratchaburi province majoring in Thai Language Teaching. During the past two years, she went back to school to study for her Master's degree in Curriculum and Instruction from Rajchapat University. She decided to study for a master's degree to further develop her teaching ability and gain the skills and credentials needed to apply for a promotion.

Duangjai was an experienced teacher with sixteen years of teaching to her credit. She used to teach in an urban elementary private school in Bangkok for three years as well as a rural elementary public school in Nakhon Ratchasima for nine years. Duangjai has taught in suburban public schools in the second educational area in Nonthaburi province for three years. However, her experience teaching science was limited. Two years previous to this study, she taught elementary science for two semesters in grade four of one academic year. During the semester of this study, Duangjai was asked to spend 20 hours teaching on a block schedule everyday. Her teaching responsibilities included the subjects of Mathematics, Art and Science. She was responsible for teaching science for two classes of grade 1; there were 30 students in each class. Most of the students in both classes came from low socioeconomic families whose parents were migratory workers moving from one province to another. Most of them had low achievement scores in science. Duangjai also had other responsibilities at the school. For example, she made school signboards for exhibitions and activities, cooked lunch and distributed food to students.

Duangjai did not want to teach science. Teaching science for her was a difficult task. She did not know how to design activities or prepare educational materials for students. She taught science by using the textbook, and students did not do many activities. Duangjai primarily had students copy concepts which appeared on the blackboard. She expressed her feelings about teaching science in an interview, explaining:

...I taught science two years ago in grade 4. I also think that this year I won't teach science. Anyway they told me to teach. I'm not a science teacher, but they commanded me to teach science. I have no choices. I'm not a good teacher. I do not prepare lessons before I teach. I don't know how to prepare them. I heard from my friends who teach science that science is a fun subject. Students do experiments and have fun. But I don't know what I should prepare for my students. I have taught by using an elementary science book. I am not good. I taught science and tried to get it done in every period. Students learned from textbook and also wrote my explanation which showed on blackboard in

their note books. They did not do many activities... (Duangjai's interview after teaching lesson plan I: November, 2007)

When the researcher offered her the opportunity to participate in a professional development experience, she agreed immediately. She felt she was fortunate to be able to participate and learn about teaching science in relation to Social Constructivist Learning Theory. She believed that professional development was important, and would provide her with an opportunity to learn how to develop her students' progress throughout an entire school year.

Duangjai's Evolving Understanding of Social Constructivist Learning Theory

This section is a discussion of Duangjai's emergent understanding of Social Constructivist Learning Theory at different points of the teacher professional development experience: before she attended a workshop, after she attended a workshop and after teaching and re-teaching two lessons. The development of her knowledge base is presented by considering her understanding of the five key aspects of Social Constructivist Learning Theory: the role of students, the role of prior knowledge, the role of teacher, group work, and discussion.

The role of students: From passive to active learners

Before Duangjai attended the workshop, she was asked to write reactions to Social Constructivist Learning Theory vignettes. An analysis of these reflections suggests that Duangjai felt that the students' role in the classroom should be that of passive learners. She thought that teaching on student center meant students participated in lessons by watching the teacher demonstrate experiments and by listening to the teacher's lectures. For Duangjai, obtaining knowledge appeared to be a rather passive activity, much like watching and listening as illustrated in a portion of her vignette reflection:

...I select teaching method of Vichai because he used student center approach. Students learned from seeing the real thing better than seeing from pictures. They had seen the experiment and listened to an explanation conducted by teacher. In this way, all students have joined in the lesson. Because science is a rather boring subject and difficult for some students, teacher should activate the learners to participate as much as possible. This way will make them understand more... (Duangjai's comment before attended the workshop: October, 2007)

After Duangjai finished attending the workshop, she was asked to respond in writing to the Social Constructivist Learning Theory vignettes again. Based on her responses, Duangjai maintained the belief that students absorbed knowledge from the teacher. She emphasized that students learn primarily from explanations of the teacher. However, she suggested that students could participate more actively by doing hands on activities as the reflection that follows indicates.

...I want students to participate in activities as much as they can. They should not only see, but we should create real situations for them to perform. Students would do activities following with teacher explanation... (Duangjai's comment after attended the workshop: October, 2007)

Duangjai's understanding of Social Constructivist Learning Theory was further developed after she collaborated in planning two lessons with her peers and teaching those lessons in her classroom. She began to conceptualize the students as having a more active role in the learning process. In an interview conducted after her re-teaching lesson plan I, she mentioned that students participated in her lesson by answering questions, exploring, and making knowledge conclusions by themselves. Specifically she noted:

...Students participated in my class by answering my question and gave me an example. They observed educational materials that I prepared for them. They also touched them and described external appearance (physical properties). After I asked students about questions, I would let them talk together, discuss

and find the answer. It meant they explored knowledge from educational materials that I prepared for them. Students would know that they understood more. Students concluded knowledge by themselves... (Duangjai's interview after teaching revised lesson plan I: November, 2007)

The role of prior knowledge: From perceptions about the advantage of prior knowledge to concerns about the connection between prior knowledge and new knowledge

Initially, Duangjai recognized the benefits of accessing students' prior knowledge even before she attended the workshop. In her written reactions to Social Constructivist Learning Theory vignettes, she indicated how teachers can use students' prior knowledge to determine the content and design appropriate for lesson activities. She wrote.

...When teacher knows about the background knowledge of students and what students know, teacher can manage about content knowledge and activities correspond to students... (Duangjai's comment before attended the workshop: October, 2007)

After Duangjai attended the workshop, she still believed that students' prior knowledge could be used for designing activities, as described below.

...When teacher knows about students' prior knowledge, teacher can prepare learning activities corresponded to students' interest... (Duangjai's comment after attended the workshop: October, 2007)

Duangjai developed deeper understandings of the importance of prior knowledge during her teaching and peer meetings. In particular, she felt that it was important for teachers to explore prior knowledge and review students' understandings of basic concepts before teaching. Duangjai explained,

...Teacher should ask questions to explore prior knowledge of students. I try to find basic knowledge and understanding of students before teaching. We can talk to students and ask questions or tell them to give examples. Teacher will review basic knowledge to make sure that students understand and have basic knowledge. When teacher knows students' knowledge, teacher will know his/ her role about teaching management. Teacher will know how to start the activities... (Duangjai's interview after teaching lesson plan II: December, 2007)

Duangjai was also concerned about building connections between new knowledge and prior knowledge and the link between new knowledge to daily life experience. She indicated that she prepared instructional materials which students were familiar with and could see in their everyday lives. She selected and used materials from students' surrounding environment. She also wanted students to apply knowledge for use in their daily lives. Duangjai emphasized this in her interview and critique:

...When the time passed one or two weeks, students forgot knowledge. I must check their knowledge before teaching. I also reviewed that knowledge too. After that I link their understanding to new topic that I would teach. For example, after students categorize the toys by physical properties, they would learn the material which made the toys... (Duangjai's interview after teaching lesson plan II: December, 2007)

...I tried to use materials that students used to see. When I asked students about those materials, they said that they knew all materials that I prepared for them. I used educational materials related to student's daily life. Even though teacher used pictures or real things, all these were advantage for students. After students learned, they also could apply to other things in their life... (Duangjai's interview after teaching revised lesson plan II: December, 2007)

The role of teacher: From teller to facilitator

At the beginning of the workshop, Duangjai was asked to complete written reactions to Social Constructivist Learning Theory vignettes. Duangjai's responses indicated that she viewed the teacher as the person who had the responsibility to prepare experimental apparatuses and instructional explanations for students. In Duangjai's view, the teacher was the key factor in filling student gaps in knowledge:

...I agree with Vichai's teaching method. He prepared materials for students and told them to observe. When students do experiment by themselves, they will learn the knowledge by themselves and can compare with theory that teacher additionally explains for them. In this way, students will understand more... (Duangjai's comment before attended the workshop: October, 2007)

After Duangjai finished attending the workshop, she began to conceptualize the students as having a more active role in the learning process. Based on her responses, Duangjai felt that teacher should activate students to do hand-on activities. In her view, the teacher should ask questions and assign students to do experiments in order to answer questions. She said:

...While students are performing activities, they will learn. In this case, they could see the difference of changing of matter. Teacher should ask questions about the definition of changing of each matter in order to let students find the answer from doing experiment... (Duangjai's comment after attended the workshop: October, 2007)

As the teacher professional development experience progressed, Duangjai's belief about the role of the teacher shifted, especially in terms of her views about effective teaching. Duangjai described a different teacher role in which an individual is a guide of students' learning, not the person who students view as the holder of right answers. According to Duangjai, a guide allows students to take ownership of learning and helps them to find answers. Duangjai said,

...I wanted them to compare and think about the same and different physical properties of their toys with their friends. However, students were confused. They saw just only figure. They thought that baby doll and plastic car do not have same properties. It is a duty of teacher to ask questions and help them to see other properties such as color, material or advantage useful... (Duangjai's interview after teaching lesson plan I: November, 2007)

Duangjai's explanation was that the "teacher was a facilitator who managed or created activities for students" (second plans' interview). The facilitator, according to Duangjai, frequently asks questions to activate students' wonder, and believes teaching science should support students' natural curiosity. In this regard, Duangjai viewed the role of the teacher as a guide with the responsibility for designing activities, preparing educational materials, asking questions and raising examples, managing the classroom and assessing students' understanding as described as follows:

...I think teaching science should start with students' wonder and students' interest. For these, I created situation and asked some questions. I asked them in order to make them wonder. Students will learn when they do the activities by themselves. Teacher not just only explains but should bring real materials for students. The materials that teacher brings should be familiar with students, for example, the toys that they always play. When students are accustomed to, they can answer question... (Duangjai's interview after teaching lesson plan I: November, 2007)

...Teacher is a guide who prepares educational materials. Teacher raises examples for students. Students can link their prior knowledge to new knowledge. Finally, teacher assesses students' knowledge. Playing in a classroom is very common for young students. However, if they play a lot, it will make my activities turn bad. Naughty students will distract other students. This is the obstacle of teaching. I must control their behavior and prohibit his

playing... (Duangjai's interview after teaching lesson plan II: December, 2007)

Group work: From the perception of the advantage of group work in terms of teacher transmitting knowledge to students' collaboration and negotiation

Initially, Duangjai's written reactions to Social Constructivist Learning Theory vignettes indicated that she thought that group work could promote student learning. However, she held an idea of learning as transferring knowledge to students from the teacher as in a pipeline. She noted:

...I agree with Klahan that students can learn when they worked in groups with their peers. However, after they talk and come with a conclusion. Teacher must explain and conclude the lesson... (Duangjai's comment before attended the workshop: October, 2007)

After Duangjai attended the workshop, she was asked to create written reactions to Social Constructivist Learning Theory vignettes again. Duangjai further explained her reasons for believing that group work could help students learn. She pointed out the advantages of interaction in group work in terms of learning together. Students could come together to do activities. They could talk, consult, share and exchange their ideas. She explained,

...I think when they work in groups they can help each other make sense of ideas. They talk and discuss the topics and that lead them to think more deeply. They exchange their ideas and reflect on them when they talk or explain to their friends. I believe that students learn together better than when they learned alone... (Duangjai's comment after attended the workshop: October, 2007)

Duangjai developed her thinking about group work more extensively during the teacher professional development experience. She understood the advantages of interaction in group work in terms of collaboration and negotiation. Specifically, she noted that:

...When students work in groups, they collaborate in learning activity and accepted their friends' idea. Students are brave and learn to express and exchange their idea with friends. They are brave to talk and show off. What's else? They would use their prior knowledge. They use their knowledge to merge with their friends' knowledge. Could knowledge support together? If not why and what is the correct answer? Students use collaborative learning. They help each other in order to learn content and conduct conclusion... (Duangjai's interview after teaching lesson plan II: December, 2007)

Discussion: From teller to eliciting correct answer

Before attending the workshop, Duangjai's written reactions to Social Constructivist Learning Theory vignettes showed that she did not appreciate the value of discussion. She only valued discussion in the context of group work, where she thought it helped students learn. Discussion, for her, was simply a part of group work. Moreover, Duangjai felt that the teacher was the primary source of knowledge. Science concepts were some things that were simply told to the students by the teacher. Therefore, even after students had discussions, it was necessary for the teacher to conclude the lesson and correct concepts for students. Duangjai commented,

...I think group working is a good teaching method. Students participate in their learning. They find the answer from discussion together. However, teacher must tell the reasons clearly for conclusion the lesson. Teacher is the important heart in order to tell the correct concept and conclude the lesson... (Duangjai's comment before attended the workshop: October, 2007)

During the workshop, Duangjai was provided with many opportunities to express and discuss her ideas with colleagues while doing activities. After the workshop, when Duangjai wrote written reactions to Social Constructivist Learning Theory vignettes, she emphasized the importance of discussion. She indicated that students can construct their own knowledge from discussion. She explained how students could exchange ideas and learn from their peers as well as the teacher. Consequently, Duangjai tried to use discussion in the lessons that followed. Duangjai's belief about the teachers' role in providing conclusions also shifted. In contrast to an initial view of teacher as "teller" of knowledge, Duangjai later viewed the teacher as a guide who builds on students' understandings to help them arrive at conclusions. She noted in her interview comments:

...I think the discussion method is a good strategy. Students have a chance to speak and express their idea. Students learn to build their knowledge from discussion with their peers and teacher. I think discussion and exchange the idea are the great method for constructing knowledge. Teacher and students can learn together from discussion... (Duangjai's comment after attended the workshop: October, 2007)

...To design activity, teacher should find the activities that students can participate in activity the most. It also must have discussion. Students would receive the idea or argument from discussion which helps them to clarify their idea or wonder. When students found the answer, teacher would help them again to conclude the knowledge from their understanding. Teacher was a very important person who guided students to the correct concept... (Duangjai's interview after teaching lesson plan I: November, 2007)

For her first teaching lesson, Duangjai wanted students to express their ideas with peers in groups. Unfortunately, Duangjai found that students in her classroom had little experience with discussion. As a result, she did not ask many questions to engage students in discussion. As she explained,

...For my young students, I think teacher should talk, ask questions in order to make them express their idea and participate in express their idea. Last time, that I taught, students seemed barely had discussion. It was because teacher did not ask questions... (Duangjai's interview after teaching lesson plan I: November, 2007)

Likewise, in a meeting with peers after Duangjai's first teaching lesson, Palita shared the comment that most of her students (grade1) were too young to participate in discussion. Duangjai's first response seemed to be in agreement with Palita. Nonetheless, Duangjai believed that she could use discussion effectively in her teaching. She reasoned that her students simply had never participated in discussion activities before. They did not know how to discuss. Therefore, they did not discuss to the point that was relevant, as described below.

Palita: "When speaking in group, students can not exchange their idea because they are too young."

Duangjai: "Discussion does not work."

Palita: "It had discussion, but only some groups could talk and understand together."

Duangjai: "That is right. Students have never practiced to think before. They do not have basic knowledge of thinking. If we want them to discuss, they won't talk about topic that we want them to talk. The problems come from learner and teacher. Teacher can not activate students to pay attention. Students want to play than learn." (Meeting after Duangjai taught lesson plan I: November, 2007)

Duangjai used discussion again in her second lesson plan. She found that students demonstrated progress in terms of their ability to engage in scientific discussions. Her students wanted to talk to their friends and ask questions in their groups. In the lesson activity, Duangjai wanted students to work in groups to discuss the materials that are used to make toys. She explained,

...When they separated in groups, they asked their friends about their toys. For example, in the group of clothes, three students touched their things. They had umbrella, T- shirt and cushioned seat. They touched them and asked each other whether they made from. This way made students talk. Students did not learn alone. That was not boring. Normally, in classroom atmosphere, students sit on their chair which their tables face to the blackboard. They sometime want to talk to other friends who sit in further corner. They can not do that... (Duangjai's interview after teaching lesson plan II: December, 2007)

Importantly in her second teaching lesson, Duangjai frequently used questions, believing they helped students learn more effectively than direct lecture teaching. Her feedback provided students encounters with many questions which were designed to elicit their ideas.

...I taught students by using discussion. I started with asking questions and telling them to discuss. For discussion, I divided into two parts. First, students discussed with whole class and then, they discussed in small groups. Students concluded lessons by themselves. Last time, I helped them conclude the lesson by asking questions. Next time, I will let them talk to each other and try to find the answer by themselves. They can find it. They also think that they understood more... (Duangjai's interview after teaching revised lesson plan II: December, 2007)

Duangjai Translated her Understanding of Social Constructivist Learning Theory into Practice.

The research findings with respect to Duangjai's practice during the professional development experience are divided into three sections; the integration of Social Constructivist Learning Theory into science lesson plans, teaching practice, and pedagogical strategies. This is intended to help the reader track how Duangjai translated her understanding of Social Constructivist Learning Theory into practice.

A relationship exists between Duangjai's understanding of Social Constructivist Learning Theory and her lesson plans

Initially, before Duangjai attended the workshop, she had never designed any science lesson plans. She did not use lesson plans. She used activities and worksheets from the textbook and the teacher's manual. Duangjai was asked to construct two lesson plans based on Social Constructivist Learning Theory. Since the professional development experience helped her understand how students learn and the role of students and teachers in the Social Constructivist Classroom, Duangjai brought these ideas into her lesson plans. In general, each component in her lesson plans included: learning outcomes, main ideas, learning activities, instructional materials, and assessment, and these were related to her understanding of Social Constructivist Learning Theory. An example of the integration of knowledge bases about Social Constructivist Learning Theory can be seen in Duangjai's lesson plan about physical properties of matter.

In her first lesson plan, Duangjai wanted her young students to explore the physical property of toys and tools around them, present their results in front of the class, and discuss them. To meet these intentions, she planned to access students' prior knowledge about the toys/tools that she had prepared for them to observe and explore. The questions were "What do students call this thing? Is it a toy or tool? What do students use it for?" Next, Duangjai planned to distribute materials for students and divide them into groups to explore physical properties such as figure, color, size and surface. After their explorations, Duangjai wanted students to present their results in front of the class. Finally, Duangjai planned for the students and teacher to discuss what they learned from their observations, and hopefully conclude that toys and tools have similar and different physical properties. To assess students' learning, Duangjai planned to evaluate the students' discussion and responses to content-specific questions on worksheets. After teaching the first lesson plan, Duangjai and her peers met to discuss her teaching. Duangjai made some small revisions by adding only information about students' expected answers.

In her second lesson plan, Duangjai wanted her students to explore the materials of toys and tools around them. To meet these intentions, she planned to access students' prior knowledge about physical properties of toy and tools around them. The questions were "What are the color, size, surface and figure of them? Next, Duangjai planned to distribute materials for students such as ball, pen and doll and divide them into groups to explore physical properties such as figure, color, size and surface and materials in relation to materials as plastics, wood, metal, clothes. After their explorations, Duangjai wanted students to discuss what they explored and the differences in materials in each toy or tools. Finally, Duangjai planned for the students to conclude the lesson by explaining that toys and tools could be made from similar or different materials. After teaching the second lesson plan, Duangjai and her peers met to discuss her teaching. Duangjai made some small revisions. The revision of the second lesson plan was modified by allowing students to select toy/tools that they wanted to explore from the teacher by themselves. The presentation activity and the information about students' expected answers also contributed to the revised second lesson plan.

The evidence suggests that Duangjai's lesson plan was related to her beliefs about the role of students, the role of prior knowledge, the role of teacher, group work and dialogue. As mentioned above, Duangjai shifted her thinking about students' roles, desiring students to be active learners. Her ideas about teaching were centered on students' participation and building on their curiosity in doing activities. Her lesson plan included opportunities for students to do activities by exploring and observing toys/tools. Her plan also provided ways for students to participate in answering questions, and presenting and discussing findings. Additionally, Duangjai's belief about group work was reflected in her understanding of Social Constructivist-based teaching and learning. She thought that students should do activities in groups because they could help each other and learn through these interactions. To meet these intentions, Duangjai designed activities for working in groups. Duangjai believed that students benefited from face-to-face interactions and opportunities to exchange ideas and learn from both peers and teacher.

As noted previously, Duangjai perceived the importance and benefit of prior knowledge. She thought about the prior knowledge and prerequisite concepts students needed before coming to her classroom. In her lesson plan, Duangjai planned to elicit student prior knowledge by asking questions about toys and tools. Moreover, Duangjai identified various kinds of teaching materials; toys/tools (e.g., ball, pen, doll, etc.) which related to students' daily lives. She was concerned about the connection between prior knowledge and new knowledge. She prepared familiar materials for students to make sure that they could link knowledge from their daily lives to science knowledge. In this regards, Duangjai stated that the primary role of the teacher was to guide and facilitate. Throughout her lesson plan, the role of "teacher" was that of a person who prepared educational materials, and divided students into groups. Duangjai also planned to assess students by using observation, discussion and worksheets.

The proceeding discussion and examples showed how Duangjai translated her understanding of Social Constructivist Learning Theory into planning lessons which related to students' learning, teaching methods and materials, and assessment in the holistic, practical ways of teaching that is characteristic of Social Constructivist Learning Theory. Importantly, this activity stimulated Duangjai to think about how to apply science curriculum to real practice.

Duangjai's classroom teaching

During the teacher professional development experience, Duangjai taught for two science topics: "Toys and Tools around You" and "What are materials made from?" She developed a lesson for each topic and implemented them with two different class periods. When trying to convert her lesson plans into teaching practice, Duangjai implemented all lessons using a three step process involving: introduction, instruction, and summary. Her classroom practices were analyzed in relation to Social Constructivist Learning Theory.

When Duangjai taught her first lesson on the topic of "Toys and Tools around You", students were expected to explore the physical properties (figure, color, size

and surface) of toys and tools in their daily lives. In Duangjai's initial practice, there were few aspects of Social Constructivist Theory reflected in the lesson. In the introduction of the lesson, Duangjai divided students in groups. Each group consisted of five students. She began by asking students yes/no questions to check their understanding of the difference between toys and tools, but did not probe deeply for prior knowledge. When students responded "yes, we already know the difference", Duangjai continued with the lesson.

Duangjai engaged students in the lesson by asking them to observe the physical properties of toys/tools in front of them. Students were active learners but did not conduct their own investigations. Duangjai distributed worksheets and used questions on these sheets to structure the observation activity. Students observed and recorded the observations following the questions on the worksheet. Duangjai acted as the manager who provided specific questions for students to investigate and directed students' observations toward correct answers. Students did a hands-on activity by following the teacher's procedures for the investigation. They had interactions with their friends only when two of the questions on the worksheet asked them to observe and compare similar and different properties of their friends' toys/tools.

Importantly, Duangjai was concerned about the product of learning more than the process of learning. She wanted to make sure that all students recorded correct answers and finished writing worksheets. She explained step by step each question in the observation activity. She had the whole class observe and answer each question at the same time. Duangjai read, explained and provided a sample answer for each question, as described below.

Duangjai: "Anucha, what do you bring? Do you bring color pencils? You write in the blank. Ratana, what do you bring? Show your thing. Show it. What is it?"

Ratana: "Toys and tools."

Duangjai: "Is it jigsaw puzzle? You write the word "jigsaw puzzle".
Therefore, in this line, Do it the same as anybody? The same

or not the same? Besides, two of you bring the same Babies dolls. Let write the name of thing that you bring on this blank. You write the word in this blank. Follow me right now! Who finish writing? Raise your hand! Ok. Then see another line. Read it. Read aloud. What does this question want you to observe? First observe about color. Everyone observes your thing. What is color? For Anucha, he brings color pencils. They are many colors. You will write the word “many colors”. (Duangjai’s teaching lesson plan I: November, 2007)

At the conclusion of the lesson, students did not have an opportunity to discuss or generate explanations. Duangjai summarized and concluded the lesson for students and did not relate it to students’ experience with the toys and tools. She also told students what they would learn in the next period, before dismissing them to leave for another class, as illustrated below.

Duangjai: “What is topic that we have learned today?”

Students: “Toys and tools around you”.

Duangjai: “What do the toys use for?”

Students: “For playing”

Duangjai: “What do the tools use for?”

Students: “For using”

Duangjai: “Can’t we use the doll instead chair for sitting? Therefore, students can tell the difference. When we select for using, we can use it in the right way. For example, what do you choose for dipping up water?”

Students: “A bowl”

Duangjai: “Don’t you use the doll? Send your worksheet to me. Does anybody want to ask question? Next time we will learn about what toys/tools make from. Ok, you can go. (Duangjai’s teaching lesson plan I: November, 2007)

Her lesson plan was revised and some activities changed when the team members met together. However, when Duangjai taught, she did not follow her revised lesson plan exactly because she was challenged by the small number of students. In the teaching of her revised lesson, many aspects of Social Constructivist Theory were evident. Duangjai understood the importance of prior knowledge and incorporated this idea into her practice. In the introduction to the lesson, she began by investigating students' prior knowledge about the difference between toys and tools. She prepared five objects for students and asked them questions about their classification of toys and tools.

In her instruction, students observed five objects in terms of specific properties of matter; color, surface, size and figure. She distributed worksheets for students to use in recording their data and explained how to use the data sheet. Students, in this lesson, had more freedom to make observations and ask questions about the physical properties they saw. Duangjai supported students' active learning by encouraging them to touch and observe objects by themselves, as she said "Who still wonders? Go to touch the objects. You can not just only see them and answer. You can not guess the answer. Your friends may touch and their answers are not as same as your answer. If you wonder, you should touch again." (Duangjai's interview after teaching revised lesson plan I: November, 2007)

Nevertheless, Duangjai's actions still reflected the belief that the teacher role should be that of a teller of important information. The lesson conclusion was still provided by Duangjai rather than deriving from and building on students' discussion. In the summary of the lesson, Duangjai defined concepts for the students and told them to write the definitions on their worksheet. Importantly, students in her classroom did not work in groups and did not have interaction together. They worked individually on worksheets. Duangjai used the rationale of student numbers for not wanting students to form groups.

In her teaching of lesson plan II, Duangjai taught the topic of "What are materials made of?" Students were expected to explore materials (plastic, wood, metal

and clothes) of toys and tools in their daily lives. Duangjai's actual practice, with respect to this lesson, reflected many aspects of Social Constructivist Learning Theory. In the introduction of the lesson, Duangjai inquired into students' prior knowledge about the advantages of toys/ tools by asking questions. During the lesson, she distributed toys/tools to every student. Toys/tools which Duangjai used were ones that appeared in students' daily lives such as a T-shirt, umbrella, stainless steel spoon, paper, etc. Students were active learners who divided themselves into groups according to the type of material. They had a chance to interact with their peers by talking with them to verify what their toys/ tools were made of. Duangjai distributed the exercise worksheet later after students had the chance to discuss and explore.

Duangjai's re-teaching of lesson plan II was, for the most part, similar. She made small changes to the educational material and student worksheet. To engage student attention and link to prior knowledge about the advantages of toys/ tools, Duangjai introduced the lesson by narrating the "Three Little Pigs" story to students. In the story, she mentioned about the advantage of different materials that each pig used for building their house. She then distributed pictures that she had cut from shopping advertisements to every student. Like the activity in lesson plan II, students divided themselves into groups. Since Duangjai was concerned about students' prior knowledge, she investigated and reviewed their prior knowledge by asking them to divide in groups by the category of toys/ tools first. She then taught about the kinds of material that toys/ tools are made of and asked students to divide into groups by using types of materials as the criterion. She created a chance for students to work in groups by distributing to each group a worksheet. Students worked together to write the name and advantage of toys/tools on the group worksheet. While students were working, Duangjai walked to each group and monitored their progress.

From the analysis of Duangjai's lesson plans and teaching practice, it was apparent that she had translated some knowledge about the tenets of Social Constructivist Learning Theory constructed during the workshop and Lesson Study into her practice. In her initial teaching, Duangjai's lesson reflected few aspects of Social Constructivist learning theory. However, Duangjai's later teaching was

somewhat more Social Constructivist oriented, reflecting some aspects of this learning theory.

The pedagogical strategies that Duangjai discussed and used in relation to her understanding of Social Constructivist Learning Theory

Duangjai reflected an understanding of Social Constructivist Learning Theory through the pedagogical strategies that she described in her lesson plans and interviews. With regard to Duangjai's lesson plan I, pedagogical strategies consisted of: investigating students' prior knowledge, group work, observation, discussion and student-led presentation and conclusion. Correspondingly, in her interview, she mentioned using other pedagogical strategies; asking questions, teacher's example, and students' formulation of explanations. Duangjai also provided some explanations about her reasons for using them in the classroom.

In her interview after teaching lesson plan I, Duangjai described how she started her first lesson with investigating students' prior knowledge. However, she did not use presentation and discussion methods in her initial teaching of the first lesson plan. She explained that she did not have enough time for students' presentation and discussion. Additionally, she revealed that she did not ask questions to stimulate a discussion. However, Duangjai expected that when she would teach the lesson a second time, she would provide students opportunities to discuss and make explanations and conclusions about the lesson by themselves. In her view, students should have a chance to do activities together in a group. She felt they could learn more by talking and exchanging ideas. Duangjai emphasized,

...I followed the lesson plan last time but students did not present and discuss. Students did not discuss anything because teacher did not ask them questions. Teacher did not lead to discussion. We lost a lot of time when students do activity... (Duangjai's interview after teaching lesson plan I: November, 2007)

After Duangjai met with her peers and revised lesson plan I, she taught again using the revised lesson plan I with another class. In terms of her revised lesson plan I, the pedagogical strategies that she mentioned were investigating students' prior knowledge, group work, observation, discussion, student-led presentations and conclusions. During the post-teaching interview, Duangjai discussed the pedagogical strategies that she used, including investigating students' prior knowledge, observation and asking questions. Duangjai explained why she included questioning strategies, even though they were not in her revised lesson plan I. She claimed that many students in her class were absent. She could not teach students using group activities because the number of students was insufficient. So in order to adjust her teaching, she used questioning methods instead. Duangjai explained,

...Last period, many students absented the class because they were sick. It was the obstacle. I determined to teach them work as a group and observed the objects according to the revised lesson plan. However, students could not be in groups. Teaching method must change. Activity should change too. I must solve the facing problem. I modified by asking students questions... (Duangjai's interview after teaching revised lesson plan I: November, 2007)

In lesson plan II, there were six pedagogical strategies that appeared in Duangjai's plan; investigating prior knowledge, observation, group work and discussion. In the post-lesson II interview, the pedagogical strategies that she discussed using were comprised of observation, asking questions, group work, examples, and exercises in worksheets, as noted below.

...I used learning collaboration and students constructed knowledge from talking and discussion. Students participated in activity. When I explained students, I used the example that students were familiar with which appeared in their daily lives. I prepared educational material for them to explore and observe. I asked students questions and gave them exercise... (Duangjai's interview after teaching lesson plan II: December, 2007)

Duangjai and team members agreed to modify lesson plan II by adding worksheets for students to do after the activity. Therefore, the pedagogical strategies that appeared in Duangjai's lesson plan were investigating prior knowledge, observation, group working, presentations, discussion, and worksheet. According to Duangjai's interview after teaching the revised lesson plan II, she indicated the pedagogical strategies that she used in her teaching were the same as in the lesson plan, she noted,

...For teaching in this class, again, I used group work. Students had a chance to discuss. Teacher asked students questions. I started the lesson by investigation students' prior knowledge. Students divided into groups by using their prior knowledge. When they understood, they could do the exercise... (Duangjai's interview after teaching revised lesson plan II: December, 2007)

Based on an analysis of lesson plans and interviews, Duangjai's pedagogical strategies for teaching elementary science included not only "individual conventional strategies" such as asking questions, observation, presentation, worksheet, exercise, but also a variety of "interactive learning strategies" such as group work, and discussion. Duangjai was also concerned about students' prior knowledge. She included ways to investigate students' prior knowledge in every lesson plan. In an interview, she explained her reasons for using those pedagogical strategies. She perceived the strengths of those strategies for teaching science in accordance with a Social Constructivist Philosophy.

Duangjai Collaborated with her Peers in the Lesson Study Approach

Reflection on practice: Reciprocal peer coaching

After team members including Palita, Somsri, and the researcher observed Duangjai's lessons, they had meetings to reflect on Duangjai's teaching. The team gave opinions and suggestions on the lessons. They indicated the problems that occurred in Duangjai's classroom, critiqued Duangjai's teaching, gave her

suggestions to improve each lesson and supported her success. In the first meeting centered on the lesson plan I, the team talked about Duangjai's teaching. They pointed out the problems in her classroom, critiqued her teaching, and suggested what could be improved. Somsri was the first person who spoke about Duangjai's teaching. She focused on student problems which consisted primarily of writing skills and short attention span. Palita concurred with Somsri's observations about students' writing skills and also brought up the quality of the discussion. Likewise, Duangjai agreed with Somsri and Palita about these problems in her teaching, as illustrated below.

Duangjai: "To teach little children used a lot of energy."

Palita: "Yes, It was like catching crabs to put into a basket." [trying in vain to get a grip on something, as it keeps on running away or slipping out of your hands.]

Somsri: "Students talked and played as their nature behavior. Minority of them listened to teacher. Some of them could write but some of them could not."

Duangjai: "It was an obstacle. It made my activities go slowly."

Somsri: "If students could not write. It was hard. They could not do anything except they learned physical subject."

Palita: "For speaking in group, students can not exchange their idea because they are too young."

Duangjai: "Discussion did not work."

Palita: "It had, but only some groups that can talk and understand together." (Meeting after Duangjai taught lesson plan I: November, 2007)

Somsri and Palita critiqued Duangjai's teaching. They commented about the role of students and teacher in using instructional materials in the classroom, in relation to their understanding of Social Constructivist Learning Theory. Palita agreed with Duangjai that students should observe and do activities by themselves. She felt that Duangjai's role as a teacher should be as a guide. She explained, "Duangjai taught students to observe. That is good. She taught students to observe and

distinguish the size, color, and figure of objects. Her teaching was good. Teacher was a guide. In teaching, teacher did not tell concepts directly.” (Palita’s comment in meeting after Duangjai taught lesson plan I: November, 2007)

In Somsri’s reflection, she mentioned the instructional material that Duangjai used in her classroom. She noticed that Duangjai used instructional materials from students’ daily lives. She commented, “Most students played in classroom, but they learned. They could tell which one was tool or toy. They can describe color and tell the difference because they know materials. It used in daily life.” (Somsri’s comment in meeting after Duangjai taught lesson plan I: November, 2007)

In this team meeting, Palita and Somsri also had other suggestions for Duangjai to improve her teaching. Palita felt that Duangjai should be the leader of the discussion activity. Duangjai agreed with Palita. She thought that the teacher should ask questions in order to motivate students to think about and become interested in the lesson. Moreover, Duangjai also discussed with her peers about problems related to discussion. She thought that students had difficulties with discussion because they did not have basic knowledge of thinking skills and had never practiced learning to think, as evidenced in the comments below.

Palita: “In discussion, teacher should be a leader and student would follow.”

Duangjai: “Teacher must ask questions to students in grade 1 and 2. If teacher does not ask question, students will not think. Students have never practiced to think before. They do not have the basic knowledge of thinking. When teacher wanted them to have group discussion, they won’t talk. When they talked about toys and tools, they would talk and boast only their toys. It does not relate to knowledge.”
(Meeting after Duangjai taught lesson plan I: November, 2007)

In terms of students’ difficulties with writing, Duangjai indicated that this problem affected all of her teaching. She mentioned that it was difficult to finish on

time because of students' writing abilities. She found a solution by changing worksheets and activities in her lesson plan. Somsri suggested that Duangjai might solve this problem by having students draw pictures instead of writing, as illustrated below.

Duangjai: "After I taught, I must adjust the time. It convinced me that students wrote too much. Should we design the worksheet as check list for students? It will eliminate the problem of spelling. However, I would like students to write some parts. Anyway, they probably can do that because they are used to marking on checklist when they learned in a kindergarten level. I will prepare things for students, maybe around 5 pieces. I will put them in front of the class and tell students to observe and record in a table in worksheet. It will save time."

Somsri: "It would be good if students drew pictures instead of writing."
(Meeting after Duangjai taught lesson plan I: November, 2007)

In the second meeting, Duangjai, Palita and Somsri discussed the issues that they observed after Duangjai taught her revised lesson plan I. Unfortunately, many students were absent that day, so they could not work in groups. Duangjai thought there were not enough students to form groups. She also saw the problem when her students did not have a chance to interact with others. Additionally, when Duangjai taught about the physical properties of toys/ tools, she noted that students did not have prior knowledge of geometric figures. She described,

...Yesterday, the numbers of students were less. So I did not divide them into groups. Students observed materials in my teaching. They would tell which were toys or tool. They also touched the surface and observed color. They determine size and figure of toys and tools. For geometry figure, students could not answer well because they did not learn before... (Duangjai's interview after teaching revised lesson plan I: November, 2007)

Palita and Somsri also saw similar problems in Duangjai's classroom. Palita agreed with Duangjai about the interaction of students and the number of students that could be divided into groups. She noted "Due to it had less students, they would not divide in group. Therefore, students did not express their idea." Palita also mentioned the problem of students' prior knowledge. She indicated that "Yesterday, some students touched the surface of toys/tools, and they could not tell which one smooth or rough." Additionally, Somsri pointed out that students were not confident with their answers. She commented "Students wanted to answer, but they were not brave because their friends did not answer. If one student was a leader to speak, other students would speak. Students were worried that their answer would be wrong. They were afraid to be scolded from teacher." (Palita's comment in meeting after Duangjai taught revised lesson plan I: November, 2007)

Duangjai reflected on the lesson from her perspective as the teacher. She described how she guided students to observe and asked questions about students' prior knowledge. She felt that the role of her students was to observe and answer her questions. Palita and Somsri also critiqued the teacher and student role in Duangjai's teaching. From Palita's view, Duangjai was a guide who asked questions and linked prior knowledge and new knowledge. She believed that Duangjai used a student centered approach, with the teacher as a guide while students constructed their own knowledge as they actively engaged with instructional materials. She commented,

...Duangjai taught student center. Teacher did not tell the knowledge, she guided students to construct their own knowledge. Duangjai asked questions and tried to link between prior knowledge and new knowledge. Students had a chance to touch and observe... (Duangjai's comment in meeting after Duangjai taught revised lesson plan I: November, 2007)

Like Palita, Somsri also commented on the role of Duangjai and her students. Somsri felt that Duangjai's primary role was asking questions and preparing the educational materials. In terms of the students, their role was to participate fully in activities. With respect to what could be improved in Duangjai's teaching, Palita

suggested revising the worksheet by using lines to make sure that different kinds of data were separated. Duangjai herself suggested giving students more opportunities to interact with peers in her next lesson.

When meeting with peers after teaching lesson plan II, Duangjai could not describe any problems with the lesson. However, her colleagues, Palita and Somsri shared the problems they observed. Palita focused on student problems such as the rate in which students did the activity and their difficulties with drawing pictures. Palita also commented about the classroom environment. She noted that students could not hear Duangjai because she distanced herself from the students by standing on a balcony when she taught. Additionally, Somsri felt that students could not write and spell as well as expected for that grade level. Palita and Somsri also critiqued Duangjai's teaching's role, the students' role, students' prior knowledge, and students' interaction and discussion, in the following comments:

...She started the lesson by review students' prior knowledge for link to the new knowledge. I observed that Duangjai distributed things to every student such as doll, pillow, and pens. Teacher told students to separate in a plastic group, metal group and wood group. Students had a chance to exchange their ideas. Teacher distributed worksheet for students to work together. When students could not spell some words, teacher helped to spell by speaking the alphabet... (Palita's comment in meeting after Duangjai taught lesson plan II: December, 2007)

...Duangjai started the lesson by review students' prior knowledge. She asked students questions and students answered. Students in this class were good. They helped each other to answer. Teacher used questions to activate students and also link to students' prior knowledge. Teacher distributed educational material to students. Students could divide into groups by using the kind of material. They also talked in their group. Teacher just only was a guide... (Somsri's comment in meeting after Duangjai taught lesson plan II: December, 2007)

After listening to her peers, Duangjai became aware of things she could do to improve her lesson, particularly by using pictures. She showed many pictures of toys/tools that she cut from shopping magazines to her peers. She thought it would be easier to prepare pictures than prepare real materials. However, Palita responded suggesting that students should have opportunities to touch real things. Duangjai agreed with her but emphasized that all pictures she distributed were objects used in students' daily lives. Students were used to touching these things in their daily lives, as she explained:

Duangjai: "I thought about changing the real materials to pictures. Using pictures instead. I used from BIC C or LOTUS departmentstore. I thought these pictures were clear enough. Students could see that which one was toy or tool. It might be small but I thought it would be ok."

Palita: "Yes. But students could not touch."

Duangjai: "I thought the weakest thing was what you said. Studnets could not touch. However, I thought that students might see these things and used to touch them before."

Palita: "Ok. Yes. They were things around students' daily life." (Meeting after Duangjai taught lesson plan II: December, 2007)

Owing to the students' problems with writing and spelling that Somsri noticed in Duangjai's classroom, Somsri suggested to Duangjai that students' drawings should be used instead of writing. However, Duangjai disagreed. She felted that pictures could not communicate effectively. She explained "Students do not draw pictures well. For example, I told them to draw a basket last time. It does not look like a basket. It is difficult to interpret." Palita recommended that students copy the appropriate words under the pictures. She said "It has the word under the pictures that Duangjai will give to students. Students can write following this word. They could practice writing Thai language too."

In the final group meeting following the re-teaching of lesson, Duangjai and Somsri did not bring up any problems with the lesson. However, Palita felt that students still had a problem with writing. She also felt that there were too many activities crowded into Duangjai's lesson. Palita praised Duangjai, emphasizing that her teaching was better. Somsri, also providing positive feedback, suggested that Duangjai could solve the problem of many activities by giving students homework, as illustrated below.

- Somsri: "Duangjai introduced the lesson by using "Three little pigs" story. Teacher linked the knowledge to this story. Students also liked the story. Teacher asked questions. Students answered with interested in. When teachers distributed the pictures, students observed pictures and divided themselves in groups. They had fun. They debated, made a group, discussed and talked. Teacher asked questions and students could answer. In conclusion the, teacher asked questions and students helped together to conclude the lesson. Students could answer because objects that teacher used appeared in their daily life."
- Palita: "I think this teaching is better."
- Somsri: "Students could divide in group."
- Palita: "Were there too many activities? Two worksheets! Students almost did not finish another exercise. It took more time."
- Somsri: "Students can do that. However, if there are too many activities like these, students can do it for homework."
- Palita: "Teaching was good. It started the lesson and activated students' interest with story telling. Students liked. Teacher could link between prior knowledge; toys/tools and new knowledge; materials. Teacher distributed pictures. Students observed but could not touch. They divided themselves in groups by material of things that appeared in pictures. Teacher tried to help students to spell the words. (Meeting after Duangjai taught lesson plan II: December, 2007)

Duangjai not only critiqued her own teaching and suggested methods to improve, but also gave her peers suggestions and support to help them improve their lesson plans. Her critiques of teaching and recommendations for change were consistent with an understanding of Social Constructivist Learning Theory. Duangjai's reflections on her own and peers' teaching showed that she had a broadened understanding of Social Constructivist Learning Theory.

The advantage of peer interaction

As the teacher professional development progressed, Duangjai relied on collaboration with other peers more than individual thinking. She said, "I feel it was easier to teach sciences if teachers collaborate and help together. It consumes a small time. When we brain storm the idea, it does not use a lot of time. When we were trained, we helped each other to think. Some teachers thought that way and others thought another way. We combined those ideas. It also brought about my idea. I sometimes am blunt. I learn a lot from working together." (Duangjai's interview after teaching revised lesson plan II: December, 2007)

Feedback from peers had a special significance to Duangjai. Her peers' feedback was a big influence on her thinking and teaching practice. Her peers not only critiqued her but also gave support and helped her revise the lesson. As noted above, she believed that people do not do well in everything, so she was always willing to listen and accept other ideas. She was thoughtful about the value of peer interaction in her professional teaching career. She explained, "It is impossible that one person will be able to know everything. He/she must have a blind spot. We should use the outstanding idea of each person and combine them together. In my idea, this method can use with all subject, all teachers who teach the same subject should have a meeting and help together to design the lesson plan." (Duangjai's interview after teaching revised lesson plan I: November, 2007) This statement is an indication that she perceived the importance of group work and collaboration.

Duangjai Perceived the Benefits and Challenges of Applying Social Constructivist Learning Theory in the Classroom.

Duangjai perceived the benefits of using Social Constructivist Learning Theory in the science classroom and saw it as an advantage for herself and students. For her own benefit, she learned more about students and the teaching and learning process. Her reflection on her own teaching showed that she learned about student differences. Duangjai claimed that they were different in prior knowledge and, by extension, in their learning needs. Therefore, she concentrated on assessing students' prior knowledge and using it to design activities, as she explained:

...It is the advantage that I investigate students' prior knowledge. I can design teaching and learning process following their basic knowledge and what they want to learn. For example, I asked them about "substance" yesterday. One student had a weird thinking. Students' answers may be strange because they are depended on students' environment or familiar. This girl may use to see an angel house. She said substance was an angel house but other students mentioned about chemical substance... [In Thai language, the words of substance and angel house are the same sound.] (Duangjai's interview after teaching revised lesson plan I: November, 2007)

Additionally, she learned to design and write lesson plans consistent with a Social Constructivist epistemology. She noted, "For benefit to myself, first, I am systematically trained to teach science according to Social Constructivism in real classroom. I also know how to design and write science lesson plans based on Social Constructivist learning theory." (Duangjai's interview after teaching lesson plan I: November, 2007)

Duangjai perceived many benefits for students when she taught science based on Social Constructivist tenets, including improved student learning, developing of positive attitudes toward science, and the building of positive peer relationships through group work. In terms of students' learning, Duangjai observed that her

students understood science concepts more deeply after she used lessons consistent with Social Constructivism. Students had the opportunity to participate in more activities than usual, and seemed happier to learn science, as she explained.

...When I observed students' behavior, I saw that they are happy to learn in this style. They were pleasure, satisfy and ready to learn in this style. It is better than students sit and listen to teacher. Another thing is they will learn more and knowledge will stick to them permanently... (Duangjai's interview after teaching lesson plan II: December, 2007)

Additionally, Duangjai saw the benefit of group work in terms of fostering positive social interactions. Duangjai described how students learned to work in groups with others, and accept different ideas. She commented. "Students would have a development in working with other people, work together with their friends. They also learned to listen to friends' idea." (Duangjai's interview after teaching revised lesson plan II: December, 2007)

At the same time, Duangjai saw many challenges in teaching science based on Social Constructivist epistemology. The main challenge, as she expressed, was the preparation of herself, as a teacher, for teaching and preparing lessons. According to Duangjai, the role of the teacher in the Social Constructivist classroom was to create the learning environment and manage activities. She said. "It challenges. It challenges me about I must control the time. I must balance time and activity and also prepare compactly lesson. Teacher must create environment for students to be familiar with social constructivist teaching." (Duangjai's interview after teaching lesson plan I: November, 2007) Duangjai's concerns about the management of the teaching and learning process corresponded with her attention to students' prior knowledge and needs. In her view,

...Yesterday, I saw that students were changed. They developed themselves about their learning. If teacher sees them develop their achievement or ability to work with other people better, teacher should improve and adjust teaching

to correspond to students' knowledge... (Duangjai's interview after teaching revised lesson plan II: December, 2007)

The Case of Duangjai: Some Conclusions

Duangjai was a grade one science teacher who had only one year experience of teaching science in grade four two years ago. Before she attended the teacher professional development experience, she did not want to teach science because it was a difficult task for her to design activities and prepare educational materials for students. She taught science by using the textbook and had students copy concepts. Before Duangjai attended the teacher professional development program, her understanding of teaching and learning process was traditional. In her view, she understood student centered as the participation in activities by students watching teacher's experimental demonstrations and listening to the teacher's lectures. Consistent with the teacher role, Duangjai viewed the teacher as a key factor in filling student gaps in knowledge. The teacher had the responsibility to prepare experimental apparatuses and instructional explanations for students. Duangjai believed that group work could promote student learning, but she did not appreciate the value of discussion. Additionally, she recognized the benefit of assessing students' prior knowledge for designing appropriate lesson activities.

Duangjai evolved in her understanding and practice after she attended the professional development program. She began to conceptualize the students as having a more active role by answering questions, observing and touching materials and constructing knowledge by themselves. For the role of prior knowledge, Duangjai was concerned about exploring students' prior knowledge and building connections between new knowledge and prior knowledge. She also believed that the role of teacher should be a facilitator who designed activities, prepared educational materials, asked questions and raised examples, managed the classroom and assessed students' understanding. Additionally, Duangjai further explained her reasons for believing that group work could help students learn in terms of collaboration and negotiation. She also recognized the importance of discussion in terms of students' interaction.

Duangjai was asked to design two lesson plans related to her understanding about Social Constructivist Learning Theory. She planned her two lesson plans to ask the students' prior knowledge and divided students into groups to explore physical properties. In her lesson plan, students had a chance to present the results in front of the class, discuss with their colleagues in a group and conclude the lesson. From the analysis, Duangjai's lesson plans were related to her understanding about the role of students, the role of prior knowledge, the role of teacher, group work and dialogue. Duangjai's teaching did not align with her lesson plans. She was challenged by many unexpected situations that occurred in her classroom. Duangjai further developed her teaching plan to be harmonized with Social Constructivist Learning after teaching lesson plan I "Toys and Tools around You". She began to ask students' prior knowledge and gave more freedom for students to select materials by themselves for investigation. Duangjai incorporated several aspects of Social Constructivist Learning Theory including: the role of student, the role of prior knowledge, group work and discussion. However, her instruction centered on the teacher emphasized the correct concept being provided by teacher. The pedagogical strategies that Duangjai used in her lesson plan and mentioned corresponded to her understanding of Social Constructivist Learning Theory. Based on an analysis of a lesson plan and interviews, pedagogical strategies consisted of asking questions, investigating students' prior knowledge, teacher's example, group work, observation, discussion, student-led presentations and conclusion.

After Duangjai's teaching, her peers and she had a meeting to reflect on her teaching. The team members in the meeting critiqued Duangjai's teaching and suggested some teaching methods for her. Duangjai listened to her peers' criticism, revised her lesson plan and implemented some suggestions from them in her classroom. She not only reflected on her teaching but also critiqued and made suggestions for her peers' teaching. Additionally, Duangjai perceived the advantage of the group meeting in Lesson Study approach. She was thoughtful about the value of peer interaction in her professional teaching career. After Duangjai taught science based on Social Constructivist learning Theory, she perceived many advantages of using Social Constructivist epistemology in her science classroom. She mentioned the

advantage for herself and her students. For herself, she claimed that she learned students were different in their prior knowledge and learning needs. Moreover, she mentioned that she learned how to design the lesson plans based on Social Constructivist Learning Theory. For her students, she claimed that the students improved their learning and positive attitudes toward science, and the building of positive peer relationships through group work. Duangjai saw that the preparation of herself as a teacher was challenged in teaching science following Social Constructivist Learning Theory. She became informed and knowledgeable about the management of teaching and the learning process.

Case II: Ms. Somsri

General Background of Somsri

Somsri is a female elementary teacher working with fifth grade students at one of the suburban public schools in the second educational area of Nonthaburi province. She is 49 years old, and attended the institute for teacher preparation at Kanphaeng Phet with a major in home economics teaching. Somsri has 13 years of experience as a science teacher. During the semester of this study, Somsri was asked to spend 15 hours teaching on a block schedule everyday. Her teaching responsibilities included the subjects of social science, science, educational guidance, and Boy Scouts. She was responsible for teaching science for two classes of grade five; there were 30 students in each class. Somsri also had other responsibilities at school such as distribution of food for students. She enjoyed teaching science even though she didn't graduate with a science major. She was happy when she taught science and thought the subject was fun because her students enjoyed the experiments. She admitted, however, that she wasn't confident about the science content. She revealed that she learned science by reading and consulting with science teachers in the school. As a result, she always organized learning experiences following the experiments in the textbook and the teacher's handbook.

When the researcher offered her the opportunity to participate in a professional development experience, she did not agree immediately. However, she changed her mind and participated in the program because it offered her a chance to receive a promotion. For her advancement, she was required to create an innovation in relation to the learning and teaching process. She thought that participation in the teacher professional development experience would guide her in the process.

Somsri's Evolving Understanding of Social Constructivist Learning Theory

In this section, an analysis of Somsri's understanding of Social Constructivist Learning Theory is presented according to the three main phases of the study: (a) the period before she attended the workshop (b) the period after she attended the workshop; (c) the period after she taught and modified her lesson plans. The development of her knowledge base is presented by considering her understanding of the five key aspects of Social Constructivist Learning Theory: the role of students, the role of prior knowledge, the role of teacher, group work and discussion.

The role of students: From passive to active learners

At the beginning of the workshop, Somsri initially expressed beliefs consistent with the idea of students as passive learners. In her written reactions to Social Constructivist Learning Theories vignettes, Somsri explained that students could participate in lessons and be active learners by looking at pictures and listening to the teacher's lectures. She explained,

...I agree with Pitaya in teaching that she brought pictures about boiling water and burning wood to show students and she explained science concepts. In this teaching, students were participated in teaching and learning process...
(Somsri's comment before attended the workshop: October, 2007)

Somsri wrote a response to the written reactions to Social Constructivist Learning Theories vignettes again after she attended the workshop. Her response indicated an understanding of active learning as giving students freedom and building

on their interests. She felt that students participated in lessons as active learners when they had a chance to select what they would learn. However, in her view, the teacher was still knowledge giver and students were the knowledge receivers. Somsri emphasized,

...I think that after showing pictures about boiling water and burning wood to students, teacher should ask many questions or write them on a blackboard. Students will participate in the lesson by choosing those questions. They have a freedom to select what they wanted to learn and teacher will explain the answer of selected question... (Somsri's comment after attended the workshop: October, 2007)

However, as her teaching practice and collaboration progressed, Somsri mentioned more about applying Social Constructivist-based teaching in her classroom. Her thinking about the role of students shifted to the idea of students as active learners who construct their own knowledge by exploration, investigation, and problem solving. She saw students participating in teaching and learning by searching out knowledge and doing experiments. According to Somsri, students should search for knowledge by asking experts questions or finding information by themselves and then they are able to construct their own ideas. She explained in an interview,

...To construct the knowledge means students interview, study or explore knowledge by themselves. They will ask adults, local experts, teachers in school and their friends. After students receive the knowledge, they discuss with their friends. Then they will think, analyze and find the answer... (Somsri's interview after teaching revised lesson plan I: November, 2007)

...They touched. They did experiment. They solved the problem. They could construct their own knowledge. They thought. They did by themselves. They constructed knowledge by exploring, thinking, doing the experiment, touching, and observing by themselves... (Somsri's interview after teaching lesson plan II: December, 2007)

...Students did the experiment, investigated, explored, found the answer and solved the problem by themselves. They were capable to discover by themselves. They tested, touched and did experiment by themselves. If this answer or that answer was not true, they repeated many experiments and could construct knowledge... (Somsri's interview after teaching revised lesson plan II: December, 2007)

The role of prior knowledge: From students' brain is an empty vessel to the mind as a reflection of life experience

Initially, Somsri did not consider the significance of students' prior knowledge. She did not realize that students had their own prior knowledge. Even though Somsri agreed to begin the lesson by asking students questions, there was no further specific probing of students' prior knowledge. Asking students about their prior knowledge, for her, was to help students clarify their knowledge so that she could make her lesson more interesting. Somsri commented,

...I agree with Somchai that teacher should ask questions. Even though students can not answer, students will be aware what they already know and don't know. Asking question also make the lesson more interest... (Somsri's comment before attended the workshop: October, 2007)

Somsri developed her understanding of prior knowledge while attending the workshop. Somsri came to realize the importance of students' prior knowledge. She indicated how teachers can use students' prior knowledge to shape the teaching and learning process. She commented,

...Teacher should ask students' prior knowledge because students will realize what they know and don't know. Teacher also uses students' prior knowledge to design teaching and learning process... (Somsri's comment after attended the workshop: October, 2007)

While Somsri attended the professional development experience in Lesson Study, she began to develop her understanding about students' prior knowledge. In particular, Somsri realized that students do not have blank minds. Rather, they have prior knowledge from experience in their daily lives. Somsri indicated that she used materials from students' surrounding environment for students could build the connection to their prior knowledge. As Somsri said,

...I used equipments appeared around students. I used everything on students' table such as notebooks, pens, rulers. Students use those things in their daily lives. They can link to their prior knowledge. They have experience from their daily lives; at house or school... (Somsri's interview after teaching lesson plan I: November, 2007)

Additionally, Somsri also indicated that teachers must explore students' prior knowledge and determine what children already know. She felt that teachers should use students' experience for designing activities that link to students' prior knowledge, as described below.

...I understand that teacher must explore students' prior knowledge, diagnose what students already know and try to create experiences for students. Asking prior knowledge help teacher know how to connect to the knowledge that teacher would teach... (Somsri's interview after teaching lesson plan I: November, 2007)

Role of teacher: From master to reciprocal and learning together

Before Somsri attended the workshop, she was asked to write a reaction to Social Constructivist Learning Theory vignettes. An analysis of these reflections suggested that her understanding of the teacher's role was that of a "master". Somsri believed that the teacher was a person who was responsible for activity management and was the holder of knowledge. She believed that teachers simply assigned work to students and rectified their work by telling them the correct answers. She commented,

...I agree with divided students into groups and gave each group a topic to study. After that the representative of each group presented the knowledge that they have studied. Teacher would conclude the correct concept for students... (Somsri's comment before attended the workshop: October, 2007)

After Somsri attended the workshop, she was asked to create written reactions to Social Constructivist Learning Theory vignettes again. Her belief about the role of the teacher shifted. Somsri described the teacher as a facilitator who encouraged students to be active learners. In her view, the teacher prepared educational materials and engaged students to participate in experiment and discussion. She wrote,

...I agree with Vichai. He started the lesson by distribute two papers for students. Students observed physical properties such as size, color, weight of two papers. After that students tore one paper to small pieces and burned another paper. Students discussed the different change of small pieces of paper and burned paper until they understand about the physical and chemical change concepts... (Somsri's comment after attended the workshop: October, 2007)

As the teacher's professional development progressed, Somsri indicated that she felt the teacher was as a guide who suggested and verified students' understanding. She said "teacher had a role to see what students did. Was it right or wrong? If it was wrong, I would tell students to do another way. If they did it right, I would say it was right. I just guided them. I advised them to do experiment in the right way." (Somsri's interview after teaching revised lesson plan II: December, 2007) Somsri also focused on the teacher role in leading students in hands-on activities, as described below:

...Students in grade 5 wanted to investigate and explore knowledge. They asked me what the result of experiment was. I told them to prepare materials for experiment if they wanted to do experiment. I told students to do the experiment followed the procedure. I was a guide. When students could do the

experiment, they were happy. When they find something that they are curious, I tell them how to do experiment... (Somsri's interview after teaching revised lesson plan I: November, 2007)

Additionally, Somsri indicated that the teacher had many other roles, for example: preparing educational materials, asking questions, motivating students to be enthusiastic and do experiments, and supporting them by using positive reinforcement. Somsri explained, "Teacher advises and guides students. Teacher also prepares educational materials and distributes them to students. Different students are interested in the lesson differently. I always said "Students, do you do the experiment yet? If not. You must touch and do it." I activate them to be interested in lesson by asking questions. I want my students to answer my questions. I praise them and tell their friends to applaud when students can answer my question." (Somsri's interview after teaching revised lesson plan II: December, 2007) Interestingly, Somsri also saw this new teacher role and student role as being reciprocal and learning together. She indicated that the teacher could learn from students. Since Somsri realized that students' experience was based on individual differences, she valued and respected students' ideas, as she described below.

...Students sometimes speak something that I do not think about. I sometimes forget or do not know some examples. Students have different experiences from me. Some ideas of students are better than my idea. When I forget to speak some content, students remind me... (Somsri's interview after teaching lesson plan II: December, 2007)

...Teaching with this way (based on Social Constructivist Learning Theory) is good. Sometime students tell me other answers that I do not conceive that. I learn from my students. When I am not sure, I ask students... (Somsri's interview after teaching revised lesson plan II: December, 2007)

Group work: From promotion of interaction to promotion of mutual learning

Initially, Somsri recognized the benefits of students working in groups. In her written reactions to Social Constructivist Learning Theory vignettes, she indicated that group work helped students learn and understand the content more thoroughly. According to Somsri, when students worked in groups, they could help each other do activities, discuss, exchange and express on their ideas through talking. After Somsri attended the workshop, she still believed that group work helped students learn better. As Somsri emphasized before and after the workshop,

...I think students learn when they study in groups. When students work in groups, they help together. Students understand the content more. Students discuss, exchange, and express their idea when they talk to their friends... (Somsri's comment before attended the workshop: October, 2007)

...Students learn when they work in groups with their friends. Students help each other and also understand the content more. Discussion makes students understand the content more clearly and deeply. They also exchange and expresse their idea... (Somsri's comment after attended the workshop: October, 2007)

Somsri developed a deeper understanding of the importance of group work during her teaching and peer meetings. She emphasized that she would encourage students to do group work because she believed that they could work together to do activities and solve problems. Somsri was holding a concept of group work that promoted participation and interaction. Students could get help each other to do activities by thinking, talking, consulting and discussing in groups. Somsri explained, "Students helped each other to do the experiment, think and solve the problem. After students touched materials, they talked, consulted and discussed together." (Somsri's interview after teaching revised lesson plan I: November, 2007) Somsri also pointed

out that working together in groups gave students opportunities to learn from and teach each other. Somsri commented,

...When students did the experiment and did not understand, they would ask and consult their friends in groups. In their group if someone knew the answer, they would tell and explain their friends. They would help each other. Friends helped friends... (Somsri's interview after teaching lesson plan I: November, 2007)

Discussion: Promoting students' participation and supporting their knowledge construction

Before attending the workshop, Somsri was asked to express her views about Social Constructivist Learning Theory. From her reflections about Social Constructivist Learning Theory vignettes, Somsri indicated that she perceived the benefits of discussion that promoted participation and gave students an opportunity to learn from their friends. In her view, "Students can participate in teaching and learning process. It is better than learning alone. Students can speak and express their idea. They also learn from friends in their group. Students also can conclude the lesson." (Somsri's comment before attended the workshop: October, 2007)

After Somsri attended the workshop, she reflected on written reactions to Social Constructivist Learning Theory vignettes again. Her responses further suggested that she recognized the advantages of discussion. In her view, students were more active learners when participating in discussion. Somsri explained, "Discussion is a good method for teaching because students have a role to participate in teaching and learning process. It is better than students just only listen to teacher. Students should express their idea. Students will learn from the conversation between teacher and students and between students and students." (Somsri's comment after attended the workshop: October, 2007)

Somsri developed her thinking about discussion more extensively during the teacher professional development experience. From her perspective, students could have valuable interactions between peers and the teacher through discussion. In her view, students could express, exchange, and debate their ideas in the form of discussion. The arguments that could occur in class discussion would force students to explain, analyze, and defend their answers. Good discussions could lead to conclusions formed through the interactions between students and teacher, which meant that students were constructing their own knowledge. Somsri emphasized using discussion activities in her teaching, as evidenced in her interview comment below.

...Students learned and had discussed in groups. They could construct their own knowledge by discussion. After they did the experiment, each of them thought and exchanged their idea. Students debated and defended their idea. First, I would let them to think and express their idea. Finally, the conclusion would derive from students' idea. Teacher also helped students to complete the conclusion by putting students' idea together... (Somsri's interview after teaching revised lesson plan I: November, 2007)

Somsri Translated her Understanding of Social Constructivist Learning Theory into Practice.

Beyond the development of knowledge components of Social Constructivist Learning Theory, Somsri integrated her understanding into practice. The research findings regarding Somsri's practice during the professional development experience are divided into three sections: the integration of Social Constructivist Learning Theory into science lesson plans, translation of theoretical understanding into teaching practice, and explication of pedagogical strategies.

A relationship between Somsri's understanding of Social Constructivist Learning Theory and her lesson plans

Somsri utilized a science elementary textbook and teacher manual as a primary source of learning activities conducted in her classrooms before she attended the workshop. During the teacher professional development experience, she was asked to construct two lesson plans based on her understanding of Social Constructivist Learning Theory. Somsri created two lesson plans for teaching the topics of "Elasticity" and "Hardness". In Somsri's lesson plans, the sequence and content totally corresponded with the national science curriculum and the grade five elementary science textbook; however, she designed her own set of activities and strategies for teaching the concepts. In general, each component in her lesson plan included; learning outcomes, main ideas, learning activities, instructional materials and assessment. The integration of knowledge based about Social Constructivist Learning Theory appeared in Somsri's lesson plans as described below.

In her first lesson, she planned to have students explore and explain their understanding of elasticity as a physical property of matter. In the introduction stage, Somsri planned to distribute five things to students (rubber band, sponge, plastic foam fruit wrap, plastic rope and cotton thread). She wanted students in groups to observe and identify which ones had elastic properties. After that she planned for students to present their results in front of the class, answer her questions about the definition of elasticity, and explain their testing methods. She also planned for students to give examples of things around them with elastic properties and describe the advantage of elasticity in their daily lives. In the summary of the lesson, she planned for students to conclude and write their ideas about the concept of elasticity and do an exercise in their worksheet.

After Somsri and her peers met to discuss the lesson plan, she made some revisions. There were small revisions to the student worksheet and presentation activity. Somsri added a few questions to the worksheet for students to write their ideas about elasticity. The lesson plan still started with the teacher distributing

materials with students exploring them and then answering the teacher's questions. Students did the activities in groups and wrote their concluding ideas about elasticity by themselves. However, student presentations did not appear in the revised plan. The details of student discussion were also omitted in her revised lesson plan.

Somsri wrote lesson plan II centered on the property of "Hardness". This topic was in the main unit of "Physical Properties of Matter." The objective of this lesson was to explore and explain hardness as a physical property of matter. In the introduction stage, she planned to divide students into groups and distribute different hardness utensils from students' daily lives such as candle, plastic comb, metal ruler, and mirror. She wanted students to observe, answer questions, discuss the materials and make conclusions about the concept of hardness. After summarizing the lesson, Somsri planned for students to do an exercise on their worksheet which focused on students thinking about hardness in their real life. After Somsri consolidated ideas from her peers in the meeting, she revised her lesson plan. This revised lesson plan did not change in terms of activities, but it was improved by adding some details about the teacher's questions and students' expected answers.

In both of the lesson plans, Somsri intended for students to be active learners who would participate through observation, answering questions, giving presentations and discussing conclusions. The role of the teacher was to prepare the educational materials and ask questions. Interestingly, Somsri planned to build on students' prior knowledge in her activities. After distributing educational materials which appeared in students' daily lives for them to observe, Somsri wanted them to explain the physical property (Elasticity and Hardness) and testing method by linking their ideas to their daily life experience. Somsri's lesson plans also reflected her belief about group work. Students were divided into groups and did activities together. Noticeably, the details of the discussion did not appear in her first lesson plan, but were added to the second lesson plan.

As noted previously, Somsri's lesson plans consisted of all essential components (from the teaching objective to assessment) in accordance with the

textbook and National curriculum. Both lesson plans suggested that Somsri was able to integrate her knowledge components of Social Constructivist Learning Theory into planning. In doing so, students were required to participate in, or have first-hand experience with phenomena, participate in group activities and engage in discussion.

Somsri's teaching

The researcher observed Somsri teaching the two science lessons for four 60-minute periods in grade five and also interviewed her after teaching. Noticeably, Somsri's understanding of Social Constructivist Learning Theory influenced her decision-makings about the teaching objectives, learning activities and assessment that were actually implemented.

During the teaching of her first lesson on the concept of "Elasticity", students were expected to explore and explain elastic properties. Somsri did not follow her lesson plan as intended. The main teaching sequences were the teacher explaining experimental procedures, students conducting an experiment, students completing worksheets and presenting their answers, and the teacher summarizing the main points of the lesson. Somsri introduced the lesson by dividing students into groups and demonstrating how they could stretch a slingshot and cotton thread. Somsri then asked students about the difference between the two objects when they were stretched. Students could answer that they were different in terms of elasticity. After that Somsri asked students to give an example of an object around them that had the elastic property. Students could not find any examples. Therefore, Somsri told them to stretch their rulers and pens in front of them. Somsri also explained how a spring in a pen had properties of elasticity. During her lesson, Somsri distributed five educational materials; rubber band, sponge, plastic foam, fruit wrap, plastic rope and cotton thread and asked students to stretch all materials. Students then were assigned to do an exercise by identifying the elastic property, and telling advantages of things in their daily lives in their worksheet. While students did an exercise, Somsri walked around the classroom and encouraged students to help and discuss to each other in their groups. She then asked each group to present the results of their exercise for the whole class. To conclude the lesson, Somsri asked students to give examples of things

around them that had the elastic property; she summarized by explaining the concept of elasticity to students. In Somsri's re-teaching of the first lesson plan, students were more active learners who conducted an experiment, presented the results and drew conclusions about their results by themselves. In this lesson, the main teaching sequences were the teacher demonstrating the experimental procedure, the students conducting an experiment, the students summarizing what they had learned, completing related exercises, presenting experimental findings, and concluding the lesson.

In her initial teaching of the second lesson plan, Somsri focused on the concept of "Hardness". Students were expected to explore the property of hardness. Somsri started the lesson by showing a rock and discussing a daily life situation about breaking windows with a rock. She linked this example to hardness by asking students why the rock could break the window. Students then gave examples of hard objects that they were familiar with in their lives. Somsri distributed materials to each group and assigned students to determine which materials had the hardness property. She gave students procedures to follow for the experiment. Students used a nail to scrape the materials and observe whether or not there was a scratch on the materials' surface. Somsri always reminded students to help each other with the experiment and she walked around the classroom to observe students as they did the experiment. Students presented the results of their experiments and completed exercises in their worksheet at the conclusion of the lesson.

When Somsri met with peers after teaching, she revised her second lesson plan. Based on their suggestions, she subsequently adjusted her teaching. She started the lesson by distributing the educational materials and asking students to conduct an experiment to determine hardness by themselves. Students conducted the experiment and wrote their results on the blackboard. As students finished doing the experiment, Somsri asked them many questions the property of hardness with respect to each material. Once Somsri perceived that her students understood the concept of hardness, she asked them to do an exercise in their worksheet.

For Somsri, capturing students' interest and attention in learning was of great importance. To engage student interest and attention, Somsri tried to prepare educational materials with which students were familiar such as fruit wrap, plastic rope and cotton thread. Although students in her classroom had a chance to carry out an experiment by themselves, for the most of part, Somsri explained the experimental procedures. However, in the teaching of the second lesson plan, students had more participation in the lesson. They investigated the property of hardness by using their prior knowledge and linking it to the concept of hardness. Students were given opportunities to do group activities followed by student-led presentations and summary exercises. Additionally, Somsri also emphasized exercises that linked with students' daily lives in order to help them think about how to apply acquired knowledge to explain everyday-life situations.

The pedagogical strategies that Somsri discussed and used in relation to her understanding of Social Constructivist Learning Theory

Somsri's lesson plans and interviews revealed the pedagogical strategies she used related to Social Constructivist Learning Theory. With respect to her first lesson plan, experiments, group activities, student-led presentation, asking questions and student formulation of conclusions were five main learning activities that Somsri planned to employ in the teaching stage. She believed that these activities had the potential to encourage students' first-hand experience and participation. During an interview, Somsri discussed using strategies such as experimenting, group work, and discussion. In an interview following her teaching of the first lesson plan she explained that experimentation was included because she believed that students would learn more as active learners where they could observe, touch and conduct investigations by themselves. She explained,

...Students could touch and do the experiment. They picked up and touch materials that I gave to them. Students tested by stretching materials out by themselves. Students learned because they touched and hold the materials. They would not learn if they only saw. I taught and found that students would

not learn if they did not touch or do the experiment by themselves. When they touched or did the experiment, they could remember and learn another concept... (Somsri's interview after teaching lesson plan I: November, 2007)

Additionally, Somsri encouraged students' group interactions. She mentioned the value of student interaction in terms of improving their learning. Somsri felt that students had an opportunity to learn from and teach each other when they worked together in groups. She explained,

...First, students might not understand why it could stretch. They would consult their friends in groups. If one student knew, he/she would talk and told their friends. When students did the experiment and did not understand, they would ask and consult their friends in groups. In their group if someone knew the answer, they would tell and explain their friends. They would help each other. Friends helped friends. They learned together... (Somsri's interview after teaching lesson plan I: November, 2007)

With regard to Somsri's revised lesson plan, pedagogical strategies consisted of: asking questions, group work, experimentation, worksheets, and students' formulation of conclusions. During the post-teaching interview, Somsri mentioned the pedagogical strategies she actually used, including asking questions, experimentation, students' synthesis and concluding of the lesson and discussion. She included discussion in her teaching even though it did not appear in her first revised lesson plan. Like her explanation in the interview after teaching her first lesson plan, Somsri believed that discussion would encourage students' interaction and lead to improve student learning. She commented, "I observed that students talked and consulted together. First, they might don't understand, but after they touched, consulted and debated they would learn." (Somsri's interview after teaching revised lesson plan I: November, 2007)

In terms of Somsri's second lesson plan, the pedagogical strategies she included were asking questions, experimentation, group work, student-led

presentation, discussion, exercises in the worksheet and student synthesizing and concluding the lesson. Correspondingly in Somsri's interview, she discussed her use of similar pedagogical strategies in the lesson; asking questions, experimentation, group work, student-led presentation, discussion and exercises in the worksheet. However, she did not mention details of students synthesizing and concluding the lesson. In revised lesson plan II, there were the same seven pedagogical strategies that appeared in Somsri's lesson plan II. In her revised lesson plan, she did not change any activities but improved the student worksheet and added some details regarding teacher and student questions and expected answers. The pedagogical strategies consisted of asking questions, experimentation, group work, student-led presentation, discussion, exercises and student synthesis and conclusion of the lesson. Additionally, she explained the reason why she used more questions in her lesson. In her view, asking questions encouraged students to participate in the activity. She explained,

...I taught by following the revised plan. I stimulated students by asking them questions. They also could answer and did activity. However, some students could not. Students had different abilities and interests. Teacher should activate them by asking questions. Asking them how their experiments were. Not many students were curious and enthusiastic... (Somsri's interview after teaching revised lesson plan II: December, 2007)

Somsri's lesson plans and interviews revealed her interpretation of Social Constructivist Learning Theory with respect to pedagogical strategies. Each lesson plan had an activity which encouraged students to do experiments and engage in students' discussion. Most of the lessons included group activities, student-led presentations, questioning, exercises in the worksheet and student synthesis and formulation of conclusions. Analysis of Somsri's responses clearly indicated that she employed many pedagogical strategies to teach science without sticking to traditional instructional strategies of listening, lecturing and writing.

Somsri Collaborated with her Peers in the Lesson Study

Reflection on practice: Reciprocal peer coaching

After Somsri's teaching, the team members had a meeting to reflect on her practice. The team critiqued Somsri's teaching, indicated problems in her classroom, and gave suggestions for improving the lesson. In the first meeting, Palita and Duangjai had similar criticisms about Somsri's teaching. They both commented about the teacher and student roles. They described Somsri as a guide who helped students to do the group activity, promoted students' active learning, and encouraged them to discuss and conclude the lesson by themselves, as can be seen in this excerpt from their meeting.

...Teacher was as a guide. Somsri did not only teach but also advised students. Students worked in groups and had a chance to consult with their friends. Student presented the conclusion. Teacher was a leader who asked questions and gave the example to students... (Palita's comment in meeting after Somsri taught lesson plan I: November, 2007)

...Somsri distributed two springs to students for investigation their understating of elasticity. Students had experience and could tell which one had elastic property. However, they did not explain the concept of elastic. Teacher tried to link their understanding to the concept of elastic. Teacher assigned students to observe things in front of them and discuss about the meaning of elastic things... (Duangjai's comment in meeting after Somsri taught lesson plan I: November, 2007)

Additionally, Duangjai discussed the problems that she saw in Somsri's classroom. She noted that students did not share and exchange educational materials with their peers. They touched and observed only the object that the teacher gave them. In her mind, Duangjai thought that students misunderstood the teacher's instruction. Duangjai suggested that Somsri clarifies her instruction and makes sure

that students understand her assignment before they start to do the activity. Duangjai explained.

...Students did not exchange materials and shared to their friends for observation. Students understood that teacher assigned everyone to observe and present what they observed. I observed students and thought that they refused to share the materials to their friends. Teacher should explain the method of doing experiment very clearly and then distributed materials. Students should be random to present in front of the class instead of the head of group always was a person who presented... (Duangjai's comment in meeting after Somsri taught lesson plan I: November, 2007)

Duangjai described another problem with the student-led presentations in the classroom. She noted that Somsri asked only the group leader to present in front of the class. Other students in the groups did not have a chance to present. In Duangjai's view, the consequence of this situation was that the group leaders were tired and other students did not pay attention. Duangjai advised Somsri not to select specific students when asking for volunteers to present in front of the class. Additionally, Duangjai felt that students should present the results of their experiment rather than the answers on their worksheet, as illustrated below.

...When teacher told students to present in front of the class, teacher specified the group leader to present. Students learned in groups. It should not identify the person who would present because that student would present every time. Group leader would present every time. It would make other students felt that they were not responsible anything. Some of them could present, but they might not feel confident. For presentation, students should present the result of experiment, but they presented about the worksheet. Therefore, in conclusion, teacher concluded from the worksheet. It should conclude the result of experiment first and then let students do exercise and discussion... (Duangjai's comment in meeting after Somsri taught lesson plan I: November, 2007)

In the second meeting after re-teaching lesson plan I, Duangjai commented on how students were active learners and the teacher served as a guide. She discussed how students participated in the lesson by observing the experiment, touching educational materials and answering teacher questions. Duangjai also mentioned that Somsri used various everyday-life materials with which students were familiar. She commented on her observations, noting “The role of teacher, she introduced the lesson by showing straw and other things which appear around students such as books, rulers and pens. The role of student was observing, touching, and answering questions. Students learned by themselves. Teacher asked questions and collected students’ ideas to be concept written on the blackboard.” (Duangjai’s comment in meeting after Somsri taught revised lesson plan I: November, 2007)

Palita also praised Somsri’s teaching, emphasizing that her teaching had improved. She felt that students were participating in the activity more actively and learning more. She explained, “I want to add that the learning environment was fun. Students learned about elastic properties. They learned the concept by themselves. Teacher taught by following the plan. Students learned by themselves. Everyone participated in activity. They talked and consulted their friend in groups. It was better than the first teaching.” (Palita’s comment in meeting after Somsri taught revised lesson plan I: November, 2007)

In the meeting following Somsri’s teaching of lesson plan II, Somsri and her peers did not discuss any problems with the lesson. Instead, Palita and Duangjai reflected on the effectiveness of Somsri’s teaching. Palita described Somsri’s role as a teacher who guided and concluded the lesson. Palita emphasized that students had many opportunities to observe, touch and discuss conclusions. Similarly, in Duangjai’s view, students were active learners and Somsri, as a teacher, was a facilitator. The following excerpts reflected Palita’s and Duangjai’s discussion of Somsri’s teaching.

...Somsri showed two stones and asked students “Are they hard?” After that she gave students educational materials which composed of comb, candle,

rubber, and rock. Students arranged materials follow hardness. Students learned from real materials. They learned from observing, touching and scratching on the surface of all materials. They were interested in activity. They worked in groups. Teacher guided and wrote the conclusion on the blackboard. Students repeated the concept sentences of hardness from teacher's speech... (Palita's comment in meeting after Somsri taught lesson plan II: December, 2007)

...Somsri used two rocks for introducing the lesson. She asked questions to activate students to be curious. For doing experiment, Somsri was a facilitator who prepared educational materials for students. Students learned by doing experiment by themselves... (Duangjai's comment in meeting after Somsri taught lesson plan II: December, 2007)

Although Duangjai did not identify any problems with the lesson, she did give Somsri some suggestions for improving her teaching. She felt that Somsri should write the main concept on the blackboard for students. She explained how writing the main concept on the blackboard could help students understand and focus better. Duangjai also suggested that Somsri wrote the experimental table on the blackboard so that students could record the results of their experiment for all to see. In this way, students could compare their results with those of their peers. Lastly, Duangjai suggested that Somsri added questions about the methods used to test elasticity in students' exercises. Duangjai explained in the following comments:

...For knowledge, the main concept should be written on the blackboard. Because students were different, some of them understood and some did not. For recording the experiment, students should record on the blackboard for comparing with other groups. Somsri might divide blackboard into the number of groups. Students in each group would write their result on the blackboard. For worksheet, the exercise should let students write the testing method too... (Duangjai's comment in meeting after Somsri taught lesson plan II: December, 2007)

Based on their observations of Somsri's re-teaching of lesson plan II, Duangjai and Palita raised the issue of Somsri's use of the word "test" in the lesson. They agreed that students misunderstood the meaning of "Test". Students thought that it meant "do the test" instead of do the "experiment", as illustrated below.

Somsri: "Students did not understand the word "test". They thought it meant "writing"

Palita: "Students thought that they would do the lesson's test. It seemed after they study, they must take a test"

Sonsri: "It meant to do the activity"

Palita: "They thought that it was a test"

Duangjai: "The easy meaning was what the result of experiment." (Meeting after Somsri taught revised lesson plan II: December, 2007)

By participating in Lesson Study, Somsri learned to improve her instruction through collaboration with colleagues. Their critiques of her teaching and recommendations influenced her thinking and teaching practice.

Somsri Perceived the Benefits and Challenges of Applying Social Constructivist Learning Theory in the Classroom.

From her experiences in the classroom, Somsri perceived the benefits and challenges of translating Social Constructivism into practice. She indicated the advantages for herself and her students. For herself, she claimed that she learned about students' individual differences, and could better recognize their prior knowledge and potential. She explained, "I know that each student has different idea. For example, this student thinks something and that student thinks another thing. Some students think the same." (Somsri's comment in meeting after she taught lesson plan I: November, 2007); "I could know students' capability. I can know that each student was different capable." (Somsri's comment in meeting after she taught revised lesson plan I: November, 2007) Explicitly, she felt proud of her students when they could answer questions. She emphasized,

...When I saw students, I was proud of them. When I taught in this way [based on Social Constructivist Learning Theory], students could answer. Teacher was happy. This method also made students understood more. Students could do worksheet and the test. That satisfied my need... (Somsri's interview after teaching revised lesson plan II: December, 2007)

With regard to the benefits for her students, Somsri felt they actually learned more when she taught in accordance with the tenets of Social Constructivism. She noted that students were active learners who could investigate knowledge by themselves. They were able to construct their own understanding by connecting between prior knowledge and new knowledge, as described below.

...It was good that students have a chance to do the experiment. They could construct their own knowledge. They did and solved the problem by themselves. They could explore, investigate by themselves and link to their prior knowledge. They used their experience that they saw in their daily life to solve problems. They had more skill and understand more... (Somsri's interview after teaching revised lesson plan II: December, 2007)

Based on her experiences in the classroom, Somsri believed that students had developed more positive attitudes toward science. Somsri felt that they were happy and more enthusiastic about learning science. She noted, "Students enjoyed learning and had fun with this activity. Students were joyful and enthusiastic to learn. They want to do next experiment." (Somsri's interview after teaching revised lesson plan I: November, 2007) Additionally, Somsri saw the advantage of the product of learning. As she said, students could finish doing the worksheet and do the test.

Beyond the benefits of teaching science based on Social Constructivist Learning Theory discussed earlier, Somsri also perceived some challenges of teaching science based on Social Constructivist Learning Theory. She discussed the competence of students and herself as a teacher. In her view, some students did not pay attention to the lesson, especially in lesson plan II. She was challenged to think

about how to engage students. She claimed that she tried to give positive reinforcement to these students and encourage them to study. She noted, “I tried to provoke my students to study. I would say “good” and “excellent”. I told their friends to applaud for students. They would have spirit to study.” (Somsri’s interview after teaching lesson plan II: December, 2007)

Furthermore, while Somsri believed that students should construct their own knowledge, she felt that it was a challenge for her students to explore and investigate knowledge by themselves. She explained, “When students constructed their knowledge, it challenged them to find knowledge.” (Somsri’s interview after teaching revised lesson plan I: November, 2007) Interestingly, Somsri also noted a problem with human resources when students explored knowledge by asking local experts. She felt that sometimes the experts did not welcome her students’ questions. It was a challenge for her to find effective ways for local resource persons to participate in her lesson. Somsri commented,

...It had some problems. Sometime when students asked questions to local people, they did not want to answer. Students really wanted to get the data. Sometime adult did not understand students and did not know how important it was. I would like their parents or some local experts understood and could be our resources... (Somsri’s interview after teaching lesson plan I: November, 2007)

The Case of Somsri: Some Conclusions

At the beginning of the workshop, Somsri initially understood about teaching and learning as traditional. In her view, she thought that students participated in the lesson as active learners when they were looking at pictures and listening to the teachers’ lecture. Somsri did not realize the importance of students’ prior knowledge. Asking students about their prior knowledge for her was to help students clarify their knowledge and made her lesson more interesting. She also believed that the teacher was responsible for telling students the correct concept. However, she recognized the

importance of group work and discussion in promoting students' interaction and participation.

As the teacher professional development progressed, Somsri developed deeper understanding of Social Constructivist Learning Theory in many aspects: the role of students, the role of prior knowledge, group work and discussion. Her thinking about the role of students shifted to the idea of students as active learners who did hands-on activities and constructed their own knowledge. Somsri developed her thinking about the importance of students' prior knowledge in designing activities and linking to the new knowledge. She also enlarged her understanding of the importance of group work in mutual learning when students had opportunities to learn from and teach each other. Additionally, Somsri developed her thinking about discussion more extensively in terms of helping students construct their own knowledge. However, her belief about the teacher role was traditional. She felt that the teacher was a facilitator who provided the experimental procedure and verified students' understanding.

Somsri translated her understanding of Social Constructivist Learning Theory in the lesson plan and teaching practice. She created two lesson plans for teaching in the topic of "Elasticity" and "Hardness". In her first lesson plan, the lesson began by distributing five things to students and allowing them to work in groups to investigate their properties. Students then presented the results in front of the class and answered questions. In summarizing the lesson, students concluded the lesson by themselves. Somsri planned her second lesson similar to her first lesson plan except she planned for students to discuss instead of to present in front of the class. According to her with both lesson plans Somsri was able to integrate her understanding of Social Constructivist Learning Theory into her plans. In her teaching practice, Somsri did not follow her lesson plan as intended. For most of her teaching, Somsri explained the experimental procedures instead of asking students to conduct an experiment by themselves. However, she developed her teaching to correspond to Social Constructivist Learning theory on other aspects including: the role of student, group work and discussion. Analysis of Somsri's lesson plan and her interview reveal that she employed many pedagogical strategies with respect to her understanding of Social

Constructivist Learning Theory. Most of lesson included asking questions, experiment, group work, experimentation, worksheets, student-led presentation, student-led conclusions, and discussion.

Somsri had a meeting with her colleagues after she taught science. Her peers critiqued her teaching and made suggestions for improving her lesson. They also indicated the problems in her classroom. From her teaching experience, Somsri perceived the benefit and challenges of translating Social Constructivist Learning Theory into practice. She learned that students had individual differences in their prior knowledge and learning potential. Somsri also felt proud of her students because they learned science better and developed more positive attitudes toward science. In her teaching practice, Somsri was challenged on how to engage students to pay attention to the lesson and conduct the experiment by themselves. Additionally, it was a challenge for her to find effective ways for local resource persons to participate in her lesson.

Case III: Ms. Palita

General Background of Palita

Palita had taught science for four years. She was the head of the science standard department at one of the suburban public schools in the second educational area in Nonthaburi province. She loved to teach science even though she didn't graduate with a degree in a science field; she held a degree in social science teaching. Palita was asked to spend 16 hours teaching on a block schedule every day. She was responsible for teaching science, educational guidance, and Boy Scouts. Her responsibility for teaching science included grade 6 at the elementary level and grades 7, 8 and 9 at the secondary level. Palita also had other responsibilities at the school such as distribution of food for students, and supervision of the laboratory. Therefore, her office was in the laboratory apart from other teachers who stayed in the teachers' common room. She was the one of four teachers in the school holding a particularly skillful position in the Thai education system. Palita's views on teaching and learning

and her teaching actions could be described as traditional. She had developed a typical classroom routine of lecturing followed by assigning of homework. She learned how to teach science from the textbook and teacher's handbook. She learned science by remembering all of the concepts in the textbook. Palita was concerned about students' content knowledge and their accurate understanding of concepts, and believed that students should memorize concepts as she did to be successful.

When the researcher offered her the opportunity to participate in a professional development experience, she agreed immediately. Palita had not attended any training courses for science teaching in three years. She was a teacher who was enthusiastic about learning new things. Palita believed that she could enhance students' enjoyment in science learning and lead them to like science. She thought that participation in the teacher professional development experience with her peers could improve science teaching and learning in her school.

Palita's Evolving Understanding of Social Constructivist Learning Theory

In order to describe the development of Palita's understanding of Social Constructivist Learning Theory during the teacher professional development experience, the research findings are presented in terms of five key aspects of Social Constructivist Learning Theory: the role of students, the role of prior knowledge, the role of teacher, group work, and discussion. This is intended to help the reader track how Palita developed her understanding of Social Constructivist Learning Theory through teacher professional development.

The role of students: From passive to active learner

Palita's written reactions to Social Constructivist Learning Theory vignettes revealed her initial understanding of the role of student as a passive learner. In her view, students were participating in a lesson when they observed an experiment or demonstration. Palita felt that students learned when they had the direct experience of observing an experiment. For Palita, the teacher was clearly an information provider,

and students were expected to receive what was provided by the teacher, as illustrated in a portion of her vignette.

...I agree with Vichai's teaching. Students saw him boiled water and burned wood. All students participated in the lesson because they saw the real experiment. Students also received the correct and important concept from explanation of teacher... (Palita's comment before attended the workshop: October, 2007)

After Palita attended the workshop, she maintained her beliefs about the teacher's role as the sole holder of knowledge. She still believed in the idea of transmitting knowledge by lecture and describing main concepts as the most effective approach to science teaching and learning. However, she did realize that students had more participation in the classroom when they actually did experiment and performed activities by themselves. She wrote:

...In Vichai's teaching, students received the right concept from teacher. They participated in the lesson more when teacher taught students to do hand-on activity... (Palita's comment after attended the workshop: October, 2007)

Palita's understanding of Social Constructivist Learning Theory was further developed after she collaborated in planning two lessons. The findings from interviews showed that her understanding of the role of students shifted from viewing students as passive learners to seeing them as active learners. Palita wanted her students to participate more fully in lessons. In her view, students could participate more in lessons by doing hands-on activities where they conducted experiments, presented results and arrived at conclusions about lessons by themselves. Palita also claimed that students learned by themselves and constructed their own knowledge, as the reflection from her interview below indicated:

...Students learned by themselves. I had educational materials for them. They participated in activity. I used materials and activities for students to perform.

Students would observe and did the experiment by themselves. They constructed their own knowledge. After they touched and observed the materials that teacher gave to them, they could present in front of the class. Students could conclude the lesson. They spoke by themselves... (Palita's interview after teaching revised lesson plan I: November, 2007)

The role of prior knowledge: From ignorance about students' prior knowledge to awareness about the connection between prior knowledge and new knowledge

At the beginning of the workshop, Palita initially did not consider the importance of students' prior knowledge. She also did not consider the benefits of accessing students' prior knowledge. She realized the benefits of asking students questions in the introductory stage of teaching. In her initial written reactions to Social Constructivist Learning Theory vignettes, she indicated that asking students questions could activate their interest. She explained, "I agree with Somchai. He asked students questions. Teacher should ask questions for activate students to be interesting in a lesson." (Palita's comment before attended the workshop: October, 2007)

Palita was asked to respond in writing to the Social Constructivist Learning Theory vignettes again after she attended the workshop. Her understanding of Social Constructivist Learning Theory was further evident in her responses. She came to consider the benefits of accessing students' prior knowledge. In particular, she felt that the teacher should explore students' prior knowledge and build connections between students' prior knowledge and new knowledge. Palita commented,

...I agree with Vichai's teaching. He asked students' prior knowledge. Teacher should ask questions in order to know students' prior knowledge. For teaching and learning process, teacher could use students' prior knowledge to link to new knowledge that they wanted to teach... (Palita's comment after attended the workshop: October, 2007)

Palita developed a deeper understanding of the influence of prior knowledge on the teaching and learning process. She recognized the importance of learning about students' prior knowledge. Palita mentioned that in the introductory stage of teaching teachers should not only ask questions, but also clarify students' prior learning. In her view, by analyzing students' responses, she could determine the appropriate activities for teaching and have a better sense of what students wanted to learn. She was also more concerned about the link between prior knowledge and new knowledge. She explained,

...Before teacher starts the lesson, teacher may ask students what they have learned or talks and has the conversation with students. Teacher will know how much prior knowledge that students have before teacher teaches new knowledge. Teacher will link new knowledge to prior knowledge. When teacher asks students' prior knowledge, it does not mean to look down on students' knowledge, but it means to review students' remember. In this way, teacher knows what knowledge should be taught and how. Teacher also can analyze about students' needs. What topics that students want to learn? What are students interesting in?... (Palita's interview after teaching lesson plan I: November, 2007)

Additionally, the awareness of students' prior knowledge was evident in Palita's description of her teaching activities. Palita mentioned that she raised examples or created situations for students in relation to their experience or environment. In her view, students' experiences were central to linking new knowledge with prior knowledge. She explained,

...I will give students examples. The examples that I use come from students' daily lives. They accustom to see these. The topic of matter is close to students. Students saw, observed and touch things around them. Teacher should try to find some examples for presenting to students... (Palita's interview after teaching lesson plan II: December, 2007)

...It related to students' daily lives. For example, I talked about launder and sun dried clothes. I used this for students to link between prior knowledge and new knowledge. Like dried beef, dried pork or dried fish, they were dry by sun. Students could link and know where was the water in the fish gone?... (Palita's interview after teaching revised lesson plan II: December, 2007)

Teacher role: From manager of learning activities to director who helps and guides students as they investigate knowledge

Initially, Palita's written reactions to Social Constructivist Learning Theory vignettes indicated that she saw her role as a "manager" of the classroom. She claimed that she taught using a student-centered approach. As a manager, she felt her job was to separate students into groups and distribute topics for them to study. In her view, students should be responsible to study on their own and present what they learned in front of the class, as evidenced in her interview comment below:

...I will teach student-centered. Students are divided into groups and each group will be responsible to study different topics. Then students will present in front of the class... (Palita's comment before attended the workshop: October, 2007)

After Palita attended the workshop, she was asked to create written reactions to Social Constructivist Learning Theory vignettes again. She developed her thinking about the teacher role more deeply. In her view, the teacher should create hands-on activities to foster student learning and build chances for them to interact and share ideas in discussions. She commented,

...Students should have a chance to do the experiment. They have discussion together which make them understand in the same way. When I correct the students' works, I know how much students understand knowledge... (Palita's comment after attended the workshop: October, 2007)

As the teacher professional development progressed, Palita further developed her understanding about the teacher role. She began to describe the teacher as a director who guides and stays behind students for support while students learned on their own. In her view, Palita saw that the teacher was responsible for preparing educational materials, asking questions and raising examples. According to Palita, The teacher was also an inspector, who examined students' learning as she explained,

...Teacher is as a guide. Teacher does not teach students to learn by rote. Teacher also does not talk alone or be a hero. Teacher will stay behind and is as a director. Students learn by themselves. Teacher will guide and inspect students' knowledge. Teacher may ask questions or test them. Teacher may tell the students to write what they have learned... (Palita's interview after teaching revised lesson plan I: November, 2007)

...Teacher distributed the materials for students to observe and match those materials with the situation of changing states of matter. I tried to raise the example that made students think, observe and present in front of the class. Students would learn and construct knowledge by themselves... (Palita's interview after teaching lesson plan II: December, 2007)

Moreover, Palita felt that it was important for the teacher to participate with students in the lesson. In this regard, Palita felt that the teacher should guide students as they investigate knowledge. According to Palita, both teacher and students should collaborate in the teaching and learning process as noted below.

...Teacher is a guide. Sometime teacher should participate in the lesson with students. It does not mean that teacher lets students study and find knowledge alone. Teacher should be a part of student learning or get to involve with students. Teacher should help and collaborate with students. Students do not reach for knowledge alone. Teacher participates in the lesson and helps students. Teacher and students may discuss together... (Palita's interview after teaching revised lesson plan II: December, 2007)

Additionally, Palita mentioned other aspects of the teacher role. She indicated that a teacher should control and motivate students to engage in activities. In her view, she claimed to use her personality and positive reinforcement for motivation and classroom management. Palita explained,

...When students learn, teacher is a guide. Teacher does not transmit knowledge. Another thing is classroom management. Teacher control students not be loud. I used a loud and serious voice to control students' behavior. I also tried to praise students and used grade to persuade students to do the activity... (Palita's interview after teaching lesson plan I: November, 2007)

Group work: From promoting positive interaction to encouraging knowledgeable students to explain information to their friends

Before Palita attended the workshop she was asked to write her reaction to the Social Constructivist Learning Theory vignettes. Palita initially discussed the importance of group work, believing it supported student learning. An analysis of vignettes revealed that Palita believed students had positive interactions when they worked in groups. She felt group work was valuable because students had opportunities to discuss and exchange ideas with each other. In her view, working in groups also promoted students unity. Specifically she noted,

...I agree with Klahan. Student worked together in groups. They had a chance to discuss and exchange the knowledge. Students helped each other in group. They learned and helped each other in groups. The unity of group would occur too... (Palita's comment before attended the workshop: October, 2007)

As the workshop progressed, Palita maintained her beliefs about the advantages of group work. According to Palita, when students work in groups, they help each other understand activities, and discussed and exchanged their ideas. In her view, Palita felt that student interactions with peers were better than individual thinking and work. She noted,

...I think students learn when they work in groups. They discuss and exchange their idea. They help each other to do activity. Working in groups is better than working alone... (Palita's comment after attended the workshop: October, 2007)

During her teaching and peer meetings, Palita still maintained her belief that group work supported positive interactions. Students could talk, exchange ideas and help each other when they worked in groups. However, Palita developed a deeper understanding about the many advantages of group work. She pointed out that students who worked in groups not only took responsibility and participated in group activities, but also became individuals who were knowledgeable enough to explain ideas to the group. Every student could learn because they consulted and helped each other by explaining information to their friends. Additionally, Palita recognized the advantages of group work in terms of promoting positive social interactions. She described how group work taught students to accept other peoples' ideas and be courageous in expression of their ideas, as illustrated in her comment below.

...Students who work in groups will help each other. They will consult to each other. Every student takes a part in collaborative learning. Students who do not understand can tell their friends to help them. They may explain to their friends in groups. It is good because it saves teacher's energy too. Every student will learn. There are advantages from separation students in groups. Students collaboratively work and understand a concept. Students will be brave to present their idea. They also learn to listen to their friends' ideas too... (Palita's interview after teaching revised lesson plan I: November, 2007)

Discussion: From perceiving valuable interactions to supporting students in expressing their ideas

At the beginning of the workshop, Palita was asked to complete written reactions to Social Constructivist Learning vignettes. Her responses indicated that she

recognized the benefits of discussion. In her view, students could have valuable interactions between peers and the teacher through discussion. Moreover, discussion could also help students arrive at conclusions. She commented,

...Using group discussion for teaching is good. Students are brave to speak and expressed their idea. They express the idea to teacher and their friends. Discussion can lead to a correct and fast conclusion... (Palita's comment before attended the workshop: October, 2007)

After Palita attended the workshop, she still believed that discussion helped students learn. In her view, students could learn from the teacher and their peers in discussion. Additionally, students could better understand the concepts after joining in discussion. As Palita emphasized in vignette critiques,

...I agree with teacher from northern part. In her teaching, it had group discussion. Students could express their idea. They learned from teacher and their friends in discussion. Student also could conclude the important concept from discussion... (Palita's comment after attended the workshop: October, 2007)

While Palita attended the professional development experience, she developed her understanding about the role of discussion in the teaching process. In her view, Palita believed that students could develop an understanding of concepts by participating in discussions. In particular, she felt that it was important for the teacher to encourage students to express their ideas in discussions. Palita explained,

...Students should express their ideas. I support students to say what they want to say. I promote them to express their ideas based on their understanding. Students exchange their ideas. They have accepted friends' ideas. Students will receive the knowledge after they join discussion. They will conclude the concept and construct the knowledge by themselves in discussion... (Palita's interview after teaching revised lesson plan I: November, 2007)

Palita Translated her Understanding of Social Constructivist Learning Theory into Practice.

In order to present Palita's practice during the professional development experience, the research findings are presented in three parts; the integration of Social Constructivist Learning Theory into science lesson plans, teaching practice, and pedagogical strategies. This is intended to help the reader track how Palita developed her PCK in her teaching practice.

A relationship between Palita's understanding of Social Constructivist Learning Theory and her lesson plans

Initially, before Palita attended the workshop, she used a science elementary textbook and teacher manual to plan lessons for her elementary science class. However, she used lesson plans which she designed by herself for her secondary science class. Her lesson plans for the secondary science class included main concept, learning objectives, learning activities, instructional materials and assessment. When considering the learning activities in Palita's lesson plans, the sequence of activities included: introduction stage, teaching stage and conclusion stage. In the activity stage, students worked in groups and had discussions. They studied by themselves, wrote the results of experiments and presented their information in front of the class. Students also wrote about the main concept in their notebooks and did exercises on their worksheets. During the teacher professional development experience, Palita was asked to construct two lesson plans based on her understanding of Social Constructivist Learning Theory for teaching elementary science. The topics of her lesson plans were "The states of matter" and "The changing states of matter".

In her first lesson plan, Palita wanted students to classify the states of matter and learn about their properties. In the introduction stage, Palita planned to organize students into groups and introduce the lesson by asking students about the five sense organs. Then, she planned to have students in each group give an example of something around them and identify the state- solid, liquid or gas. After that she

wanted each group to do an experiment to investigate the properties of states of matter: shape, volume and density. Palita also planned to have students discuss the properties of solid, liquid and gas after they did the experiment. Finally, she wanted students to present the results of their experiments in front of the class. The lesson would end with teacher and students discussing together and making conclusions about the concept of states of matter.

After Palita and her peers met to discuss the lesson plan, she made revisions. There were revisions to some activities and the student worksheet. Palita added a role play activity that she planned to have students do later, after finishing the experiment. In this activity, Palita planned to have students learn about the nature of chemical bonds in each state. Students would act out particles of matter in solids, liquids and gases. She wanted them to use their arms and pretend to be bonds by hugging and holding hands with each other. In terms of the student worksheet, Palita added a few questions where students could write their ideas about the states of matter and their properties. Additionally, the first lesson plan was improved by adding some details about the teacher's questions and students' expected answers.

Palita's second lesson plan centered on "Changing states of matter". The objective of this lesson was to explain about the changing states of matter: evaporation, melting, sublimation and condensation. Palita planned to start the lesson by asking students about their prior knowledge of the states of matter. She then planned to distribute material such as dry chilies, candles, ice cream and mothballs (a small strong smelling ball used for keeping moths away from clothes) to students. Palita wanted to demonstrate daily life situations such as clothes drying by the sun, ice turning to be water, a mothball turning to a smaller size and a drop of water on the rice cooker lid. After that she planned to ask students in each group to discuss and match the materials that she handed out with the situations that she described. She wanted students in each group use the materials to present and explain the situations and how they were linked to changing states of matter. She then planned to have them share examples or other situations of changing states of matter they found in their daily lives and discuss in terms of the concepts of evaporation, melting, sublimation

and condensation. In the summary of the lesson, Palita planned to have the teacher and students work together to make conclusions about the changing states of matter concept. She also planned for students to do exercises on their worksheets. After Palita and her peers met to discuss the lesson plan, she made some small revisions. The revised lesson plan II did not change in terms of activities, but it was modified by adding information about students' expected answers. The worksheet was also improved by adding questions in the exercise section for students to write their ideas about the concepts of changing states of matter.

In conclusion, all lesson plans created by Palita showed that she was able to integrate the knowledge components of Social Constructivist Learning Theory into lesson plans. Palita's lesson plans reflected how her planning for student learning was consistent with what she believed about teaching and learning. Each lesson plan had an activity which encouraged students to be active learners. Students were required to participate in, or have first-hand experience. The role of the teacher was to prepare the educational materials and ask questions. Moreover, most of the lesson plans began by ascertaining students' prior knowledge. Palita's lesson plans also reflected her belief about group work. According to her lesson plans, students would be divided into groups and do activities together. Each lesson plan had an activity which encouraged students' discussion. However, noticeably, the details of the teacher's questions and students' expected answers were not provided before Palita met with her peers.

Palita's teaching

During the teacher professional development experience, Palita taught two science topics: the states of matter and changing states of matter. Her classroom practices were analyzed in relation to Social Constructivist Learning Theory. Palita's classroom practice was somewhat Social Constructivist oriented as it contained some aspects of Social Constructivist Learning Theory, but not all aspects of this Theory. An example of the integration of knowledge bases about Social Constructivist Learning Theory can be seen in Palita's teaching below.

In her first lesson plan, Palita taught about “the states of matter”. Students were expected to classify the states of matter and explain about the properties of states of matter: solid, liquid and gas. Palita taught according to her lesson plan in the introductory and summary stages. However, in the teaching stage, she added a play role activity to her actual teaching. Palita started the lesson by asking students about the five sense organs. Students were able to answer that the five sense organs consisted of eyes, ears, nose, mouth and skin. Palita also asked students to give examples of things around them and identify their states of matter. This activity elicited students’ prior knowledge about the states of matter with respect to items in the surrounding classroom. Palita implemented aspects of active learning by allowing students to conduct experiments by themselves. She divided students into groups, distributed materials and explained how to do the experiment. Students investigated the properties of matter by putting pens, water and air in different containers (plastic bag, plastic cup and balloon). They observed and compared the changing of figure and volume when the pen was in a plastic bag, plastic cup and balloon, the same as when water and air was in different containers. While students did the experiment, Palita encouraged them to help each other in their groups. After students finished the experiment, each group presented results in front of the class. Next, students were asked to role play particles of matter. They were asked to hold hands together and pretend to be the particles of matter in different states. Palita then asked questions to relate different strengths in holding hands to each state: solid, liquid and gas. When the time was up, students were asked questions as a review of what they had learned that day. In her teaching of revised lesson plan I, Palita taught much the same as she did in lesson plan I. Students answered questions, conducted experiments, presented results in front of the class and participated in a role play. However, Palita raised more examples for students when she taught the revised lesson.

In her teaching of lesson plan II, Palita taught the topic of “changing states of matter”. Students were expected to explain about the properties of matter in accordance with change in state and explain the causes of the phase changes. At the beginning of the lesson, Palita divided students into groups and distributed different educational materials to each group. The materials that she distributed were the set of

instruments for doing an experiment related to evaporation, melting, sublimation and condensation such as dry chilies, ice, moth balls and rice cooker. Palita started the lesson to elicit students' prior knowledge by giving examples of matter in each state: solid, liquid and gas and asking questions about these states of matter. Palita engaged students in activities to get their attention by raising daily life situations such as the clothes drying by sun, the ice melting in room temperature, the large candle melting by heat. Students were asked to match the materials that Palita handed out with those daily life situations and present their experiments with those materials in front of the class in relation to the situations that she had described. Palita explained and summarized the main aspects of the concept after each group presented their experiment. At this point, students completed exercises in their worksheets and shared what they had learned. In her teaching of revised lesson plan II, Palita taught much the same as in lesson plan I. Students answered questions, conducted experiments, and presented results in front of the class.

During the lesson, the researcher observed Palita engaging students in activities to get their attention by asking questions. The questions that Palita used also elicited students' prior knowledge and experiences of the topics at the beginning of the lesson. Palita facilitated her students' learning by providing active hands-on activities. She provided opportunities for students to work together in groups by doing experiments. However, she did not lead students step by step to a solution. Palita assisted students in participating and sharing their personal experiences and relevant prior knowledge to further develop understanding about the states of matter and changes in states of matter.

The pedagogical strategies that Palita discussed and used in relation to her understanding of Social Constructivist Learning Theory

Palita evidenced an understanding of Social Constructivist Learning Theory through the pedagogical strategies that she used in her lesson plans and interviews. According to Lesson plan I, pedagogical strategies consisted of: investigating students' prior knowledge, group work, experimentation, discussion, student-led

presentations and asking questions. During an interview, Palita also mentioned using many of these same pedagogical strategies, as well as role play. She also provided an explanation of her reasons for using these strategies in her classroom. Palita explained that she tried to determine students' prior knowledge in order to link it to the new knowledge that she wanted to teach. She also discussed how she wanted her students to receive first-hand experience by actively participating in experiments and activities. She explained, "I taught students to learn by themselves. I prepared materials. Students participated in activities. They perform the activities." (Palita's interview after teaching lesson plan I: November, 2007) Additionally, Palita encouraged her students to work in groups. She mentioned the value of student interaction in terms of improving their learning and the quality of their work. In her view, students should work together in groups, and exchange ideas because the quality of their work was better when they learned together in groups. "All students learned. Everyone knew the same knowledge." (Palita's interview after teaching lesson plan I: November, 2007)

Palita met with her peers and revised lesson plan I. There were revisions to some activities and to the student worksheet. She added a role play activity in her revised lesson plan I and included additional questions on the students' exercise. With regard to her revised lesson plan, pedagogical strategies consisted of: investigating students' prior knowledge, group work, experimentation, discussion, student-led presentations, asking questions, role play, students' formulation of conclusions and exercise in worksheets. Palita taught the revised lesson plan I again with another class. She discussed the lesson in an interview that followed. In the interview, the pedagogical strategies that she mentioned using were group work, experimentation, student-led presentations, asking questions, exercises in worksheets, and role play.

In terms of Palita's lesson plan II, the pedagogical strategies she included were investigating students' prior knowledge, group work, discussion, student-led presentations, asking questions, students' formulation of conclusions and exercises on a worksheet. Palita discussed using strategies very similar to how they appeared in her lesson plan II. In her revised lesson plan II she did not change any activities; but she

simply improved the students' worksheet. Likewise, the pedagogical strategies that Palita discussed using were the same.

Palita Collaborated with her Peers in the Lesson Study Approach

After team members and the researcher observed Palita's lessons, they shared opinions and suggestions. They critiqued her teaching, indicated problems in her classroom, and gave suggestions for improving the lesson. In the first meeting after Palita had taught lesson plan I, Somsri was the first person to speak about Palita's practice in the classroom. She started to delineate Palita's teaching in relation to the teaching and learning process. In her view, Palita was a teacher who engaged students in the lesson and elicited their prior knowledge by asking questions. Somsri also viewed Palita's role primarily as one of distributing the educational materials and helping students arrive at conclusions about the lesson. In terms of students, Somsri viewed their role as active learners who participated in hands-on activities. Somsri noted how students observed, touched and conducted the experiments by themselves. She also discussed how they worked in groups, and collaborated on the activity together, as illustrated below.

...Teacher posed the questions. Students answered. They could answer the questions. Students participated in the activity. They helped each other to answer questions. When teacher activated students by posing questions in order to link to their prior knowledge, students answered back and forth to teacher. Teacher asked students' prior knowledge. Students joined the activity. They were divided in group to do the experiment. Student did the experiment in groups. Teacher distributed the educational material for them. Students observed, consulted and talked together in groups. They touched materials, did the experiment by themselves. Then teacher guided them to record the experimental result. Students discussed in groups and sent a group representative to present in front of the class. Teacher and students helped each other to conclude the lesson... (Somsri's comment in meeting after Palita taught lesson plan I: November, 2007)

Like Somsri, Duangjai commented on Palita's teaching. She felt that Palita's primary role involved asking questions to ascertain students' prior knowledge and motivating students to participate in the lesson. She saw Palita as a facilitator who gathered the students' ideas and used them in helping them form conclusions. In terms of students, she viewed their role as conducting independent activities and discussions in their groups. She commented:

...In Palita teaching, teacher asked students' prior knowledge and activated them to think and answer questions. Teacher also tried to link the knowledge. From the observation, I interpreted that students answered the questions and teacher used the questions for students to participate the lesson. The thing that I observed was student role. Students participated in the activity well. Students worked in groups. They debated to their friends and then presented in front of the class. Teacher tried to collect the scatter ideas of students to be center... (Duangjai's comment in meeting after Palita taught lesson plan I: November, 2007)

Palita and Somsri discussed the problems that they saw in Palita's teaching as well. They agreed about problems related to students. In their view, students were not confident about expressing themselves in front of the class. They were shy and hesitant about presenting in front of the class. Students argued with their friends about who would be the group representative. Palita also perceived the problem and wanted her students to change and alternate with others in giving presentations. Somsri also suggested that Palita herself might identify the students to present in front of the class, thereby decreasing the presentation problem. Palita agreed with Somri's advice, as can be seen in this excerpt from their meeting:

Somsri: Students who wanted to speak did not know what to be presented. They were dumb and could not speak well. Students who could speak did not present. They argued with friends and did not want to present. If the group had leader, that leader would be the representative and be the only one who presented.

Researcher: How could we solve this problem?

Somsri: We try to activate students presented in front of the class.

Palita: Students should take turn to present in front of the class.

Somsri: Teacher should speak to guide them. Like “Your turn to speak”. Then students would speak. If teacher did not say, students still argued together and said to their friends that “You go”. Teacher must indicate students to present in front of the class. Students could speak but they were shy and were not brave to express themselves.

Palita: Students, who were brave, always were fearless to present. Students, who were shy, always did not present. Teacher would say “This student, you presented” It would help the shy students to express themselves more. (Meeting after Palita taught lesson plan I: November, 2007)

Additionally, Duangjai and Somsri felt that students did not understand how to do the activity. They felt that students were confused by the experimental table on the worksheet. Palita agreed with Duangjai and Somsri, feeling that the worksheet had perplexed students. She and Duangjai agreed that the worksheet should be improved. Duangjai recommended that Palita could solve this problem by explaining and demonstrating how to do the activity. Additionally, Duangjai, Somsri and Palita also noted that some students did not pay attention to the lesson. Palita was thankful to Duangjai and the others for giving her advice on her teaching.

In the second meeting after Palita taught the revised lesson plan I, Duangjai, and Somsri did not note any problems in Palita’s classroom. Duangjai and Somsri critiqued Palita’s teaching, commenting on the role of students and teacher in the classroom. They noted that students were active learners and the teacher served as a guide. Somsri discussed how students participated in the lesson by answering Palita’s questions, did the experiment and arrived at conclusions about the lesson by themselves. She also noted that students worked well in their groups and had interaction with each other. They helped each other to do the activity as well as discuss conclusions. Somsri described Palita’s role as a teacher who distributed educational materials, asked questions, guided students in doing the experiment and

helped students arrive at conclusions about the lesson. The following excerpt reflects Somsri's discussion of Palita's teaching.

...Teacher asked question and students answered. It had the link between prior knowledge and new knowledge. Students talked and answered teacher questions. They were divided in groups and did the experiment. Teacher guided students about doing experiment. She also distributed the educational materials to students. Each group expressed the idea and had discussion. Students helped in groups to do the experiment. They debated, explained and guided to each other in groups. They presented and concluded the experiment in front of the class and then teacher helped them conclude the lesson again... (Somsri's comment in meeting after Palita taught revised lesson plan I: November, 2007)

Like Somsri, Duangjai also commented on the role of Palita and her students. She described Palita as a facilitator who promoted student learning. She noted how Palita used familiar examples from the environment to link between prior knowledge and new knowledge. She commented on how students had a chance to interact with their peers, expressing and exchanging their ideas in groups. According to Duangjai, students were active learners who did the activity and arrived at conclusions about the lesson by themselves. Moreover, Duangjai also found that students learned and participated in the lesson more actively than in the first lesson. She explained in the following comments:

...Students had more interaction in their groups. They concluded the lesson by themselves. Teacher was a facilitator. When she guided students, they understood and could link to the new knowledge faster. Students responded to teacher better. Students participated in a classroom. They were interested in answering teacher's questions. Teacher tried to use the environment to link to the knowledge that she would teach. Teacher gave a chance for students to express their idea. Students had discussion and did the activity by

themselves... (Duangjai's comment in meeting after Palita taught revised lesson plan I: November, 2007)

When meeting with peers after teaching lesson plan II for the first time, Duangjai and Somsri noted some problems. They agreed that students lacked writing skills. Duangjai also indicated that there were some problems with the presentations. She commented that students did not take turns when presenting in front of the class. She explained, "Students who wrote on the blackboard was the same students who presented in front of the class. Students did not take turn to present. They did not believe their friends. It should have a chance for all students." (Duangjai's comment in meeting after Palita taught lesson plan II: December, 2007). Similar to the meeting after lesson plan I and revised lesson plan I, Duangjai and Somsri critiqued Palita's teaching in terms of student and teacher roles. Duangjai felt that Palita needed to do more to engage students in discussion. In her view, she wanted students to speak and express their ideas more openly. Duangjai explained "In conclusion, if we emphasize students to discuss. I mean discussion for concluding the concept. It will be good if students speak more than they did. It should let students speak and express their idea more." (Duangjai's comment in meeting after Palita taught lesson plan II: December, 2007) Additionally, Somsri advised Palita to improve the worksheet by adding questions where students could express their ideas in writing. In the meeting following Palita's teaching of revised lesson plan II, Duangjai and Somsri did not emphasize any problems in Palita's classroom. However, they critiqued Palita's teaching in terms of student and teacher roles.

Palita Perceived the Benefits and Challenges of Applying Social Constructivist Learning Theory in the Classroom.

Beyond the development of understanding the components of Social Constructivist Learning Theory and translation of theoretical understanding into practice as discussed earlier, Palita realized the benefits and challenges of applying Social Constructivist Learning Theory in her classroom. Palita believed there were many benefits for students when she taught science based on Social Constructivist

tenets. She felt that her teaching based on Social Constructivist Learning Theory developed students' conceptual understandings, promoted positive social interactions, fostered positive student attitudes about science and generally improved students' work.

With respect to students' learning, Palita explained that students had a chance to investigate and make sense of science knowledge by themselves. She commented, "Students investigate when they learn science. They investigate from the activity that they do. This is an advantage." (Palita's interview after teaching revised lesson plan I: November, 2007) In addition, she emphasized that when students participated in the activity and learned together, they made sure that everyone in the group understood the science concepts. She expressed her thinking about the advantages of teaching science related to Social Constructivist Learning theory in an interview. She explained:

...All students participate and learned together. Students help friends who do not understand in their group. Students receive the knowledge. There are many advantages to divide students in groups. Students learn together and understand better. It saves time for teacher. Students also listen to friends' opinions. They are brave to present too. Students conduct the experiment. They do it by themselves and present in front of the class. They can conclude the lesson by themselves. They construct their own knowledge... Palita's interview after teaching revised lesson plan I: November, 2007)

Additionally, Palita described in more detail how group work taught students to be unified and confident in themselves. She explained, "The advantage for students is the unity in their group. Students learn to construct their own knowledge. They have to achieve consensus in their groups and students also have to be brave to express their ideas." (Palita's interview after teaching revised lesson plan I: November, 2007) Importantly, Palita found that her students were happy and liked to learn science in groups. She said, "Students like to learn in groups. I asked them they said that they like group work. Students said that they like to learn. They said that

they have fun. Students said that it is good and they have fun. It is not boring.” (Palita’s interview after teaching revised lesson plan I: November, 2007) With regard to the quality of students’ work, Palita claimed that students finished their work in a more timely manner and took care to make it neater.

In terms of advantages for herself, Palita indicated that she did not feel as tired when she taught in accordance with the tenets of Social Constructivism. She explained that not having to give lectures to students helped in terms of her own energy level. She explained,

...I think the benefit is I do not speak too much. It means I do not stand and explain all content. I need not to speak. Students investigate by themselves. I am not tired. It means students learn by themselves. I do not to explain what this/that was... (Palita’s interview after teaching lesson plan I: November, 2007)

Additionally, Palita felt that there were advantages in terms of how she felt about students’ accomplishments. In her mind, she was proud of her students. She noted, “The advantage is I am proud. I am proud of my students. Students pay attention in learning. They can bring knowledge that I teach to use or teach their friends.” (Palita’s interview after teaching revised lesson plan I: November, 2007)

Palita also perceived many challenges in teaching science based on Social Constructivist epistemology. The main challenges, as she explained, were the potential of students, the preparation of herself as a teacher, and group work in teaching. In terms of the potential of students, Palita indicated that students had different ability levels. It challenged her to support all students in learning science. She explained:

...It challenges me about some students still do not understand. I do not know how to do. It means one hundred percents of students do not understand science. There are some groups or some students in group are inferior capable.

I help them by teaching them again after school finish or at lunch time. It challenges me that I want all students receive knowledge. If there are not 100% of students understand, it means I do not teach students well enough. Teacher may exhort low achievement students. Teacher should have some technique or method to make them learn and be enthusiastic... (Palita's interview after teaching lesson plan II: December, 2007)

The above excerpt also reveals some aspects of Palita's preparation as a teacher. In light of her role, Palita mentioned some aspects of teaching and classroom management. In her view, she felt that she participated in the activity with her students as can be seen in this interview excerpt:

...Teaching in this way is challenged. Teacher must control, explain and guide students. It is not meant students learned alone. Teacher participates in activity. Teacher will learn with students. Teacher and students join together. Sometime teacher must explain or do the activity with students... (Palita's interview after teaching lesson plan I: November, 2007)

In terms of classroom management, Palita tried to encourage students to be interested in the lesson. She felt that students, by nature, were easily distracted from lessons. Her duty as a teacher was to motivate students to participate in the lesson as described below:

...Normally, students are naughty. Some of them did not behave well. They are distracted from listening to teacher. Students do not listen to me when I speak. Students always play materials in front of them. For this point, I try to induce students pay more attention to the lesson. The duty of teacher is to activate students to pay attention to lesson and teacher... (Palita's interview after teaching revised lesson plan I: November, 2007)

Palita also found that it was challenged to use group work in her classroom. Palita said that before she attended the workshop, she did not divide students into

groups because she was limited in terms of location, time and support. Palita claimed that because her classroom was small, there was not enough space for teachers to walk around the classroom when students worked in groups. The time restriction also was another reason for her avoiding the use of group work. In her view, rearrangement of students' tables and chairs into groups took time. She mentioned that she was not the only teacher who used the room to teach. For other subjects, other teachers would come into the class. Therefore, students had to rearrange their tables and chairs again for the next subject. Additionally, Palita indicated that the next teacher might not like to teach students in groups. She explained,

...The place, the place is not convenient. The classroom is small. Sometime, I divided students in groups and we could not walk through. Another thing is it depends on home room teacher if she stays in the room all the time. If we rearrange in groups in that class, it takes time. Like, it uses five minutes for dividing into groups. When teacher finish teaching, other teachers will come to that class and teach another subject. That teacher may not like to teach in groups. I can not use her time. I must use my time to rearrange the table. It means I taught less than 60 minutes. I should listen to the majority of teachers who teach in that class because I am not the one person who teaches. It may be convenient for me but not for other teachers... (Palita's interview after teaching lesson plan I: November, 2007)

The Case of Palita: Some Conclusions

Before Palita attended the teacher professional development experience, she initially understood the teaching and learning process in a traditional way. In her view, the student was a passive learner who observed experiments and listened to the teacher's explanation. Palita did not consider the importance of students' prior knowledge. Palita also felt that her role was to separate students in groups and distribute topics for them to study. However, she recognized the importance of group work and discussion in promoting students' positive interaction.

After Palita attended the teacher professional development experience, she developed further understanding of Social Constructivist Learning Theory. The findings from interviews showed that her understanding of the student role shifted from passive to active learner. In her view, students could do hands-on activities and construct their own knowledge. Palita developed her thinking about the importance of students' prior knowledge in the teaching and learning process. She emphasized the importance of exploring students' prior knowledge for designing the appropriate activities. She was also concerned about the link between prior knowledge and new knowledge. Her thinking about the teacher role shifted from the ideas of teacher as a teller to teacher as a director who was responsible for preparing educational materials, asking questions, raising examples, managing the classroom, and motivating students to engage in activities. She also saw the teacher as an inspector who examined students' learning. Moreover, Palita felt that both teacher and students should collaborate in the teaching and learning process. Palita expanded her ideas about group work. She pointed out that students who worked in groups not only took on responsibility and participated in group activities, but also became individuals who were knowledgeable enough to explain ideas to the group. For discussions, Palita felt that it was important for teachers to encourage students to express their ideas.

Palita integrated the knowledge components of Social Constructivist Learning Theory into lesson plans. She created two lesson plans for teaching the topics of "The states of matter" and "The changing states of matter". Most of the lesson plans began by ascertaining students' prior knowledge. Students were divided in groups to conduct experiments and discuss with their colleagues. Palita planned for students to present in front of the class. In the summary of the lessons, Palita planned to have the teacher and students work together to make conclusions. Palita, for the most part, taught according to her plans and included many aspects of Social Constructivist Learning Theory. However, she used an unplanned role play activity in teaching her first lesson and provided experimental procedures for students. The pedagogical strategies that Palita used in her lesson plan and mentioned correspond to her understanding of Social Constructivist Learning Theory. Her lessons included investigating students' prior knowledge, group work, experimentation, discussion, student-led presentations,

asking questions, role play, students' formulation of conclusions and exercises on worksheets.

After team members and the researcher observed Palita's lessons, they shared opinions and suggestions. They critiqued her teaching, indicated problems in her classroom, and gave suggestions for improving the lesson. Palita realized the benefits and challenges of applying Social Constructivist Learning Theory in her classroom. She felt that teaching based on Social Constructivist Learning Theory developed students' conceptual understandings, promoted positive social interactions, fostered positive student attitudes about science and generally improved students' work. In terms of advantages for herself, Palita indicated that not having to give lectures to students helped in terms of her own energy level. She also was proud of her students and their accomplishments. Palita also perceived many challenges in teaching science based on Social Constructivist epistemology. The main challenges, as she explained, were the potential of students, the preparation of herself as a teacher, and group work in teaching.

Summary

The purpose of this chapter was to describe the cases studies of three elementary teachers based on their practical knowledge of Social Constructivist Learning Theory. Four main research questions served as the basis for investigating teachers' understanding and practice including: (a) their understanding of Social Constructivist Learning Theory in the teaching and learning process (b) the translation of Social Constructivist Learning Theory into practice; science lesson plans, teaching practices and pedagogical strategies (c) the nature of collaboration between elementary teachers during Lesson Study meetings, and (d) teachers' perceptions of the advantages and challenges of teaching science based on Social Constructivist epistemology. Written reactions to Social Constructivist Learning Theory vignettes, individual interviews, focus group discussions, classroom observations and teachers' lesson plan were utilized to study the development of teachers' understanding and practices. Analysis of data from these different sources revealed that the teachers

developed further understanding of Social Constructivist Learning Theory after participating in the professional development experiences. The findings of the three case teachers also showed that their understandings of Social Constructivist Learning Theory influenced their translation into practice including: science lesson plans, teaching practices and pedagogical strategies. In terms of change and growth, opportunities for collaboration and reflection in the professional development experience supported teachers in constructing their own knowledge and translating their understandings of Social Constructivist Learning Theory into practice. All teachers not only perceived many advantages of teaching science related to Social Constructivist Learning Theory but also recognized many challenges of teaching science based on Social Constructivist perspective.

The next chapter will present a discussion of the findings reported in Chapter IV and attempt to elucidate the broader themes that underlie the participants' comments. The researcher will draw conclusions that she feels are justified by the data and compare these conclusions to other literatures related to her study.

CHAPTER V

DISCUSSIONS AND ANALYSIS

Introduction

This chapter aims to compare and contrast the three in-service teachers—Duangjai, Somsri, and Palita regarding their understandings and practice in relation to Social Constructivist Learning Theory. The first part of this chapter focuses on common findings that emerged from the cross-case analysis of how these in-service elementary teachers developed their understanding of Social Constructivist Learning Theory in the context of a professional development program. The second part discusses more fully the dynamics of the three in-service teachers' understandings, based on epistemological, philosophical and theoretical perspectives. The results are presented according to the four main research questions; the in-service teachers' existing understanding about teaching and learning before and after the professional development experiences; the teachers' translation of their understanding about Social Constructivist Learning Theory into practice, the nature of collaboration between elementary teachers during the Lesson Study, and teachers' perceptions of advantages and challenges of teaching science according to Social Constructivist Learning Theory.

Research Question 1. How do Thai Elementary Teachers' Understandings of Social Constructivist Learning Theory Compare and Change at Different Points of the Lesson Study Process?

In-service elementary teachers' initial understanding of Social Constructivist Learning Theory

The survey of initial understanding of teaching and learning was conducted at the beginning of the first week of the teacher professional development experience. The responses to the written reactions to Social Constructivist Learning Theory

vignettes indicated that all three case study teachers held conceptions of traditional teaching. In these teachers' initial views of the student role, Duangjai, Somsri and Palita wrote reactions indicating they viewed students as passive receivers. They suggested that the student role was to watch, listen, and repeat knowledge or facts based on the teachers' explanations of science concepts to the whole class. Duangjai and Palita indicated that students learned by watching demonstrations and experiments with teacher explanations of concepts. Similarly, Somsri mentioned that students learned by looking at pictures and listening to teachers' lectures. Overall, these teachers viewed the role of student as a passive learner who should consume knowledge or facts from the teacher who was an information provider. Interestingly, all three teachers initially thought that students participated in lessons and received direct experience simply by looking and listening. The role of students as passive learners is an idea that corresponds with the notion of students with "knowledge holes" that need to be filled with information. According to Somsri and Palita, they had never considered the significance of the prior knowledge that students bring with them to the science classroom. Only, Duangjai initially recognized the benefits of accessing students' prior knowledge in designing appropriate activities for students.

In terms of Duangjai, Somsri and Palita's ideas of the teacher's role, all three teachers viewed the teacher role as one of exerting power and holding responsibility for controlling the student learning environment. Duangjai, in particular, expressed very traditional beliefs. In this regard, she indicated that her responsibility was to explain or give knowledge to students. Somsri and Palita had similar ideas about managing student learning. In their view, while students could study using discovery approaches, the teachers' role was to correct students' understandings after they shared what they learned in front of the class. With regard to their understanding of group work, all three teachers agreed that this instructional format supported student learning. Somsri and Palita, in particular, believed that group work encouraged positive student interaction. In their view, students could exchange and discuss ideas when they participated in group activities. Somsri also indicated that when students worked in groups, they had a chance to talk, discuss, and help each other do activities. Similarly, Duangjai felt that group work supported student learning, even though she

held the idea of the teacher as a transmitter of knowledge to students. In her view, the teacher should explain concepts for students after they completed activities in groups. Before the three teachers participated in the professional development workshop, two of them, Somsri and Palita perceived the benefits of discussion for promoting student learning. In Somsri's view, discussion promoted participation and gave students an opportunity to learn from their peers. For Palita, students could have valuable interactions between peers and arrive at conclusions from discussion. However, Duangjai initially did not appreciate the value of discussion.

With regard to the Social Constructivist Learning Theory vignettes, teachers held a variety of initial understandings about basic aspects of Social Constructivist Learning Theory; the role of students, prior knowledge, the role of teacher, group work and discussion. However, their initial understandings were not fully aligned with an in-depth understanding of Social Constructivist Learning Theory. For the most part, their initial understandings of science teaching and learning reflected beliefs consistent with conceptions of traditional teaching. According to Cohen (1988), "traditional teachers are seen as tellers of truth who inculcate knowledge to students and students play a relatively passive role seen as accumulators of material who listen, read, and perform prescribed exercises" (Cohen, 1988: 15) The results of this study indicated all three teachers believed that students knew little about science and therefore their role was to translate or present them the facts. In their view, the teacher was simply a presenter of the facts of science, transferring knowledge to students; learning was a process of knowledge reproduction.

All three teachers viewed knowledge as an absolute truth to be transmitted by the teacher without subject to students' interpretation. Somsri and Palita believed that students should search for knowledge and look to the teacher for verification of its authenticity. Consistent with Gallagher (1991), these teachers expressed a traditional-empiricist-view of science. As Gustafson and Rowell (1995) and Koballa *et al.* (2000) pointed out, these conceptions of knowledge as truth are held by teachers of different cultures and various educational systems. Additionally, all teachers mentioned using the textbook and teachers' handbook as a foundation for teaching science before they

attended the workshop. They claimed that the textbook was a valuable instrument for teaching and provided them with guidance on what to teach and how to teach science. In this way, we can assume that the teachers were unfamiliar with planning differentiated instruction based on students' individual differences, because their instructional planning and teaching utilized a fixed teaching method from the textbook.

The fact that Thai teachers hold traditional views of teaching science may stem from their experiences and context. From an experience perspective, teachers may have experienced traditional ways of teaching while they were science students. Tsai (2002) supports this explanation by indicating that the reason many teachers value a specific view or teaching approach might be due to their own scholastic experience such as in the science classroom. Therefore, experiences of teachers in both high school and higher education likely were influential in their understanding of teaching and learning since the education they received was probably in a traditional-oriented environment. From the Thai context perspective, teachers have historically been respected by society and viewed as "experts of knowledge". Certainly, teachers traditionally tended to place their highest priority on content knowledge in terms of the ability to explain concepts clearly. This assumption corresponds to the research of Stevenson (1989) cited in Prawat (1992) who showed that Asian teachers tended to place themselves as deliverers of content more than American or Western teachers. Moreover, the Thai educational system has historically placed strong reliance on the highly competitive national examination with its paper-pencil test, which lends itself to a teaching approach in which content is transmitted directly from teacher to students.

Even though the National Education Act B.E. 2542 (1999) and Amendments (ONEC, 2002) was enacted almost ten years ago to foster student-centered approaches in the Thai educational system, as this study suggests, teachers still grapple with traditional modes of teaching. This finding was consistent with the study of Chareonwongsuk *et al.* (2005) in which Thai teachers were not fully successful in

developing student-centered teaching approaches during the educational reform period (A.D 2542-2547).

In-service elementary teachers' development of understanding of Social Constructivist Learning Theory over the course of the teacher professional development experience: workshop and Lesson Study

The three case study teachers developed further their understanding of Social Constructivist Learning Theory while attending a workshop which was a part of the teacher professional development experience. In terms of their views of the role of students, Duangjai and Palita developed similar ideas. Both teachers expanded their views, believing that students could participate in the classroom more actively through hands-on activities. In the case of Somsri, she also viewed students as active learners but felt that when students had a chance to build on their own interests they would be more actively engaged in learning. However, all three still maintained the idea that the teacher was a holder of knowledge. At the end of workshop, two teachers, Somsri and Palita developed a deeper understanding of students' prior knowledge. Somsri realized the importance of prior knowledge in designing meaningful lessons. Palita developed her thinking more extensively by exploring and building the connection between students' prior knowledge and new knowledge. However, Duangjai maintained the same understanding about the importance of prior knowledge that she had expressed before attending the workshop. All three teachers' views of the teacher role shifted during the course of the professional development experience. All came to recognize the importance of the teacher having a role in creating hands-on activities for students and encouraging them to participate in these activities. Somsri and Palita engaged and supported students in experimentation and discussion. Duangjai motivated students to take ownership in doing activities independently by asking them questions. At the end of workshop, Somsri and Palita maintained their beliefs about the advantages of group work in fostering positive interactions. They indicated that various forms of interactions encouraged students learning. Duangjai, in particular, developed a deeper understanding of group work, and could articulate a clearer rationale believing that interaction in group work could

benefit student learning. During the workshop, all three teachers were provided with many opportunities to express and discuss their ideas with peers while doing activities. As a consequence, Duangjai saw how discussion could be used to help students construct their own knowledge. She also came to value the importance of students exchanging ideas and learning from their peers in discussion. However, Somsri and Palita maintained a more superficial understanding of discussion as a pedagogy that simply promoted student participation and interaction.

At the end of the professional development experience, the teachers were interviewed and asked about their understanding of Social Constructivist Learning Theory. Duangjai, Somsri and Palita all believed that the essence of Social Constructivist Learning Theory was the idea that students are active learners who construct their own knowledge by doing hands-on activities. Palita and Somsri felt that students' participation in teaching and learning took place primarily through involvement in experiments. Additionally, Palita viewed students as active learners when they presented results from their experiments and generated conclusions by themselves. Interestingly, Somsri felt that an important part of investigation was the ability to search out knowledge from key informants such as teachers or other experts. In the case of Duangjai, students participated actively in lessons by answering questions, investigating, observing and touching materials, and making knowledge conclusions by themselves. It is clear that all three teachers developed their thinking about the role of the learner more extensively in relation to Social Constructivist Learning Theory. They gradually shifted their thinking about the role of the student from one of passive learner to hands-on active learner, and eventually to minds-on active learner, where students construct their own knowledge. The changes in their classroom practice reflected an increase in the level of student engagement in learning. With respect to their views of prior knowledge, all three case teachers showed more concern for the elicitation of students' prior knowledge, the link between prior knowledge and new knowledge and the preparation of everyday life materials. As a result of participation in Lesson Study, the teachers were more systematic and careful in thinking about the students' prior knowledge. They paid

more attention to designing activities and using materials that related to students' prior knowledge, and ones that would foster conceptual understanding.

At the end of the professional development experience, the teachers were also asked about their understanding of the role of teacher. The findings from the interviews revealed that Duangjai, Somsri and Palita thought that the role of teacher should be that of a facilitator. In their view, the teacher should ask questions, motivate students' curiosity, prepare educational materials and manage classroom activities. Additionally, Duangjai and Somsri felt that the teacher should raise examples and assess student learning. Somsri and Palita agreed that the teacher should also give students positive reinforcement to encourage their engagement in activities. Interestingly, Somsri saw the role of teacher and students as mutual learners, a relationship where both could learn together and learn from each other. Likewise, Palita agreed that teacher and students should collaborate in the teaching and learning process. From the above, it is apparent that the changes in perceptions of the teacher and student roles reflected a more reciprocal relationship between teachers and students, more communication, and more respect between teachers and students.

Results of this study suggest that all three teachers do not fully understand Social Constructivist Learning Theory. Teachers' explanations indicated that they held a mixture of traditional and constructivist beliefs. Traditional science teaching concentrates on the direct transmission of knowledge or facts from teacher to students involving non-interactive teaching activities. By contrast, from a Social Constructivist perspective, teachers do not deliver instruction to students; rather they encourage and facilitate learning within a social context to assist students in actively constructing their knowledge. The three teachers viewed teaching as a process in which students learn by actively constructing their own knowledge and integrating new knowledge with prior knowledge. They also believed that interaction in group work was a necessary condition for student learning to take place. However, these three teachers also held traditional beliefs because they felt that their responsibilities were to provide the procedures for experiments and verify the correct concepts for students. In particular, students in Somsri's and Palita's classrooms did not have a chance to

design their own experiments or create their own curious questions. Moreover, Duangjai, Somsri and Palita believed that it was the role of teacher to ask students questions. Specially, Duangjai tried to use questions to elicit students' correct answers. In this process, the learning environment was not always designed to support and challenge students' thinking; instead it was designed for students to discover knowledge.

Social Constructivism is based on specific assumptions that emphasize that knowledge is a human product which is socially and culturally constructed (Ernest, 1999). For the Social Constructivist, knowledge cannot be discovered because it does not exist prior to its social invention. The Social Constructivist learning process involves individuals creating meaning through their interactions with each other and with the environment. Therefore, learning is not simply the absorption of new knowledge; rather it is a complex process related to internal mental activity. From a Social Constructivist view of teaching, the teacher should provide students with an effective learning environment where they can achieve goals with the support and guidance of the teacher. In doing so, teachers should encourage students to pose their own questions and investigate the answers to questions in their own way. As the teachers in this study developed new understandings of Social Constructivist learning theory, they did so in a somewhat simplistic manner. They understood Social Constructivism, for the most part as engaging students in active hands-on experiences and discussion rather than an internal process of mentally constructing relationships and understandings.

Teachers' understanding about how science is developed related to their understandings of how to teach science and how students learn science. As the results suggest, all three teachers viewed science as having the correct answers. Learning science for them involved acquiring knowledge from credible sources such as experts or teachers. In accordance with an empiricist view of knowledge, the teachers believed that the aim of science was to collect facts about the world and that scientific knowledge was objective, permanent, and discovered (rather than invented). Somsri, in particular, viewed science as empiricist knowledge which was objective and

something to be discovered. As she mentioned, students should search out knowledge from experts and “discover” scientific knowledge by doing experiments. Duangjai and Palita emphasized correct conceptual understandings. Duangjai tried to use questions to elicit correct answers from students and Palita explained the correct concepts to students at the end of lesson.

Koballa *et al.* (2000) categorized three frameworks of teachers’ belief about teaching and learning science; traditional, process and constructivist. The ‘traditional’ category portrays science teaching as transferring knowledge from teacher to students. The ‘constructivist’ category portrays science teaching as helping students construct their own knowledge. The results of this study reflect the ‘process’ category of teaching and learning science which is portrayed as an activity which focuses on the processes of science. In this category, scientific knowledge is viewed as facts being discovered through the scientific method. As a result, teachers provided the process of doing experiments for students instead of encouraging students to investigate answers in their own way. Teachers viewed teaching science as discovering knowledge. The conceptions of learning science were considered as reproductive rather than constructive. Their conceptions of teaching were also viewed as facilitating reproductive learning. In doing so, teachers helped students as facilitators by verifying the correct concepts for students.

Research Question 2. How do Thai Elementary Teachers Translate Understandings of Social Constructivist Learning Theory into Practice Using the Lesson Study Approach?”

Research question 2.1 What relationships exist between the teachers’ conceptions of social constructivist learning theory and their design of lesson plans?

All case study teachers were asked to construct two lesson plans based on Social Constructivist Learning Theory. In general, each component in their lesson plans that all teachers designed included; learning outcomes, main ideas, learning

activities, instructional materials, and assessment. All plans created by Duangjai, Somsri and Palita showed that they could integrate the knowledge components of Social Constructivist Learning Theory into their lessons. The teachers perceived the importance and benefit of students' prior knowledge. Duangjai and Palita planned to elicit students' prior knowledge in the introduction stage of their lesson plan while Somsri planned to have students explore and observe educational materials by using their prior knowledge. In addition, the teachers planned to prepare educational materials for the lessons that related to students' daily lives. In this regard, all three teachers were concerned about the connection between prior knowledge and new knowledge. In almost all of the lesson plans, the teachers prepared educational materials and distributed them to students. However, in the revised lesson plan of Duangjai, she allowed students to select their educational materials. In this sense, Duangjai supported students' curiosity in a more constructivist manner, because students had the freedom to select what they wanted to learn. According to the activities in the lesson plans, all teachers designed activities for students to work in groups and participate as active learners through observations, exploration of materials, experiments, responding to teachers' questions, presenting results in front of the classroom and participating in role play simulations. All three teachers were also concerned about opportunities for students to interact and exchange ideas as a way to learn from their peers; thus they included discussion activities in their lesson plans.

As can be seen from the above, the data suggests that teachers planned their lesson plans in accordance with their understanding of five main tenants of Social Constructivist Learning Theory. In this way, all three teachers, to some extent, became curriculum makers. They decided to design their own lesson plans in a way which was appropriate for their own students and context. The teachers used their understanding of Social Constructivist Learning Theory to give meaning to the decision and actions that they made. According to Henson (2001), teacher decisions to plan certain content and activities are influenced by their philosophies. Throughout the lesson design process, teachers designed structured lesson plans. For the most part, with the exception of Duangjai, teachers did not allow students many

opportunities to design their own investigations. However, teachers did design activities for students to observe, explore and do experiments. However, they still viewed the purpose of these activities as supporting students to learn a measurable and absolute Scientific Knowledge. Concepts were considered by the teachers to be approximations of absolute knowledge that was ultimately attainable precisely and objectively by the minds of humans.

Parke and Coble (1997) in their study of teachers designing curriculum as professional development noted that teachers' experiences with curriculum development were of significant value in making decisions concerning the design of classroom environments. The opportunity to participate in curriculum development provided teachers with experiences involving decision making with respect to their lesson plans such as choices of content, instructional strategies, and decisions about scope and sequence. Importantly, teachers in this study became curriculum makers, rather than simply technicians who implemented curricula developed by others. In this sense, they were less dependent on textbooks. Noticeably, all three teachers mentioned that they used and learned how to teach science from the textbook and teachers' handbook before they attended the professional development experience. In doing so, their initial understandings of teaching and learning were traditional. Similar to studies conducted by Apple (1990) and Ball and Cohen (1996), prior to participating in professional development, these teachers would simply remold new curriculum to fit their traditional practice when they did not understand the intent of the curricula design, were not pressured to make changes, or did not have a voice in curriculum decisions.

Lemberger, Hewson and Park (1999) also noted that teachers also broadened their fundamental ideas from deliberately making connections between classroom-based and school-based activities in curriculum development. Teachers in this study encountered many opportunities to link Social Constructivist Learning Theory in their classroom-based activities to a real classroom setting. School-based professional development implies that teachers accept greater responsibility for curriculum decision making as it applies to their authentic teaching context. By extension,

classroom-based curriculum decision making is carried out in schools with this kind of site-based professional development where individual teachers design a curriculum especially to meet particular needs of their students. Therefore, this study suggests that in the process of collaborating to plan lessons based on Social Constructivist learning theory, the teachers became more aware of the nature of elementary students, including their behaviors, abilities, and learning potentials. Additionally, teachers learned about the resolution of curriculum problems and the intricacies of the process of developing meaningful curriculum. The opportunities to collaborate with colleagues and reflect on their understandings of Social Constructivist Learning Theory seemed to have a significant influence on the groups' planning processes and associated end products.

Research question 2.2 How do teachers teach their lessons plans based on Social Constructivist Learning Theory?

In teaching lesson plan I, none of the teachers followed their lessons exactly as planned. Their teaching reflected only a few aspects of Social Constructivist Learning Theory. Specifically, in Duangjai and Somri's teaching, students explored and observed materials by following set procedures provided by the teacher instead of conducting their own investigations. Duangjai started her first lesson by asking yes-no questions to ascertain students' prior knowledge instead of using more open-ended, probing questions. Duangjai was also concerned about the product more than the process of learning. Similarly, in Somsri's teaching, she explained the experimental procedures and summarized the concepts for students. In her teaching, students did not draw on their prior knowledge to investigate and conduct experiments by themselves. By contrast, Palita, for the most part, taught according to her plans and included many aspects of Social Constructivist Learning Theory. She started the lesson by asking students about their prior knowledge of the topic. However, she added an unplanned role play activity to her actual teaching and discussed experimental procedures with students. Noticeably, in Duangjai, Somsri and Palita's teaching, students had a chance to interact with their peers by doing group activities. Students were active learners who participated in activities but according to the

teachers' procedures. In Somsri and Palita's teaching, students were encouraged to discuss activities and worksheet exercises together with peers.

In teaching revised lesson plan I, Duangjai did not follow her plan because she was challenged by a small number of students. However, she improved her teaching by probing students' prior knowledge, asking more open-ended questions and providing students with freedom to observe materials. She used many questions for engaging students in the lesson. However, she still summarized the major ideas for students at the conclusion of the lesson. Students did not participate in group work because of the small number present. Somsri and Palita taught revised lesson plan I similar to how they taught lesson plan I. Somsri explained the experimental procedures before allowing students to conduct the experiment by themselves. Students had a chance to interact and discuss with their peers by doing group activities, and arrived at conclusions about the main concepts in the lesson by themselves.

In lesson plan II, teaching was in closer alignment with the lesson plans and teachers' actual practice reflected many aspects of Social Constructivist Learning Theory. In Duangjai's teaching, students were active learners who organized themselves into groups. Duangjai probed students' prior knowledge and encouraged their group discussions. During Somsri's lesson, students used their prior knowledge to investigate and conduct an experiment by themselves. Students did the experiment in groups and had a chance to discuss their observations and results with peers. Similarly, in Palita's teaching, students were asked about their prior knowledge, worked in groups and had discussions. With respect to revised lesson plan II, all teachers taught in a way that was consistent with their lesson plan except Duangjai. She started the lesson by narrating a story which was used to probe students' prior knowledge. She also distributed pictures instead of real materials to students. However, in teaching revised lesson plan II, all three teachers maintained the stance that teachers were the holders of the correct knowledge. For example, Duangjai repeatedly asked the same questions until students finally gave her correct answers.

Duangjai and Somsri always said, “It was not right. What else?” or, like Palita, would tell the correct answers to students when they had finished their experiments.

A significant idea of this study is that teachers may have realized or understood new ideas about Social Constructivist Learning Theory, but they did not fully incorporate them into their classroom practice. For example, Duangjai and Somri did not follow their lessons exactly and did not apply their understanding of the role of prior knowledge in their first lesson. In this regard, teacher’s prior experience and understanding of teaching might impede their development of new beliefs and teaching practices. Teachers' long-held traditional beliefs about learning and teaching are resistant to change because of the lack of successful experience with alternative ways of teaching (Adams and Krockover, 1997; Gess-Newsome, 1999). The teachers’ attempts to incorporate what they had learned about Social Constructivist Learning Theory into their first teaching might have been a struggle because it was their first time teaching in practice, in accordance with a new theory. The teachers were not familiar with this new teaching approach and needed time to improve their teaching ability and techniques. This result highlights the challenges that teachers have in learning to teach in new way. As many authors suggest, changes in beliefs and teaching actions do not occur easily (Gess-Newsome, 1999; Hewson *et al.*, 1999) and need time (Loucks-Horsley *et al.*, 1998)

All three teachers increased their application of Social Constructivist Learning Theory in their actual classroom after their first teaching attempts. They incorporated several aspects of Social Constructivist Learning Theory including: the role of students, prior knowledge, group work and discussion. According to Richardson (1994), teachers’ beliefs influence their teaching practices. In this study, the three teachers held to some beliefs that continued to influence their practice during the teacher professional development experience. The analysis of the three cases showed that teachers’ beliefs about hands-on activity, probing of students’ prior knowledge, interactions between students in group work activity and construction of knowledge through discussions influenced their teaching in their classrooms.

The three cases examined in this study also revealed a disconnection between what the teachers said they did or tried to do versus what the researcher saw them doing in the classroom. Words such as “facilitator” and “knowledge construction” are well represented in their descriptions of their understanding and practice in their interviews. Teachers regarded themselves as facilitators and as advocates of knowledge construction. Based on classroom observations of their teaching practice, however, they clearly modeled lessons more consistent with direct instruction practice. Teachers’ instructions centered around the teacher ultimately providing explanations for the correct concepts. Even though the teachers emphasized the elicitation of students’ prior knowledge and encouraged student group work, they still believed that science was based on fact which was objective and something to be discovered. Therefore teachers provided procedures for experiments or correct answers, rather than allowing students to investigate by themselves or seek out answers in their own way.

Although prior teaching experience and new experiences in the professional development program influenced teachers’ beliefs and practice, their teaching was not independent from context or content (Hewson, Kerby, and Walter, 1993). As illustrated above, Duangjai was challenged by the small number of students in her teaching revised lesson plan I. She decided not to teach in alignment with her lesson plan. Teachers were challenged to reflect-in-action when they encountered unforeseen events. Those unpredicted incidents often required the teachers’ immediate judgment so that they could react in an appropriate way. Schon (1983) points out that in order to make those instructional decisions while teaching, teachers have to frame and reframe the situation, identify a number of alternative strategies, and make a reasonable and moral choice from among the alternatives within a short period of time. It has been generally recognized that teachers, through their classroom practice, have always been involved in decision-making. The teachers in this study confronted many unexpected outcomes in the real classroom when teaching based on Social Constructivist Learning Theory. These unexpected situations provoked teachers to think and solve problems in the classroom.

This importance of context in teachers' reflection-in-action provides significant insight into teacher education. It promotes a thoughtful, contextualized view of teaching with which teachers learn how to make choices about educational practices. Reflective teachers link theory (i.e., Social Constructivist Learning Theory) into practice by using their beliefs or understandings and examining their own practice in order to become better teachers. In contrast, teachers who are unreflective-in-action might be called merely skilled technicians who are limited in their ability to make good decisions, to consider the consequences of their actions, or to alter their actions. In this regard, if teachers' practice is strictly aligned with lesson plans, then they would not learn what students think or how to help students construct their own knowledge. Teachers would pay attention to the teaching method rather than their students' thought processes. On the other hand, unpredicted incidents might be an obstacle for teachers in their attempts to translate their understanding of Social Constructivist Learning Theory into practice. Teachers might reflect on their prior teaching experience, generally based on traditional approaches, instead of Social Constructivist Learning Theory in order to manage the classroom when challenged by unforeseen events. In doing so, teachers might provide the experimental procedures, give the correct answers or describe conclusions for students.

Research question 2.3 What pedagogical strategies do teachers infer through their understanding of Social Constructivist Learning Theory?

Based on an analysis of lesson plans and interviews, the three teachers, Duangjai, Palita and Somsri used similar pedagogical strategies in their lesson plans including; investigating students' prior knowledge, asking questions, group work, discussion, student-led presentations, student-led conclusions and exercises on worksheet. In the teaching stage Somsri and Palita used experiments in their lesson plans as well and Duangjai used observation and teacher's examples. In addition, Palita used role play in her teaching. The choices of pedagogical strategies that teacher selected revealed their interpretation and understanding of Social Constructivist Learning Theory.

An understanding of Social Constructivist Learning Theory can be seen as teachers' beliefs about the teaching and learning process that guide their perception of a situation and shape actions in the classroom. Pedagogical Strategies are the way beliefs are put into practice. According to Wallace and Kang (2004), teachers' views of effective instruction influence their choices of pedagogical strategies. Data from this study suggests that all three teachers understood the role of students as active learners so they encouraged students to observe or do experiments by themselves. The three teachers were also concerned about the importance of prior knowledge and therefore all of them planned to investigate students' prior knowledge. Because the teachers also believed that students would learn when they had interactions with their peers, they designed collaborative activities where students worked in groups and had opportunities for discussion.

Interestingly, the pedagogical strategies that the teachers used were similar and common methods for science teaching were applied such as asking questions, student-led presentations and conclusions. The findings might suggest that the teachers used these pedagogical strategies because they had experience with them before. Teachers might have been familiar with these pedagogical strategies from their teacher manual. According to Huibregtse, Korthagen, and Wubbels (1994), many teachers use pedagogical methods that are very similar to those they preferred in their own teachers when they were students. Additionally, as described above, the teachers used many pedagogical strategies in their lesson plans and classroom teaching; thus, one could infer that the teachers were developing the ability to differentiate instruction based on Social Constructivist Learning Theory.

Analysis of teachers' pedagogical strategies clearly indicated that all three teachers could employ many strategies based on Social Constructivist Learning Theory, without sticking to traditional pedagogies such as listening to lectures or watching demonstrations. However, this was not enough because, from the researcher's perspective, students were not receiving science instruction that was challenging. Students need opportunities to ask questions and establish a dialogue that will allow them to construct their own explanations of the challenges or situations

presented to them, to consider evidence that confirms or disconfirms these explanations, and to articulate arguments that support these explanations. Lehrer *et al.* (2000) point out that effective science teaching considers a three step process that starts by asking challenging questions (questioning), encouraging students to come up with ways of collecting evidence that will test their assumptions (experimentation), and assisting and guiding students as they construct convincing and viable arguments that will support their explanations (argumentation).

Research Question 3. How do Thai Elementary Teachers Collaborate in the Lesson Study Approach to Understand Social Constructivist Learning Theory as It Applies to their Science Instruction?

During the professional development experience, the three teachers learned and modified their understandings and practices by participating in meetings through the Lesson Study experience. In these meetings, the teachers discussed problems that occurred in the classroom, gave opinions, critiqued the lessons, provided suggestions to their colleagues for improving lessons, and supported their peers' success.

There were many problems that the teachers discussed with their peers. The problems often were related to students and the learning environment. Many of the problems were related to the ability of students, student attention and the courage it took for students to present and express their ideas in the context of Thai culture. The problems that teachers associated with the learning environment were inconvenient location and too many activities in one period. Throughout the meetings, teachers critiqued peers' teaching and student learning from the perspective that the role of the teacher should be a guide and the role of student is to be an active learner who constructs his/her own knowledge. Teachers also suggested methods of teaching and advised their peers on how to improve the lessons. However, most suggestions related to teaching methods such as using more questions, allowing students to write the results on the blackboard, having students take turns for presentations and asking students to draw pictures instead of writing. Additionally, teachers supported peer success by using admiration with their peers. Most teachers, after listening to their

peers, made attempts to change their teaching. Typically, they revised their lesson plan by adding more details such as teacher questions, student answers, or additions to the exercises on the worksheets. Teachers tried to adjust and improve their teaching in order to design the best activities.

Noticeably, teachers critiqued and suggested many technical methods such as asking more questions or drawing pictures instead of critiquing science conceptual knowledge or other factors. In other words, through their suggestions, teachers tried to control and manage the learning environment. Their concerns were related primarily to the ability to manage a classroom in an orderly fashion. In doing so, teachers wanted students to learn to follow teacher procedures. It was apparent in the Lesson Study discussions that the teachers conceived curriculum according to the nature of their dominant cognitive interests, and that each interest gave rise to a distinctive type of pedagogical rationality. For the most part, they viewed students as having little power to determine their own learning objectives. As a result, students, together with their teachers, were caught up in a seemingly inexorable process of attaining predetermined lesson objectives. Consistent with Grundy (1987), this technically-informed curriculum, which comprises predetermined content, or learning objectives, is designed to be implemented in learning environments in which students' behavior and learning are strongly controlled by the teacher.

Throughout the Lesson Study meetings, all teachers developed greater knowledge of Social Constructivist Learning Theory and its application to classroom practice. They learned to reconstruct and modify their understanding and practices after they met with their colleagues. Unquestionably, when the teachers engaged in group meetings, the opportunity for meaningful interactions was enhanced. Teachers' interaction with colleagues was crucial because the colleagues validated and challenged their experience and connected them with a wide range of related ideas and information. As Grossman, Wineburg, and Woolworth (2001) suggest, when teachers engage in a dialogue with other peers, they learn to justify their approaches by presenting convincing arguments when confronted with conflicting ideas and strategies. They also learn to listen to their peers through the process of discussion.

The interaction with the group also provided a kind of scaffolding whereby an individual gains the ability to solve a problem that she was unable to solve alone. Solving problems with peers provided an opportunity for discussion as the group weighed the merits of plausible approaches that could be used in making instructional decisions. Additionally, when the teachers talked and listened to each other, they had the opportunity to reflect on their ideas and develop their understandings of Social Constructivist Learning Theory and teaching practice. As illustrated above, teachers were asked to design their own lesson plans with organizing learning activities. They realized the limitations of their understanding of Social Constructivist Learning and necessity of improving their lesson plans after other teachers reflected on their lesson plans. Reflection on their own teaching and others' teaching by discussing issues relate to Social Constructivist Learning Theory helped teachers see the progressions and limitations of their own teaching. The findings are consistent with reports by Zembal-Saul, Starr, and Krajcik (1999), who suggested that reflection on teaching appears to help teachers in identifying and examining key issues associated with their teaching, and developing an initial framework for thinking about the complexity of learning and content. The teachers could see progress in their understanding and practice through the reflection on teaching in the Lesson Study. They came to realize their weaknesses and strengths in teaching (Bryan and Abell, 1999)

Teachers also had the opportunity to share their success and frustrations, which helped them recognize that they were not alone and that other teachers were experiencing similar problems. Importantly, by discussing their own experiences with their colleagues, each teacher compared her experience to that of the others and began to generalize across different classroom contexts. The chance to see and discuss what happened to their peers' classroom allowed them to look beyond their own ideas of what to do in the classroom. This Lesson Study process gave them opportunities to articulate their ideas and get feedback from others. In this way, all three teachers were able to find new ways to manage problems of practice. The teachers began the process of learning from experience and adopted new perspectives in both theory and practice.

Ultimately, the data suggest that the Lesson Study process helped the teachers become more flexible and inventive teaching problem solvers.

Research Question 4. How do Thai Elementary Teachers Perceive the Benefits and Challenges of Applying Social Constructivist Learning Theory in their Science Instruction?

All three teachers perceived many benefits and challenges of using Social Constructivist Learning Theory in the science classroom. All three saw the advantages for students and themselves. In terms of student benefits, all teachers agreed that teaching based on Social Constructivist Learning Theory could improve student learning and foster positive student attitudes toward science. Duangjai and Somsri indicated that their students appeared to be much happier about learning science. Somsri likewise felt that students were more enthusiastic about learning science. In addition, Somsri and Palita saw advantages in terms of the products of learning, noting how the quality of students' work improved. Lastly, Duangjai and Palita perceived the advantages to having students do activities in groups. They claimed that group work helped students build positive peer relationships, develop unified ideas and build confidence in themselves. In terms of teacher benefits, all three teachers felt that they learned more about student individual differences. Somsri and Palita claimed that they learned about difference in learning potentials. Duangjai and Somsri described their increased awareness of differences in students' prior knowledge. Additionally, Duangjai saw how students differed in terms of their learning needs. With respect to student learning, Somsri and Palita felt that there were benefits in terms of how they felt about students' accomplishments. They developed a greater sense of pride in students' work. Palita also noted that she did not feel as tired when she taught in accordance with Social Constructivist Learning Theory. Moreover, Duangjai felt that she had developed confidence in designing and writing science lesson plans consistent with a Social Constructivist epistemology.

In addition to the benefits of teaching science based on Social Constructivist Learning Theory, the teachers also perceived some challenges of teaching in relation to

this epistemology. All three teachers were challenged to think about how to engage students in their lessons. Moreover, Duangjai and Palita were concerned with how to create a Social Constructivist Learning environment and manage activities. Duangjai felt that decisions about managing activities and time needed to be considered in relation to students' prior knowledge and needs. Palita felt that she should participate in the activities with her students and support all students in learning and understanding science. Additionally, she also found it challenging to use group work in her classroom because of the restrictions in location and time.

All teachers found that teaching science based on Social Constructivist Learning Theory was a good model to embrace to truly focus on student learning. Their attitudes about teaching were positive at the conclusion of the teacher professional development experience. The data showed that all three teachers believed in the potential of teaching based on Social Constructivist Learning theory to make instruction engaging, enjoyable, involving, challenging, and relevant to students' learning. Teachers not only understood many of the key aspects of Social Constructivist Epistemology, but also developed skills and attitudes needed to change their practice.

CHAPTER VI

CONCLUSIONS AND IMPLICATIONS

Introduction

This chapter will present conclusions and implications of this study. Conclusions are introduced in relation to the main research questions. The final section discusses the implications of this study with respect to professional development, research methodology, science teaching and learning, and further research studies.

Review of Research Framework

Research Aims

The present study is relevant to elementary science teachers who participate in the teacher professional development program. In response to the National Education Act B.E. 2542 (1999), and the National Science Curriculum Standards, this study aimed to investigate and promote Social Constructivist Learning Theory for Thai elementary science teachers. Social Constructivist Learning Theory was a specific epistemology believed to enhance student learning, and thus an integral part of the study. An assumption behind this study was that related to Social Constructivism would be beneficial to teacher professional development centered around pedagogies and student learning. During this study, teachers attempted to construct an understanding of Social Constructivist Learning Theory and implement it in practice in their actual classrooms. In this study, teachers' understanding and implementation of Social Constructivist Learning Theory is explored in the context of a professional development experience, which included Lesson Study. Thus the process of collaboration between teachers reconstructing their knowledge and practice of learning theory as part of Lesson Study was also studied. Lastly, the perspectives of

teachers regarding the advantages and challenges of applying learning theory were investigated.

Research Questions

To achieve the aims of this research study, four research questions were formulated.

1. How do Thai elementary teachers' understandings of Social Constructivist Learning theory compare and change at different points of the Lesson Study process?

2. How do Thai elementary teachers translate understandings of Social Constructivist Learning Theory into practice using the Lesson Study Approach?

2.1 What relationships exist between the teachers' conceptions of Social Constructivist Learning Theory and their design of lesson plans?

2.2 How do teachers teach their lessons plans based on Social Constructivist Learning Theory?

2.3 What pedagogical strategies do teachers infer through their understanding of Social Constructivist Learning Theory?

3. How do Thai elementary teachers collaborate in the Lesson Study approach to understand social constructivist learning theory as it applies to their science instruction?

4. How do Thai elementary teachers perceive the benefits and challenges of applying Social Constructivist Learning Theory in their science instruction?

Methodology

The methodology used to study the teacher development and practice in relation to the research questions was educational interpretive research. The method of the study was case study, which consisted of three cases of grade one, five and six teachers who were research team members. To obtain rich and descriptive information of what happened when teachers participated in workshop and Lesson Study professional development experiences, common techniques of data gathering included anecdotal notes of classroom observation, focus group discussions, individual interviews, lesson plans and written reactions to learning theories vignettes were used.

Conclusions of the Study

This section presents the conclusions for this research study, which are divided into four parts according to the four research questions:

Conclusions in Relation to the First Research Question

To learn about the first research question, Social Constructivist Learning Theory development was considered in terms of what teachers learned about particular aspects of Social Constructivist Learning Theory through their professional development experiences. Two data sources, written reactions to Social Constructivist Learning Theory vignettes and individual teacher interviews were developed and utilized to assess teachers' understanding of Social Constructivist Learning Theory. The findings in relation to this research question revealed that teachers' initial understanding of teaching and learning was traditional in nature, prior to their participation in the professional development experiences. They viewed students as passive learners who should watch, listen and repeat knowledge based on the teacher's explanation.

The format for the teachers' professional development included workshop and Lesson Study experiences. During the workshop, teachers were provided with many

opportunities to express their opinions and discuss ideas with colleagues. Workshop activities focused on discussion, reflection, and collaboration in small groups, all with the aim of introducing teachers to the tenants of Social Constructivist Learning Theory. The Lesson Study was designed to support teachers' professional development by focusing on collaboratively working on planning lessons, real teaching practice and analysis of effective teaching. The three case study teachers developed a partial understanding of Social Constructivist Learning Theory through their participation in the professional development experiences. However, results of this study revealed that teachers did not fully develop their understanding of five aspects of Social Constructivist Learning Theory including: the role of students, the role of prior knowledge, the role of teacher, group work and discussion. The findings suggest that after participating in the professional development experiences, teachers held a mixture of traditional and constructivist beliefs. They viewed teaching as a process in which students could actively engage in activities. However, these activities were based on teacher procedures rather than designed to encourage students to investigate on their own way by themselves. Nevertheless, the findings point to the significant role that learning activities in the workshop and Lesson Study played in helping these teachers develop a clearer understanding of each component of Social Constructivist Learning Theory in their teaching.

Conclusions in Relation to the Second Research Question

The second research question aimed to explore how teacher translate their understanding of Social Constructivist Learning Theory into practice. The findings in relation to this research question are summarized in terms of planning and application in the real classroom context. Results are presented in terms of three sections: the integration of Social Constructivist Learning Theory into science lesson plans, its translation into teaching and explication of pedagogical strategies.

The integration of Social Constructivist Learning Theory into science lesson plan

Before the three case study teachers attended the professional development experience, they utilized a science elementary textbook and teacher manual as a primary source of learning activities. During the teacher professional development experience, each of them was asked to construct two lesson plans based on their understanding of Social Constructivist Learning theory. In teachers' plans, each lesson included: learning outcomes, main ideas, learning activities, instructional materials and assessment. Examination of their lesson plans suggested that all three teachers did integrate some aspects of their understanding of Social Constructivist Learning Theory into their lesson plans. Teachers were aware of the importance of students' prior knowledge which was reflected in the plans through different ways of assessing what students' knew about the topic during the introduction stage. According to the lesson plans, all teachers included activities where students could be active learners with opportunities to discuss and work in groups.

The translation of theoretical understandings into practice

When teachers implemented their lesson plans, their teaching was influenced by their understanding and beliefs about teaching and learning science. The teachers came to the classroom with an understanding of Social Constructivist Learning Theory derived from the workshop. As a result, their teaching reflected a mixture of positivist and constructivist views. Even though teachers believed that students' prior knowledge and hands-on discovery approaches were important, they were still concerned with "giving" correct answers. In doing so, the teachers provided the procedures of experiments or correct answers rather than allowing students to investigate by themselves or seek out answers in their own way. Noticeably, teachers incorporated many aspects of Social Constructivist Learning Theory including: hand-on activities, assessment of prior knowledge, group work and discussion. Additionally, the three case study teachers did not follow their lesson plans as intended. There were many factors that influenced the way in which teachers

implemented their lesson plans in actual practice. Even though teachers were well prepared for teaching, the physical restraints of the classroom, students' misbehavior or lack of response from students forced them to adjust their teaching.

The explication of pedagogical strategies

Before the three cased study teachers attended the professional development experience, they used lectures as a primary teaching strategy. In that time, the teachers were rarely aware of the importance of student's prior knowledge and don't know how to design lessons that supported student individual differences. After the teachers attended the teacher professional development experience, they develop further their understandings of science teaching and learning. Based on an analysis of lesson plans and interviews, all three teachers used a greater variety of pedagogical strategies for teaching elementary science. Interesting, most pedagogical strategies that all three teachers used in their lesson plans were similar. With regard to teachers' lesson plans and interviews, pedagogical strategies consisted of investigating students' prior knowledge, asking questions, group work, observation, discussion, teachers' examples, student-led presentations, student-led conclusions, role play and exercises on worksheets. Analysis of teachers' responses clearly indicated that they employed new pedagogical strategies to teach science, and did not fall back on the traditional instructional strategy of lecture.

Conclusions in Relation to the Third Research Question

After team members including Duangjai, Somsri and Palita observed each other teach, they had meetings to reflect on what they were learning. In these meetings, the teachers discussed problems that occurred in the classroom, critiqued the teaching and learning process, provided suggestions to their colleagues for improving lessons and supported their peers' success. Most of the problems that the teachers discussed related to students and the learning environment. Throughout the meetings, the teachers reinforced the perspective that the role of teacher should be a guide and the role of students should be active learner in a classroom oriented toward

Social Constructivist Philosophy. In terms of student learning, most of them agreed that students were learning science better when strategies consistent with Social Constructivism were used. The teachers suggested methods of teaching and advised their peers on how to improve the lesson. However, most of the methods which the teachers suggested were technical methods, where the emphasis is at controlling and managing the learning environment.

Conclusions in Relation to the Fourth Research Question

Teachers saw many advantages and challenges to teaching science according to Social Constructivist Learning Theory. The teachers felt that they learned more about student individual differences such as learning potentials, prior knowledge and learning needs. Some of them developed a greater sense of pride in students' accomplishments. In terms of student benefits, all teachers agreed that teaching based on Social Constructivist Learning Theory could improve student learning and foster positive student attitudes toward science. Some of them saw the advantages in terms of the products of learning and the benefits to having students do activities in groups. Teachers were challenged to think about how to engage students in their lesson. Some of them were concerned with how to create a Social Constructivist learning environment and manage activities.

Implications of the Study

A number of implications were derived from the findings of this study. The implications that emerged from this study are discussed in the following section.

Implications for Professional Development

The results from this study offered insights for future professional development endeavors. This study explicitly underscored the significance of collaboration and the reflective process. Collaboration provided a structure for fostering teacher learning and engaging in group reflection, shared decision-making and mutual respect. When teachers were given opportunities for reflection, they were

able to modify their visions of what the science teaching and learning process could be like. Teachers become cognizant of their understanding of teaching and learning according to Social Constructivist Learning Theory. Experience in collaborating with hands-on activities during the workshop and planning and discussing ideas in Lesson Study provided perturbing encounters for teachers that highlighted tensions in thinking and revising practice.

Lesson Study was perceived positively by in-service teachers on a number of dimensions including its value in changing views about the teaching and learning process, and changing teaching practice. To participate in the lesson study experience as a team led teachers to feel a sense of “community and professionalism”. Teachers exchanged stories about events in their classrooms, share responsibility for teaching and admitted that they did not know everything, and that they might have something to learn from their peers. It means shifting teaching from the private to the public sphere. Most school work cultures are characterized by individualism and isolation among teachers, which can lead to competition and lack of desire to share ideas. By contrast, lesson study led teachers in this study to collaborate in ways they had not done before. Teachers from the same school developed common goals, shared instructional materials, and exchanged ideas and experiences arising from a common context. A school culture in which teachers collaborate and share responsibility is most effective for bringing about good teaching practice. The Lesson Study model intended to help teachers to learn new teaching methods, broaden their subject matter content knowledge, or stay informed of changing policies.

The findings of this study supported the potential of Lesson Study to promote teacher collaboration and reflection in ways which emphasize the value of peer contributions and feedback for the development of understanding and teaching based on Social Constructivist Learning Theory. This research supports the claim that Lesson Study could be used as an effective tool for professional development. Furthermore, this study raised issues that have implications for teacher educators in the role of teacher as curriculum developer. The results of this study revealed that teachers could become curriculum makers, rather than simply technicians who

implement curricula developed by others. When teachers had the freedom to make choices and to take responsibility for their own teaching, they gained a sense of their own power, and become empowered. Importantly, teachers are persons who know their context the best. Teachers can gain insights into the problems that arise with appropriate solutions in the implementation process. This implication suggests the need for professional development experiences for teachers which include opportunities to become curriculum makers.

Implications for Methodology

This study used purposeful sampling according to the criteria of research site, teaching experience, participants' interest in this study, and their willingness to be involved in this research. This study does not attempt to generalize beyond the stories of the three teachers in their knowledge, and practice. Confronting the tough issues of generalization, it is hoped that readers learn more about the issues surrounding teachers' practical knowledge regarding Social Constructivist Learning Theory directly from the thick description of each case.

This study analyzed data at both within-case and cross-case levels which reflected on teachers' understanding and practice about Social Constructivist Learning Theory. The researcher presented teachers' portraits by being a witness who tried to understand and interpret what teachers thought and did in their real classrooms. However, every theoretical lens is always framed within the boundaries of language, gender, social class, race, culture and ethnic norms. Thus, the researcher attempted to check her emotions, assumptions, and interpretations as much as possible as a researcher. Likewise, readers are invited to openly and collaboratively share and reinterpret or create more portraits about teachers' practical knowledge regarding Social Constructivist Learning Theory.

Implications for Science Teaching and Learning

In the professional development program, teachers experienced workshop activities by taking on the same role that their students would experience in the

classroom. This was followed by actual practice and analysis of classroom experiences during follow-up Lesson Study experiences. Teachers reported that their confidence in their ability to teach science increased because they had hands-on experiences with materials in the workshop and confronted real problems in the classroom. Just as students, teachers in this study learned best when they were actively engaged in their learning. Experiences in workshop and classroom were valuable resources for teacher professional development. Teachers had initial experience and learned Social Constructivist Learning theory in the workshop. They experienced teaching based on Social Constructivist Learning Theory when been asked to act on their knowledge in the classroom with a supportive environment from their peers. This process allowed teachers to develop an understanding of Social Constructivist Learning Theory and transferred it into the classroom. Based on this result, the implication suggests the need for professional development experiences for teachers which provided with activities that help teachers translate their understanding into real classrooms.

Social Constructivism served a referent for teachers in creating a vision for new roles as guides or facilitators who attempt to provide students with more ownership over learning. The results of this study revealed the positive effects of teachers' understanding of Social Constructivist Learning Theory in terms of the use of a wider range of effective strategies for teaching students. These multiple-type strategies were more in harmony with the teachers' Social Constructivist beliefs than other less effective strategies, such as the presentation of information in ways incongruent with constructivist beliefs. It is not surprising that Social Constructivist teachers are better prepared than empiricist teachers to induce student conceptual change. The teacher role based on Social Constructivist Learning Theory is helping students to build on what they already know. When students are encouraged to follow up their own idea, they are more likely to see relationships between ideas and concepts, and to become problem finders as well as problem solvers. This professional development experience sought to help teachers incorporate Social Constructivist Learning Theory, not as an add on, but as integral to their classroom practice. Therefore, teachers should have opportunities to experience Social

Constructivism, not as a rote education reform to science teaching. Rather, it should become a part of the way that teachers think about and plan for the science teaching and learning process.

Implications and Recommendations for Future Research

Participants in this study initially had a positivist epistemology in which they defined their role as information provider and learners as knowledge receivers. Teachers expressed understandings and practices more consistent with Social Constructivist Learning Theory after they participated in the professional development program. However, teachers did not fully demonstrate all aspects of Social Constructivist Learning Theory. This result suggests that changes in beliefs and teaching actions do not occur easily, consistent with Hewson *et al.* (1999). Although the teacher professional development program put efforts into changing teachers' understanding and teaching actions, only a few significant changes were reported. Teachers' long-held traditional beliefs about learning and teaching were resistant to change. Without alternative epistemologies in mind, teachers' teaching actions were aligned with their initial positivist epistemologies. Although the teachers in this study obtained more experience with Social Constructivist Learning Theory, they failed to perceive that students should be the ones who construct and make sense of their own knowledge. They perceived that students' active participation in the learning processes was a motivation that is unrelated to their meaning construction. Importantly, understanding teachers' epistemologies and connecting those with their beliefs about teaching and learning seems to be critical in changing beliefs and teaching actions. Since teachers in this study did not fully develop their understandings of Social Constructivist Learning Theory, the influence of teachers' epistemological beliefs should be considered in further research studies.

It is important to remember that the findings of this study were intended to answer questions about the sample group, and that there was no intention for generalizing these findings to a larger population. Instead the goal was transferability. This study was conducted with a sample size of three purposefully selected

participants who were from the same educational area of Nonthaburi province. Therefore, future studies should determine what information might be useful to them when considering the limitations of this research. Studies that investigate the relationships between teachers' epistemological beliefs and their practice, in general, are worth conducting in the future. This study may serve as a foundation for future investigations of teacher education. In particular, a better understanding of how to make this professional development model work in a variety of contexts is needed in future research.

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APPENDICES

Appendix A

Essential Features of Social Constructivism Classroom

Appendix Table A 1 Essential features of Social Constructivism classroom

Essential Feature	Less-----Amount of Social Constructivism in Classroom-----More			
The role of student	Learners engage in scientifically oriented questions.	Learners engage in question provided by teacher.	Learners select a question provided by teacher.	Learners pose a question.
	Learners do hand-on and mind-on activities.	Learners listen to information from teacher.	Learners do hand-on activities follow teacher's directions.	Learners do hand-on activities with their own procedures and construct their own knowledge
The role of prior knowledge	Learners strive to make sense of new input by relating it to their prior knowledge.	Teacher provides information and lead learners through activities and assignments.	Teacher asks learners about their prior knowledge.	Teacher asks learners about prior knowledge and helps them to make sense of new input by relating it to their prior knowledge.
The role of teacher	Teacher and learners responsible for initiating and guiding learning effort	Teacher transmits information or text to learners.	Teacher guides learners step by step through the directions of an experiment in a book or he/she provides or through procedures	Teacher acts as facilitator leader who poses questions, seeks clarifications, promotes dialogue, and helps group recognize areas of consensus and of continuing disagreement.

Appendix Table A 1 (Continued)

Essential Feature	Less-----Amount of Social Constructivism in Classroom-----More			
Group work	Learners collaborate by acting as a learning community that constructs shared understandings through sustained dialogue.	Learners work mostly alone, practicing what has been transmitted to them in order to prepare themselves to compete for rewards by reproducing it on demand.	Learners work in a group but with little real collaboration.	Learners work with others by collaborating in dialogue and sharing their understandings.
Discussion	Knowledge as developing interpretations co-constructed through discussion.	Teacher as source of expert knowledge gives data and formulate explanations. Learners memorize or replicate what has been explained or modeled.	Discourse emphasizes drill and recitation in response to convergent questions; focus is on eliciting correct answer.	Discourse emphasizes reflective discussion of networks of connected knowledge; questions are more divergent but designed to develop understanding of the powerful ideas that anchor these networks; focus is on eliciting learners' thinking.

Appendix B

Objectives and Activities in Workshop

Appendix Table B 1 Objectives and activities in workshop

Phase	Date	No.	Activities	Objectives	Time	Note
		1	My Mask	<p>1. To allow participants the opportunity to socialize, relax, and informally introduce themselves to each other and built rapport between researcher and participants.</p> <p>2. To allow participants learn how to collect and analyze data in the form of symbols.</p>	30 minutes	<p>- Building rapport.</p> <p>- Learning science process skill.</p>
1	1	2	Introduction to the Teacher Professional Development Experience	<p>1. To enable participants to understands the objectives of the professional development program.</p> <p>2. To provide participants with an overview of experiences comprised the program.</p>	30 minutes	- Describe an overview and objectives of the workshop.
		3	Written Reactions to Learning Theories Vignettes.	1.To explore the understanding of elementary teachers about science teaching and learning before they attend the workshop	1.30 hours	- Elicit teachers' prior knowledge about science teaching and learning.

Appendix Table B 1 (Continued)

Phase	Date	No.	Activities	Objectives	Time	Note
1	1	4	How do Elementary Students Learn Science?	1. To allow participants to reflect on their own ideas about how elementary students learn science and share them with others in the group. 2. To help participants feel familiar with working in a group, motivate them to participate in discussion, energize and help them to focus individually and as a group on the activities.	30 minutes	- Review and reflect teachers' understandings of students' learning. - Group work.
		5	Describe the Story from the Pictures	1. To enable participants to realize that prior knowledge has an influence on their decisions. 2. To help participants feel familiar with working in a group, motivate them to participate in discussion, energize and help them to focus individually and as a group on the activities.	30 minutes	- Prior knowledge - Group work

Appendix Table B 1 (Continued)

Phase	Date	No.	Activities	Objectives	Time	Note
1	1	6	What I know and What I Want to Know	<p>1. To allow participants to learn about technique of KWL as a tool for ascertaining prior knowledge, student interest or for evaluation.</p> <p>2. To help participants feel familiar with working in a group, motivate them to participate in discussion, energize and help them to focus individually and as a group on the activities.</p>	30 minutes	<ul style="list-style-type: none"> - Prior knowledge - KWL - Group work
		7	What do You Call Me?	<p>1. To allow participants to learn about concepts of matter, energy, objects and materials by doing the activity based on Social Constructivist Learning Theory.</p> <p>2. To allow participants to learn the importance of ascertaining prior knowledge in designing teaching activities.</p>	1 hour	<ul style="list-style-type: none"> - Concept of matter, energy, objects and materials. - Use prior knowledge for design activities

Appendix Table B 1 (Continued)

Phase	Date	No.	Activities	Objectives	Time	Note
		8	Categorize Matter	<p>1. To allow participants to learn about concepts of physical properties and states of matter by doing the activity based on Social Constructivist Learning Theory.</p> <p>2. To allow participants to construct ideas of how activity link to the role of student as active learner and the role of teacher as facilitator.</p>	1 hour	<ul style="list-style-type: none"> - Concept of physical properties and states of matter. - The role of student - The role of teacher
1	2	9	Making Monster	<p>1. To allow participants to learn about concepts of physical properties by doing the activity based on Social Constructivist Learning Theory.</p> <p>2. To allow participants to construct ideas of how activity link to the role of student, the role of teacher, the role of prior knowledge, group work and discussion.</p>	1 hour	<ul style="list-style-type: none"> - Concept of physical properties. - The role of student - The role of teacher - the role of prior knowledge - Group work - Discussion

Appendix Table B 1 (Continued)

Phase	Date	No.	Activities	Objectives	Time	Note
		10	Mysterious M&M's	1. To allow participants to learn about concepts of physical properties and science process skill. 2. To allow participants to understand and construct knowledge of social constructivist learning theory. by doing an activity related to social constructivist learning theory. 3. To allow participants to construct ideas of how they would translate social constructivist learning theory in their classroom.	1 hour	<ul style="list-style-type: none"> - Concept of physical properties. - The role of student - The role of teacher - the role of prior knowledge - Group work - Discussion
1	2	11	How do Elementary Students Learn Science?	1. To allow participants to reflect on their own ideas about how elementary students learn science and share them with others in the group after they attended the workshop	30 minutes	- Reflect teachers' understandings of students' learning.
		12	Written Reactions to Learning Theories Vignettes.	1. To explore the understanding of elementary teachers about science teaching and learning after they attend the workshop	1.30 hours	- Teachers' knowledge about science teaching and learning.

Appendix C

Written Reactions to Social Constructivist Learning Theory Vignettes

Vignette I: Enthusiasm with New Knowledge

Pitaya is a 6th grade teacher with two years of science teaching experience. Last summer she had a chance to participate in science teacher professional development where she learned about inquiry based teaching strategies and learning theories. Pitaya is an enthusiastic and dedicated teacher. She is determined to use what she learned from the workshop in her classroom of thirty five students. She hopes to make science meaningful for her six grade students. The vignette below reflects a lesson that Pitaya has taught about physical and chemical change.

After the bell rang, Pitaya entered the classroom with pictures of people boiling water, burning wood, painting wood, breaking glass, eating melting ice-cream, baking cookies, and lighting up a cigarette. After students stood as a sign of respect, she asked them to sit down and said “today we will learn about physical change and chemical change.” She started the lesson by asking Wandee to stand and hold the picture of boiling water in front of the class. Pitaya then told the students, “when you heat water, it will boil and become a vapor.” She explained how the composition of water is the same as vapor and told the students that this was called a physical change. After that Pitaya told Wandee to take her seat and directed every one in the class to read about the concept of physical change on page 56 of their textbooks. When students were finished reading about physical change, she asked Nakorn to hold up the picture of the burning wood. She proceeded to teach the concept of chemical change in the same way she did with physical change: show a picture, explain the concept, and ask the students to read about the concept in their book. After Pitaya had finished explaining the concepts of physical and chemical change, she passed out the other pictures to students. In the same way, Pitaya asked the students to work in pairs and exchange with each other by holding the picture up for their classmate and asking “Is this a physical or chemical change?” Pitaya observed the conversation between Sarunya and Udon, Wanpen and Numfon and then joined the conversation without invitation.

(Udon holding a picture of a person painting wood)

Pitaya: Take a look at this picture. Is it a physical change or chemical change?

Sarunya: Chemical change.

Pitaya: It's a physical change because the composition of matter is still the same.

Pitaya then moved across the room to observe another pair of students, Wanpen and Numfon discussing their pictures. She observed for a few minutes and then spoke up.

(Wanpen showing a picture of a person breaking a glass)

Pitaya: 'Kay, now think about this picture. Is it a physical change or chemical change?

Numfon: I'm not sure, but I think it is a physical change.

Pitaya: Yes, it is a physical change.

Pitaya walked around the room and talked with other students in much the same way as above until the bell rang and she dismissed the class.

The story of Pitaya is read by five elementary science teachers during a group discussion in a professional development program. Five teachers discussed three questions (item1-3) and then provided suggestions. Read the discussion questions and the suggestions provided by each teacher. Then decide which suggestion best reflects an understanding of social constructivist learning theory.

1. In a group discussion, five teachers discussed the extent to which Pitaya let students engage during her lesson. The following section describes the five teachers' suggestions for increasing student participation. Which teachers' suggestion would increase students' engagement in the lesson on physical and chemical change?

A. Teacher Daungjai

I think the method that Pitaya used in this lesson was very good because students participated in her class by holding the pictures. She taught the concepts and used the pictures to examine students' conceptions. Moreover, she introduced the concept of physical and chemical change in a very clear and systematic way. I think it was a good idea to have students hold the pictures because they were engaged in the lesson, not only sitting and listening.

B. Teacher Somchai

I think that Pitaya should first show the pictures of boiling water and burning wood at the same time and then ask questions to make students curious and interested before explaining the concepts. For example, Pitaya might ask "How is water becoming a vapor and wood burning and becoming a black color similar or different?" Furthermore, after asking the question, Pitaya should give students a chance to answer. By having time to think about the teacher's question, students will be more engaged in the lesson.

C. Teacher Pranee

If I were Pitaya, I would start the lesson by showing the picture as she did, but I would then write many questions on the backboard such as:

1. What makes water boil?
2. What makes wood burn and change into a black color?
3. How are the changes in the water and wood different or the same?
4. How does the composition of wood compare before and after it was burned?
5. How does the composition of water compare before and after it became a vapor?

I would then give students freedom to select the question that they want to learn about and I will start to explain about that question. I think students will be more engaged in the lesson when they have freedom to choose which question they want to learn about.

D. Teacher Vichai

I will start by showing the two pictures of boiling water and burning wood and then ask students to generate a list of questions about each picture. After that I will ask students to share their questions with their friends and vote on the most interesting questions. I will introduce and conduct an activity that can address one of the interesting questions on students' list. I think students will be more engaged in the lesson when they ask their own questions.

E. Teacher Suksang

I will teach the lesson using a method similar to what Pitaya did. However, I will not show pictures of boiling water and burning wood. Instead, I would actually boil some water and burn some wood for students to look at and then I would explain the concepts and teach in the same way as Pitaya. I think students will be more engaged in the lesson when they see the real situation.

Comment

Respond D (Teacher Vichai) is the desired response according to the social constructivist learning theory in according with Table 1 Essential features of the social constructivism classroom. For learners engage in scientifically oriented questions, D suggests that the teachers should guide students to pose questions that they want to study. Both B and C represent less constructivist approaches. In B, the teacher engages students through teachers' question that make students notice and suspect. In C, students engage by choosing the questions from the teacher ideas. A and E do not represent constructivist approaches because students do not engage through questions about what they want to know.

2. In a group discussion, five teachers talked about whether Pitaya should ask students the question “What do you know about physical and chemical change?” The following section includes the reflections of the five teachers. Which teachers’ ideas do you agree with most?

A. Teacher Daungjai

I think Pitaya’s lesson is good because she does not ask many questions before she starts teaching students the concept. Asking questions first is not a good idea because students can not come up with the correct answer before they are taught the concept. Students always have alternative conceptions before they learn. They come to class to study and learn the correct explanations. If the teacher asks this question before teaching the lesson, students will only be confused; thus it is a waste of time.

B. Teacher Somchai

I think Pitaya should ask that question, even though students may not answer the question correctly. Asking questions makes students aware of what they know and don’t know. It will make the lesson more interesting for students.

C. Teacher Pranee

I think Pitaya should ask that question, even though students may not answer the question correctly. By asking this question Pitaya lets students know in advance what they will be learning about in class.

D. Teacher Vichai

Pitaya should ask that question. Students’ responses to the question will help her understand what students already know. She can use the responses of the students to design an appropriate lesson for student learning.

E. *Teacher Suksang*

I do not think Pitaya should ask this question before teaching the lesson. I think that elementary students do not know any thing about physical and chemical change. I think these students are very young and have not had any experiences with physical and chemical change. The result of asking this question is that Pitaya will receive a lot of nonsense answers. That will change the environment of the classroom and students will not be focused on learning.

Comment

Respond, D (Teacher Vichai) is the desired response according to the social constructivist learning theory in accordance with Table 1, essential features of the social constructivism classroom. For the role of students' prior knowledge, D suggests that the teacher should ask learners about prior knowledge and helps them to make sense of new input by relating it to their prior knowledge. Both B and C a less social represent less constructivist approaches because in B the objective of the teacher in asking the question is to motivate students to feel interested in the lesson. In C, the teacher asks the question in order to help students know in advance what they will be learn. A and E do not represent a social constructivist approach because the teacher does not believe that students have prior knowledge that can be used to make sense of new input.

3. After a group discussion, five teachers were assigned to write about the methods they would use to teach this topic (Physical and Chemical change). The following section includes the reflections of the five teachers. Which teachers' method do you think best represents the notion of a teacher as a facilitator?

A. *Teacher Somprasong*

I will start by writing a main heading on the board "Physical and Chemical Change". After that I will explain the concept of Physical and Chemical Change to

students and write an explanation of those concepts on the blackboard. After I finish explaining, I will tell the students to write the definitions for main concepts in their notebooks. I will then assign students to do homework from the exercises that appear at the end of the book.

B. Teacher Somchai

I will start the lesson by telling students, “today we will learn about Physical and Chemical Change”. I will then have several students in succession read paragraphs aloud from the textbook. Next, I will ask students to individually read about the concepts that appear in their textbook. I believe that when students read, they will learn. They will particularly learn from the textbook because it is very systematic and correct. Afterwards, I will assign the students to do homework from the exercises that appear at the end of the book.

C. Teacher Sakorn

I will start out the lesson by telling students to open the textbook and do the experiment following the directions in the book. I think teaching by using experiments will make students learn more and develop more interest in the lesson. In my class, I want students to do the experiments by following the exact directions to make sure that the results are correct in terms of the answer in the teachers’ guide book. I do not assign students homework because I know that their time is limited.

D. Teacher Sawang

I will start the lesson by distributing two pieces and the paper to students. I will tell them to observe physical properties such as size, color, weight of the paper when one piece is torn in a little pieces and another is burned. After that I will engage students in a discussion about the different result between the torn paper and the burnt paper. Through conversation I will try to help students understand the concept by asking them questions that make them think and can connect the new knowledge with

their prior knowledge. After students have had an opportunity to discuss the questions with each other and I will better be able to tell they understand the difference between physical change and chemical change. I will assign them homework from the exercises that appear at the end of the book.

E. Teacher Sathron

I believe that students have the potential to learn by themselves. The best way for students to learn is to let them construct their own knowledge. Before I start the lesson, I will divide students into groups. Each group will be responsible for learning about a different subtopic. They will design a presentation to share their knowledge of the sub-topic with other students. I do not assign students homework because I think it will be too much of a burden for the students.

Comment

Respond D (Teacher Vichai) is the desired response according to the social constructivist learning theory in accordance with the Table 1 Essential features of the social constructivism classroom. For Teaching and learning roles, D suggests that the teacher acts as facilitator leader who poses questions, seeks clarifications, promotes dialogue, and helps the group recognize areas of consensus and of continuing disagreement. Both A and B do not represent a social constructivist approach because the teacher transmits information or text to learners. C and E represent a less constructivist approach because in C the teacher tries to teach step by step, following the directions of an experiment in the teacher guide book. The role of teacher was seen as help to confirm book knowledge rather than that of a facilitator who helps students generate knowledge. For E, the teacher is a manager who assigns and divides students to study.

Vignette II: Did it work in my classroom?

Naree is a new science teacher. After graduating from the Department of Language education she decided to be an elementary teacher. She loves to teach young children and planned to teach English language after graduation. However, she was employed by a school that did not have a science teacher; therefore, the principle assigned her to teach science. This semester she is responsible for teaching science in grade 3. Because Naree did not finish her teaching degree with a concentration in science education, she was anxious about make science meaningful and interesting for her third grade students.

She plans to use collaborative teaching strategies in her classroom. She is determined to make her classroom a place where students can learn together in groups. In stead of the traditional seating arrangement where students sit in straight rows and face the blackboard, Naree plans to move students' desks into group configurations consisting of four or five students. In grade 3, the physical science unit on matter is typically taught at the beginning of the semester. As part of this unit the school curricular guidelines require students to describe the properties of matter. Naree has been working on her lesson plans for several days. She wants to make sure that they are both scientifically accurate and exciting for her students. The vignette below reflects a lesson that Naree has taught about matter.

Naree enters the classroom and asks students to rearrange their desk into groups. Once students had organized their groups, Naree signals the class to be quiet and then she started her first lesson by asking "what is matter?" There is no immediate reply from any of the students. At the moment, Witcha strolls into class late. Naree seizes the opportunity by asking Witcha very casually, "Witcha, can you tell the class what you think matter is?" Witcha does not immediately respond, and remains quiet. Immediately, Naree berates him for being late and continues, saying "Go ahead and take a seat. Everyone put your books down on the table and open to page 28: Matter and properties of matter."

Naree then introduces the definition of matter to students by saying: “Matter is something that has mass, can exist and occupies space”. After that she looks around the class, pointing to the table and says “that table is matter because it’s heavy, touchable and it needs an area to lay down. Pointing to another object, Naree says “the book is matter because it has weight, you can touch it and it occupies space.” After Naree points to other examples of substances that are matter, she asks students to do the exercise that appears at the end of the book as a group. The exercise asks students to classify substances that are matter or not matter and explain why they grouped them in that way. Naree asks students to discuss the exercise with their group to find the answers.

The third grade students began to discuss to the exercise in small groups. Soon the room is quite messy. The students’ desks, rearranged into groups, are in disarray. In addition, there was a lot of activity as some students walk around the room, listening to the other groups’ discussions and appearing to copy their answers. In one part of room, some students in one group are debating with students in another group. The noise level in the classroom becomes louder and louder. However, Naree does not pay much attention to the noise and mess until the math teacher, who teaches in a nearby classroom comes into her room and say “my students are taking a test, can you ask your students to quiet down a bit?” Then Naree tell her students to quite down. While she walks around the room to control the noise level and check students’ progress on the exercise, she hears students in one group debating whether or not a gas is matter. Naree joins their discussion.

Samapon: I think air is not matter. We can not see it. It does not exist.

Pakpao: Yes. But when you wave your hand, you can feel it. I think it does exist.

Lawan: I agree. You can inhale air. So it’s something.

Kanda: Yeah. You can inhale it, but it doesn’t fill up the room.

Naree: But does it have a volume?

Pakpao: Uhm... Yeah. (hesitated sound)

Naree: Does it take up space?

Kanda: No. It does not fill up the room.

Naree: Yes. It takes up space.

Kanda: Yeah. It takes up space.

Lawan: Yess! That's what I said! It does take up space.

Samapon: But you can't measure it with a ruler.

Naree: Well. We will not measure it with a ruler because it doesn't have a boundary. However, that does not mean that it doesn't occupy space.

Pakpao: So...air takes space.

Naree: Absolutely positive. Therefore, air is matter.

Lawan: Yes, I agree air is matter.

Pakpao: Ok. Air is matter.

Naree: How about you Kanda? Do you agree?

Kanda: It's fine. Air is matter.

Samapon: We will remember that air is matter.

Naree's discussion with the other groups of students continues for another fifteen minutes. However, when she glances at the classroom clock, it is already 10:10. Only five minutes are left before she has to dismiss the students to leave for another class. There is barely time to clean up or review the homework assignment with students.

4. At noon, Naree had a chance to talk to her friends who were also elementary science teachers about the activity in her classroom. She told them how students worked in groups to do the exercise at the end of the book. The teachers discussed whether Naree should use group work to teach the type of matter. The following section includes the reflections of the five teachers. Which teachers' ideas do you agree with most?

A. Teacher Namjai

When I teach students, I prefer that they study and do exercises by themselves, rather than in a group. I used to teach students using groups. I thought they could learn a lot from each other. However, the classroom was always messy. Some students walked around the classroom, making loud noises which bothered the other classrooms. Moreover, at end of the class period, the room was very dirty and the tables and material were not in order. When I corrected the exercises that they did, their answers were always the same. I think they simply copied answers from each other. This made me angry and I no longer let them work in groups.

B. Teacher Mongkut

I think students enjoy science and are happy when they study in groups. When I start to teach I always ask students to rearrange the tables to face one another. Now students know automatically that they should rearrange their tables before I come into class. In my class, I teach students by explaining the content to them word by word. I then ask them to copy my explanation directly into their notebook. After that I ask students to do the exercise at the end of the book by themselves without talking to the other students in their group. That way, if their answers are the same I can tell that they copied from other students.

C. Teacher Klahan

I would not support the idea of group work in a science class. When students work in groups, I think they do not learn. I have observed students in the past working in groups. Some students in the group did not do anything and spent the time on homework for other subjects. There are usually only one or two students in the group who are really involved in the activity. I do not think students achieve better by working in groups.

D. Teacher Bongkot

I think students really learn when they work in groups with their peers. I think when they work in groups they can help each other make sense of ideas. They talk and discuss the topics and that leads them to think more deeply. They exchange their ideas and reflect on them when they talk or explain to their friends. I believe that students learn together better than when they learn alone.

E. Teacher Chamrat

I think students can learn both by themselves and in group situations. However, I prefer students to study and do activities by themselves more than in a group because I can monitor them more closely. I can see all their faces. It's easier for me to tell if students are paying attention and listening when I teach. Students do not always listen to teacher when they work in groups because their backs are facing teacher.

Comment

Respond D (Teacher Bongkot) is the desired response according to the social constructivist learning theory in accordance with Table 1 Essential features of social constructivism classroom. For the element of collaboration in social constructivist learning theory, D suggests that learners collaborate by acting as a learning community that constructs shared understandings through sustained dialogue. A, C and E do not represent a social constructivist approaches because students do not work collaborating in the group. B represents less collaboration because students have no interaction to each other.

5. Naree is a new science teacher who did not major in science education. She decides to share her story of teaching on the internet to get suggestions from other teachers. She hopes other teachers will share suggestions for revising her lesson plans and other tips that will help her grow as a science teacher. Five

elementary science teachers read her internet story and gave her suggestions as follows. Which teachers' ideas do you agree with most?

A. West elementary science teacher

I think the discussion method that Naree used is a good strategy. It engages students in the lesson. It is better for students to be engaged than sitting and listening to the teacher. Students should have a chance to speak and express their ideas. From the conversations you can tell that students learned from discussion with their peers and teacher. They understand and can explain why air is matter.

B. South elementary science teacher

I don't agree with Naree's use of discussion methods. Students were making loud noises and the room appeared to be quite messy. I don't want to bother other classrooms. I think we can use other methods such as telling students to look for answers in the book by themselves or having the teacher explain the concept to them. I think students can learn and understand in these ways, which are less disruptive, the same as they can from a discussion.

C. East elementary science teacher

I think the discussion method that Naree used is good. All students seemed to understand the concept of matter. Naree asked questions to let students think and then gave them the correct answers to the questions. Students should know the correct answer so that they can learn from their mistakes. After their conversations were finished, you could see that all the students understood that air is matter.

D. North elementary science teacher

I think the discussion method that Naree used was not an effective strategy. She did not try to understand the students' thinking. She asked questions and then

gave the answers to those questions. It seems to me that students did not really demonstrate genuine understanding. They accepted the answer that Naree gave to them and then tried to remember that.

E. Center elementary science teacher

I think Naree's discussion method did not help students understand the science concept of matter. From the conversation, it seems that students were confused about the questions that Naree asked. From my perspective, explaining the correct concept for students is the best way to teach. Moreover, when you engage students in discussion, you will spend most of your time repeating the same questions or content over and over. Believe me; it will save your lots of time when you avoid starting discussions with students.

Comment

Respond, D (North elementary science teacher) is the desired response according to the social constructivist learning theory in accordance with Table 1, essential features of the social constructivism classroom. For dialogue between teacher and students, D suggests that discourse should emphasize eliciting learners' thinking and trying to connect new knowledge with prior knowledge. Both A and C represent a less social constructivist approach because discourse focus on eliciting correct answer. B and E do not represent constructivist approach because the teacher does not believe that a discussion method will help students understand the concept.

Appendix D
Interview Protocol

Interview after teaching the Lesson Plan

Date: _____

Name: _____

Interviewer: _____

Interview Context:

1. What have you learned about Social Constructivist Learning Theory?
2. How did you teach properties of matter in your classroom?
3. What pedagogical strategies did you use in this lesson plan? Why?
4. How can Social Constructivist learning help you design lesson plans that help students genuinely understand science?
5. What part of lesson plan do you think that should be revised? Why?
6. What part of your teaching do you think that should be revised? Why?

Interview after teaching the revised lesson plan

Date: _____

Name: _____

Interviewer: _____

Interview Context:

1. How do you teach properties of matter in your classroom?

2. What differences did you notice in the quality of your lesson when using the revised lesson plan?

3. What happen after you change that unit?

4. How do you come to understand social constructivist learning theory?

5. What benefits and challenges did you face when you tried to teach in ways consistent with tenants of social constructivism?

6. Do you think you will use social constructivist knowledge to design future lessons? Why or why not?

Appendix E

Field Notes

Field notes

Date.....

Time.....

Class.....

Teachers' name.....

Topic.....

Time	Issue	Descriptive notes	Interpretive	Methodological
	Introduction of the lesson			

Time	Issue	Descriptive notes	Interpretive	Methodological
	Teaching and learning activities			
	Conclusion of the Activities			

Note.....
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BIOGRAPHICAL DATA

- NAME:** Miss Apisata JUNTARAPRASERT
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 - The scholarships for research funding from the Graduate School, Kasetsart University, Thailand.